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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, alongside 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
elements 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 Fernandnez-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 ($SMD = 0.72, 95\% \text{ CI} [0.45, 1.00]; p < 0.01$). 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 ($SMD = 1.07, 95\% \text{ CI} [0.44, 1.70]; p < 0.01$) and the low subgroup produced a smaller effect ($SMD = 0.57, 95\% \text{ CI} [0.29, 0.86]; p < 0.01$).

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.

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
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.
References marked with an asterisk indicate studies included in the meta-analysis. The in-text citations to studies selected for meta-analysis are not preceded by asterisks.


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Practitioners, 21(2), 95-100.
Table 1

<table>
<thead>
<tr>
<th>ID</th>
<th>Author, date</th>
<th>Design</th>
<th>Sample (n, IG and CG)</th>
<th>Intervention (FITT)</th>
<th>Control (FITT)</th>
<th>Outcomes relevant to this review</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Antunes (2005)</td>
<td>RCT, Parallel trial, Randomized, Individual randomization</td>
<td>23:23; Analyzed, 23:23</td>
<td>Stationary cycling, 20-60 minutes, 3 x weekly, 6 months</td>
<td>None</td>
<td>SF36-PF</td>
<td>The IG showed significant improvements in SF36-PF ($p &lt; 0.05$), however, no change was detected in the CG</td>
</tr>
<tr>
<td>2</td>
<td>Barrett (2002)</td>
<td>RCT, Parallel trial, Randomized, Individual randomization</td>
<td>22:22; Analyzed, 20:20</td>
<td>Strength training, 60 minutes, 2 x weekly, 10 weeks</td>
<td>Stretching</td>
<td>5STS, SF36-PF</td>
<td>Both groups significantly improved 5STS ($p &lt; 0.003$), but only small improvements in the groups were seen in SF36-PF ($p &gt; 0.05$)</td>
</tr>
<tr>
<td></td>
<td>Study Details</td>
<td>Design</td>
<td>Randomization</td>
<td>Intervention</td>
<td>Measures</td>
<td>Results</td>
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<td>3</td>
<td>Baum (2003)</td>
<td>RCT, Randomized, 11:9; Analyzed, 11:9</td>
<td>Strength training 60 minutes, 3 x weekly, 6 months</td>
<td>Recreational therapy</td>
<td>TUG, BBS, PPT</td>
<td>Statistically significant improvements across all measures in IG ($p &lt; 0.05$) compared with CG ($p = 0.068$)</td>
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<td></td>
<td></td>
<td>Semi-crossover trial, Individual randomization</td>
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<tr>
<td>4</td>
<td>Benavent-Caballer (2014)</td>
<td>RCT, Parallel trial, Randomized, 22:23</td>
<td>Strength training, 30-35 minutes, 3 x weekly, 16 weeks</td>
<td>None</td>
<td>TUG, BBS, 6MWT, BI</td>
<td>All scores improved in the IG, with BI reaching statistical significance ($p = 0.003$) but not for the CG</td>
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<tr>
<td></td>
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<td>Individual randomization</td>
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<tr>
<td>5</td>
<td>Bird (2012)</td>
<td>RCT, Crossover trial, Randomized, 17:15; Analyzed, 14:13</td>
<td>Pilates, 60 minutes, 2 x weekly, 5 weeks (6 week washout period)</td>
<td>None</td>
<td>TUG</td>
<td>Pooled data at study completion showed significant improvements for TUG in the IG ($p &lt; 0.001$) but not the CG</td>
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<tr>
<td></td>
<td>Study</td>
<td>Design</td>
<td>Randomization</td>
<td>Interventions</td>
<td>Measures</td>
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<td>6</td>
<td>Borges (2012)</td>
<td>RCT, Randomized, Dancing, 50 minutes, 3 x weekly, 8 months</td>
<td>80 (total); 39:36</td>
<td>None</td>
<td>FA</td>
<td>The IG significantly improved in FA ($p &lt; 0.001$), but no improvement was found in the CG.</td>
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<tr>
<td>7</td>
<td>Buchner (1997)</td>
<td>RCT, Randomized, IG1 stationary cycling; IG2 strength training.</td>
<td>IG1, 25; IG2, 25; CG, 30;</td>
<td>None</td>
<td>IADL</td>
<td>There were no changes in IADL for any group ($p &gt; 0.05$).</td>
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<tr>
<td>8</td>
<td>Cassilhas (2007)</td>
<td>RCT, Randomized, IG1 strength training (50% 1RM); IG2 strength training (80% 1RM). 60 minutes,</td>
<td>IG1, 20; IG2, 19; CG, 23;</td>
<td>Light exercises</td>
<td>SF36-PF</td>
<td>Groups did not differ significantly on SF36-PF measures ($p &gt; 0.05$).</td>
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<td></td>
<td>Running head: PHYSICAL ACTIVITY AND ADL IN OLDER ADULTS</td>
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<td></td>
<td>IG1, 20; IG2, 19; CG, 23</td>
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<td></td>
<td>3 x weekly, 24 weeks</td>
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</tbody>
</table>

**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**
<table>
<thead>
<tr>
<th>11</th>
<th>Day (2012)</th>
<th>RCT, Randomized, Parallel trial, Individual randomization</th>
<th>Tai Chi</th>
<th>Flexibility exercise</th>
<th>TUG, 6MWT, BBS-Mod</th>
<th>Little difference was observed within or between the two groups for TUG, 6MWT or BBS ($p &gt; 0.05$)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>250:253; Analyzed, 190:171</td>
<td>60 minutes, 2 x weekly, 24 weeks</td>
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<tr>
<td>12</td>
<td>De Vreede (2005)</td>
<td>RCT, Randomized, Parallel trial, Individual randomization</td>
<td>IG1 Functional training; IG2 Strength training.</td>
<td>ADAP, TUG, 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.</td>
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<td>IG1, 33; IG2, 34; CG, 31; Analyzed, 30:30; IG1, 30; IG2, 28; CG, 26</td>
<td>60 minutes, 3 x weekly, 12 weeks</td>
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<tr>
<td>13</td>
<td>Dechamps (2010)</td>
<td>RCT, Randomized, Parallel trial, Individual randomization</td>
<td>Tai chi, 30 minutes, 4 x weekly, 6 months</td>
<td>Usual care Katz ADL, TUG, 5STS</td>
<td>The CG significantly declined in ADL ($p = &lt;0.001$), TUG ($p = 0.003$)</td>
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<tr>
<td>Study</td>
<td>Design</td>
<td>Randomization</td>
<td>Intervention</td>
<td>Control</td>
<td>Outcome Measures</td>
<td>Findings</td>
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<tr>
<td>Eyigor (2009)</td>
<td>RCT,</td>
<td>Individual</td>
<td>Dancing, 60 minutes, 3 x weekly, 8 weeks</td>
<td>None</td>
<td>6MWT, BBS, SF36-PF</td>
<td>The IG improved significantly in 6MWT, BBS and SF36-PF (p &lt; 0.05), while the CG showed no change</td>
</tr>
<tr>
<td>Faber (2006)</td>
<td>RCT,</td>
<td>Parallel trial, Cluster</td>
<td>IG1 functional training; IG2 balance training</td>
<td>Usual activity</td>
<td>GARS</td>
<td>Compared with the CG, the IG1 demonstrated small, significant improvements in GARS (p &lt; 0.05).</td>
</tr>
<tr>
<td>Study</td>
<td>Author</td>
<td>Design</td>
<td>Intervention</td>
<td>Control</td>
<td>Outcome</td>
<td>Findings</td>
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<tr>
<td>16</td>
<td>Fahlman (2007)</td>
<td>RCT, Parallel trial, Randomized, Analyzed, Individual randomization</td>
<td>Strength training 40 minutes, 3 x weekly, 16 weeks</td>
<td>None</td>
<td>6MWT</td>
<td>All groups improved 6MWT performance ($p = 0.05$),</td>
</tr>
<tr>
<td>17</td>
<td>Federici (2005)</td>
<td>RCT, Parallel trial, Randomized, Analyzed, Individual randomization</td>
<td>Dancing, 60 minutes, 2 x weekly, 3 months</td>
<td>None</td>
<td>SUG</td>
<td>Compared with the CG, the IG significantly improved in SUG scores ($p &lt; 0.001$)</td>
</tr>
<tr>
<td>18</td>
<td>Gothe (2015)</td>
<td>RCT, Parallel trial, Randomized, Analyzed, Individual randomization</td>
<td>Yoga, 60 minutes, 3 x weekly, 8 weeks</td>
<td>Stretching</td>
<td>8FUAG</td>
<td>Both groups showed improvements, with a significant time effect for 8FUAG ($p &lt; 0.001$)</td>
</tr>
<tr>
<td>19</td>
<td>Granacher (2012)</td>
<td>RCT, Parallel trial, Randomized, Analyzed, Individual randomization</td>
<td>Core instability strength training, 60 minutes, 2 x weekly, 9 weeks</td>
<td>None</td>
<td>TUG</td>
<td>The IG significantly improved TUG scores ($p = 0.05$) whereas the CG showed no change</td>
</tr>
<tr>
<td></td>
<td>Study</td>
<td>Design</td>
<td>Interventions</td>
<td>Comparator</td>
<td>Outcomes</td>
<td>Findings</td>
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<td>20</td>
<td>Holmerova´ (2010)</td>
<td>RCT, Randomized, Individual randomization</td>
<td>Dancing, 75 minutes, 1 x weekly, 12 weeks</td>
<td>None</td>
<td>TUG</td>
<td>The IG significantly outperformed the CG in TUG ($p = 0.14$)</td>
</tr>
<tr>
<td>21</td>
<td>Hosseini (2011)</td>
<td>RCT, Randomized, Individual randomization</td>
<td>Aquafit, 60 minutes, 3 x weekly, 8 weeks</td>
<td>None</td>
<td>BBS, 5STS, BBS, 5STS and TUG</td>
<td>Scores improved significantly in the IG ($p &lt; 0.05$) whereas the CG showed no change</td>
</tr>
<tr>
<td>22</td>
<td>Jorgensen (2013)</td>
<td>RCT, Randomized, Individual randomization</td>
<td>Wii fit, 40 minutes, 2 x weekly, 10 weeks</td>
<td>Usual activity</td>
<td>TUG</td>
<td>The IG improved significantly in TUG ($p = 0.01$) compared to the CG</td>
</tr>
<tr>
<td>23</td>
<td>Kalapotharakos (2006)</td>
<td>RCT, Randomized, Individual randomization</td>
<td>Walking, 20-40 minutes, 3 x weekly, 12 weeks</td>
<td>None</td>
<td>6MWT, 5STS</td>
<td>The IG significantly improved in 6MWT and 5STS ($p &lt; 0.05$), whereas</td>
</tr>
<tr>
<td>Study</td>
<td>Design</td>
<td>Randomization</td>
<td>Intervention</td>
<td>Control</td>
<td>Outcomes</td>
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<tr>
<td>Kováč (2013)</td>
<td>RCT, Parallel trial, Individual randomization</td>
<td>IG1 Pilates; IG2 aquafit. 60 minutes, 3 x weekly, 6 months</td>
<td>IG1, 22; IG2, 17; CG, 15</td>
<td>None</td>
<td>6MWT, 8FUAG</td>
<td>Both IG’s significantly improved in 6MWT ($p = &lt;0.001$) and 8FUAG (IG1, $p = &lt;0.001$; IG2, $p = &lt;0.01$), with the IG1 improving the most, whereas the CG showed little change</td>
</tr>
<tr>
<td>Maillot (2012)</td>
<td>RCT, Parallel trial, Individual randomization</td>
<td>Exergaming (Wii), 60 minutes, 2 x weekly, 12 weeks</td>
<td>IG1, 22; IG2, 17; CG, 15</td>
<td>None</td>
<td>6MWT, 8FUAG</td>
<td>The IG significantly improved in both measures ($p = &lt;0.5$) compared with the CG.</td>
</tr>
<tr>
<td></td>
<td>Author</td>
<td>Study Type</td>
<td>Intervention</td>
<td>Activity</td>
<td>Length</td>
<td>Control Group</td>
</tr>
<tr>
<td>---</td>
<td>--------</td>
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<td>---------------</td>
</tr>
<tr>
<td>26</td>
<td>McKinley (2008)</td>
<td>RCT, Randomized, Parallel trial, Individual</td>
<td>Dancing, 90 minutes, 2 x weekly</td>
<td>Walking, 5STS</td>
<td>Both groups improved, with the IG reaching statistical significance ($p &lt; 0.5$)</td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>McMurdo (1993)</td>
<td>RCT, Randomized, Parallel trial, Cluster</td>
<td>Strength training, 45 minutes, 2 x weekly</td>
<td>Reminiscence sessions</td>
<td>BI</td>
<td>The IG post-test BI scores were significantly different to the CG ($p &lt; 0.5$)</td>
</tr>
<tr>
<td>28</td>
<td>Mesquita (2015)</td>
<td>RCT, Randomized, Parallel trial, Individual</td>
<td>IG1 Stretching; IG2 Pilates, 50 minutes, 3 x weekly</td>
<td>None, BBS, TUG</td>
<td>Both IG’s improved significantly in TUG ($p &lt; 0.001$) and BBS ($p = 0.001$) with little change in the CG</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Study</td>
<td>Design</td>
<td>Intervention</td>
<td>Recruitment</td>
<td>Duration</td>
<td>Primary Outcome</td>
</tr>
<tr>
<td>---</td>
<td>-------</td>
<td>--------</td>
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<td>-----------</td>
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</tr>
<tr>
<td>29</td>
<td>Moore-Harrison (2008)</td>
<td>RCT, Parallel trial, Individual randomization</td>
<td>Walking, 30-60 minutes, 3 x weekly, 16 weeks</td>
<td>13:13; 12:12</td>
<td>SF36-PF</td>
<td>The IG significantly improved in SF36-PF ($p &lt; 0.001$), while the CG showed little change</td>
</tr>
<tr>
<td>30</td>
<td>Nagai (2012)</td>
<td>RCT, Parallel trial, Individual randomization</td>
<td>Balance training, 40 minutes, 2 x weekly, 8 weeks</td>
<td>24:24; 24:24</td>
<td>TUG</td>
<td>The IG improved significantly in TUG ($p &lt; 0.5$) whereas the CG did not change</td>
</tr>
<tr>
<td>31</td>
<td>Ni (2014)</td>
<td>RCT, Parallel trial, Individual randomization</td>
<td>IG1 Tai chi; IG2 yoga</td>
<td>IG1, 16; IG2, 16; CG, 16; 12:12; 13:15</td>
<td>8FUAG</td>
<td>Significant 8FUAG improvements were observed in all groups ($p &lt; 0.5$), with the IG2 showing the greatest improvement</td>
</tr>
<tr>
<td>32</td>
<td>Oken (2006)</td>
<td>RCT, Parallel trial, Individual randomization</td>
<td>IG1 Yoga, 90 minutes, 1 x weekly, 12 weeks</td>
<td>IG1, 11; IG2, 13; CG, 15</td>
<td>SF36-PF</td>
<td>SF36-PF scores did not change in either IG,</td>
</tr>
<tr>
<td>Study</td>
<td>Design</td>
<td>Randomization</td>
<td>Intervention</td>
<td>Control</td>
<td>Outcome Measures</td>
<td>Results</td>
</tr>
<tr>
<td>-------</td>
<td>--------</td>
<td>---------------</td>
<td>--------------</td>
<td>---------</td>
<td>------------------</td>
<td>---------</td>
</tr>
<tr>
<td>33</td>
<td>RCT</td>
<td>Individual</td>
<td>IG1, 44; IG2, 47; CG, 42</td>
<td>IG2 Walking, 60 minutes, 1x weekly, 6 months</td>
<td>BBS, TUG, SF36-PF</td>
<td>The IG significantly improved in TUG, BBS and SF36-PF (p &lt; 0.05). The CG showed no change</td>
</tr>
<tr>
<td>34</td>
<td>RCT</td>
<td>Individual</td>
<td>IG1, 38; IG2, 38; CG, 42</td>
<td>IG2 Walking, 60 minutes, 1x weekly, 6 months</td>
<td>8FUAG</td>
<td>The IG significantly improved in 8FUAG (p = &lt;0.001) while the CG showed no change</td>
</tr>
<tr>
<td>Study ID</td>
<td>Authors (Year)</td>
<td>Study Design</td>
<td>Intervention</td>
<td>Duration</td>
<td>Randomization</td>
<td>Outcome Measure</td>
</tr>
<tr>
<td>----------</td>
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<td>---------------</td>
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</tr>
<tr>
<td>35</td>
<td>Rendon (2012)</td>
<td>RCT, Randomized,</td>
<td>Exergaming, 35-45 minutes, 3 x</td>
<td>None</td>
<td>8FUAG</td>
<td>The IG significantly improved in 8FUAG compared with the CG ($p = 0.0385$)</td>
</tr>
<tr>
<td>36</td>
<td>Rodrigues (2010)</td>
<td>RCT, Randomized,</td>
<td>Pilates, 60 minutes, 2 x weekly, 8 weeks</td>
<td>None</td>
<td>FA</td>
<td>The IG significantly improved in FA compared with the CG ($p = 0.0003$)</td>
</tr>
<tr>
<td>37</td>
<td>Saravanakumar (2014)</td>
<td>RCT, Randomized,</td>
<td>IG1 Tai chi; IG2 Yoga, 30 minutes, 2 x weekly, 14 weeks</td>
<td>Usual care</td>
<td>BBS</td>
<td>IG2 was the only group to show an improvement in BBS, while the other groups declined in performance ($p = 0.456$)</td>
</tr>
<tr>
<td>38</td>
<td>Sato (2007)</td>
<td>RCT, Randomized,</td>
<td>Aquafit Recreation activities</td>
<td></td>
<td>SF36-PF, FIM</td>
<td>Significant pre-post differences were found for</td>
</tr>
</tbody>
</table>
Individual randomization
12; CG, 8; 60 minutes, once/twice x weekly, 6 months
Analyzed, IG1, 10; IG2, 11; CG, 8

RCT, Parallel trial, Randomized, IG1 balance training; IG2 walking 40 minutes, 2-3 x weekly, 12 weeks
Individual randomization Analyzed, IG1 12, IG2 11, CG 9

40 Stanziano (2009)
RCT, Parallel trial, Randomized, Active, assisted stretching, 30 minutes, 2 x weekly, 8 weeks
Individual randomization Analyzed, 8:9; 8FUAG 5:8

IG1 (p = 0.004) and IG2 (p = 0.002) in FIM. No significant differences were observed in SF36-PF (p > 0.05).

All three groups improved in TUG scores, with only IG2 scores reaching statistical significance (p < 0.05).
The IG showed significant improvement in the 8FUAG (p = 0.041) while the CG significantly
<table>
<thead>
<tr>
<th>Study</th>
<th>Design</th>
<th>Randomization</th>
<th>Intervention</th>
<th>Comparator</th>
<th>Measure(s)</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tiedemann (2013)</td>
<td>RCT, Parallel trial, Individual randomized</td>
<td>Yoga, 60 minutes, 2 x weekly, 12 weeks</td>
<td>None</td>
<td>5STS</td>
<td>The IG improved significantly in 5STS (p &lt; 0.001) whereas the CG showed a decline in scores.</td>
<td></td>
</tr>
<tr>
<td>Tousignant (2012)</td>
<td>RCT, Parallel trial, Individual randomized</td>
<td>Tai chi, 60 minutes, 2 x weekly, 15 weeks</td>
<td>Physiotherapy</td>
<td>BBS, TUG</td>
<td>Both groups improved similarly over time in both measures (p = .001)</td>
<td></td>
</tr>
<tr>
<td>Tsang (2013)</td>
<td>RCT, Parallel trial, Individual randomized</td>
<td>Qigong, 60 minutes, 2 x weekly, 12 weeks</td>
<td>Newspaper reading</td>
<td>TUG</td>
<td>TUG scores improved in the IG and declined in the CG, but this did not reach statistical significance (p = 0.54)</td>
<td></td>
</tr>
<tr>
<td>Study (Year)</td>
<td>Design</td>
<td>Randomization</td>
<td>Activity</td>
<td>Control</td>
<td>Outcome</td>
<td>Findings</td>
</tr>
<tr>
<td>-------------</td>
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<td>---------</td>
<td>----------</td>
</tr>
<tr>
<td>Tse (2010)</td>
<td>RCT, Parallel trial, Cluster randomized</td>
<td>26:27</td>
<td>Gardening, 1 hour per week (over 3-5 days), 8 weeks</td>
<td>Normal care</td>
<td>BI</td>
<td>There were no significant differences in BI for either group ($p &gt; 0.05$)</td>
</tr>
<tr>
<td>Varela (2011)</td>
<td>RCT, Parallel trial, Individual randomized</td>
<td>IG1, 27; IG2, 26; CG, 15</td>
<td>IG 1 stationary cycling (40% HRR); IG 2 stationary cycling (60% HRR), 30 minutes, 3 x weekly, 12 weeks</td>
<td>Recreation</td>
<td>TUG</td>
<td>TUG scores improved across all groups, but did not reach statistical significance ($p &gt; 0.05$)</td>
</tr>
<tr>
<td>Wei (2014)</td>
<td>RCT, Parallel trial, Individual randomized</td>
<td>30:30</td>
<td>Handball None</td>
<td>IADL</td>
<td>ADL decreased in the IG group ($p &lt; 0.05$), while there were no changes in the CG</td>
<td></td>
</tr>
</tbody>
</table>
Wolf (2001) RCT, Randomized, Balance training Arts and crafts BBS The IG improved
Parallel trial, 47:47; 30 minutes, 2-3 x significantly in BBS
Individual Analyzed, weekly, 4-6 weeks compared with the CG (p =
randomization 37:40 (12 sessions total) <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

9,303 potentially relevant articles identified through database search

7,612 titles and abstracts screened

386 full text articles assessed for eligibility

1,691 duplicates removed

7,226 articles excluded

19 articles retrieved via researcher knowledge and examination of reference lists of full text articles assessed

357 articles excluded

Reasons:
(95) Not an RCT
(3) Participants mean age not 60+ (55 years old minimum)
(16) Recruitment for disease state
(57) Was not a specific PA type/volume
(113) Multicomponent intervention (e.g. Included educational sessions)
(2) Physical activity <10 minute sessions
(69) No accepted ADL measure
(2) PEDro score <4

48 articles (47 studies) included in review

33 studies included in physical activity level meta-analyses; 31 studies included in multitask activity level meta-analyses
1. **Figure 2.** Physical Activity Level (with low, moderate and high subgroups) versus control on physical performance ADL outcomes

<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>Experimental Mean</th>
<th>SD</th>
<th>Total</th>
<th>Control Mean</th>
<th>SD</th>
<th>Total</th>
<th>Weight</th>
<th>IV, Random, 95% CI</th>
<th>Std. Mean Difference IV, Random, 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bernie (2002)</td>
<td>-1.02</td>
<td>2.3</td>
<td>29</td>
<td>-9.2</td>
<td>1.2</td>
<td>20</td>
<td>2.0</td>
<td>2.1%</td>
<td>-0.51 [1.17, 0.10]</td>
</tr>
<tr>
<td>Beattie-Cabriale (2014)</td>
<td>-1.07</td>
<td>3.08</td>
<td>22</td>
<td>-12.41</td>
<td>7.42</td>
<td>23</td>
<td>3.6%</td>
<td>0.28 [0.34, 0.63]</td>
<td></td>
</tr>
<tr>
<td>Fahlman (2007)</td>
<td>-1.37</td>
<td>43.16</td>
<td>39</td>
<td>-1.40</td>
<td>43.61</td>
<td>33</td>
<td>3.0%</td>
<td>0.10 [0.29, 0.44]</td>
<td></td>
</tr>
<tr>
<td>Ganz (2012)</td>
<td>-1.17</td>
<td>5.9</td>
<td>27</td>
<td>-23.4</td>
<td>14.5</td>
<td>25</td>
<td>3.6%</td>
<td>1.00 [0.47, 1.14]</td>
<td></td>
</tr>
<tr>
<td>Jorgensen (2013)</td>
<td>-0.4</td>
<td>3.2</td>
<td>27</td>
<td>-19.8</td>
<td>5.1</td>
<td>30</td>
<td>3.7%</td>
<td>0.64 [0.38, 0.96]</td>
<td></td>
</tr>
<tr>
<td>Kalpak et al. (2009)</td>
<td>-1.15</td>
<td>1.4</td>
<td>12</td>
<td>-12.1</td>
<td>1.7</td>
<td>10</td>
<td>3.1%</td>
<td>0.67 [0.17, 1.17]</td>
<td></td>
</tr>
<tr>
<td>Mager (2012)</td>
<td>-7.5</td>
<td>1.7</td>
<td>24</td>
<td>-9.2</td>
<td>2.5</td>
<td>24</td>
<td>3.0%</td>
<td>0.03 [0.24, 1.42]</td>
<td></td>
</tr>
<tr>
<td>Na (2014)</td>
<td>-0.65</td>
<td>0.84</td>
<td>24</td>
<td>-7.23</td>
<td>6.39</td>
<td>15</td>
<td>3.1%</td>
<td>2.39 [1.50, 3.29]</td>
<td></td>
</tr>
<tr>
<td>Oken (2008)</td>
<td>-0.9</td>
<td>2.56</td>
<td>78</td>
<td>-9.1</td>
<td>2.1</td>
<td>42</td>
<td>4.0%</td>
<td>-0.21 [0.09, 0.17]</td>
<td></td>
</tr>
<tr>
<td>Ovskar (2015)</td>
<td>-0.5</td>
<td>1</td>
<td>16</td>
<td>-7.4</td>
<td>1.1</td>
<td>16</td>
<td>3.2%</td>
<td>1.58 [0.77, 2.38]</td>
<td></td>
</tr>
<tr>
<td>Pinto (2014)</td>
<td>-2.02</td>
<td>0.28</td>
<td>19</td>
<td>4.74</td>
<td>0.69</td>
<td>17</td>
<td>2.2%</td>
<td>1.96 [0.87, 2.96]</td>
<td></td>
</tr>
<tr>
<td>Regin (2016)</td>
<td>-23.69</td>
<td>3.86</td>
<td>27</td>
<td>-27.19</td>
<td>3.69</td>
<td>25</td>
<td>3.0%</td>
<td>0.04 [0.36, 1.52]</td>
<td></td>
</tr>
<tr>
<td>Baran (1983b)</td>
<td>2.97</td>
<td>16.57</td>
<td>13</td>
<td>29.8</td>
<td>14.3</td>
<td>10</td>
<td>2.1%</td>
<td>0.24 [0.59, 1.67]</td>
<td></td>
</tr>
<tr>
<td>Shindan (2003)</td>
<td>-2.317</td>
<td>17.76</td>
<td>23</td>
<td>17.4</td>
<td>4.8</td>
<td>9</td>
<td>3.2%</td>
<td>-0.38 [1.17, 0.39]</td>
<td></td>
</tr>
<tr>
<td>Gandini (2009)</td>
<td>-7.0</td>
<td>2.4</td>
<td>5</td>
<td>-14.5</td>
<td>11</td>
<td>9</td>
<td>2.4%</td>
<td>0.77 [0.43, 1.15]</td>
<td></td>
</tr>
<tr>
<td>Taidman (2013)</td>
<td>-5.8</td>
<td>9.6</td>
<td>27</td>
<td>-13.6</td>
<td>0.1</td>
<td>25</td>
<td>3.0%</td>
<td>1.02 [0.44, 1.60]</td>
<td></td>
</tr>
<tr>
<td>Tse (2014)</td>
<td>-20.5</td>
<td>6.6</td>
<td>29</td>
<td>-21.7</td>
<td>3</td>
<td>34</td>
<td>3.0%</td>
<td>0.24 [0.09, 0.79]</td>
<td></td>
</tr>
<tr>
<td>Tsai (2013)</td>
<td>-22.10</td>
<td>13.7</td>
<td>42</td>
<td>-22.17</td>
<td>11.72</td>
<td>35</td>
<td>3.9%</td>
<td>-0.06 [0.45, 0.45]</td>
<td></td>
</tr>
<tr>
<td>Yilmaz (2011)</td>
<td>4.25</td>
<td>11.11</td>
<td>37</td>
<td>38.12</td>
<td>15</td>
<td>40</td>
<td>3.9%</td>
<td>0.37 [0.08, 0.68]</td>
<td></td>
</tr>
<tr>
<td>Subtotal (95% CI)</td>
<td>522</td>
<td>457</td>
<td>60</td>
<td>0.57 [0.25, 0.86]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Heterogeneity: Test = 0.32, Chi² = 85.32, df = 19 (P = 0.00001); T = 78%
Heterogeneity: Test for overall effect Z = 1.92 (P = 0.050)

1.1.4 Moderate physical activity level

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) 611 662 100.0% 0.72 [0.45, 1.00] |

Heterogeneity: Test = 0.45, Chi² = 166.16, df = 20 (P = 0.00001); T = 23%

Test for overall effect Z = 2.11 (P = 0.033)

Test for outcome differences: Chi² = 1.08, df = 1 (P = 0.30), N = 98.9%
Figure 3. Physical Activity Level (with low, moderate and high subgroups) versus control on self-reported ADL outcomes

<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>Experimental Mean</th>
<th>Experimental SD</th>
<th>Experimental Total</th>
<th>Control Mean</th>
<th>Control SD</th>
<th>Control Total</th>
<th>Std. Mean Difference IV, Random, 95% CI</th>
<th>Std. Mean Difference IV, Random, 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barrett (2002)</td>
<td>73.8</td>
<td>19</td>
<td>20</td>
<td>78.5</td>
<td>18.9</td>
<td>20</td>
<td>11.4%</td>
<td>-0.29 [0.69, 0.37]</td>
</tr>
<tr>
<td>Benware-Caballeri (2014)</td>
<td>92.22</td>
<td>6.89</td>
<td>22</td>
<td>93.33</td>
<td>6.51</td>
<td>23</td>
<td>0.0%</td>
<td>-0.17 [0.75, 0.42]</td>
</tr>
<tr>
<td>Okon (2004)</td>
<td>62.96</td>
<td>14.82</td>
<td>70</td>
<td>58.7</td>
<td>9.6</td>
<td>42</td>
<td>12.0%</td>
<td>-0.24 [0.61, 0.11]</td>
</tr>
<tr>
<td>Oliveira (2015)</td>
<td>93.4</td>
<td>16.8</td>
<td>10</td>
<td>78.2</td>
<td>22.8</td>
<td>10</td>
<td>16.7%</td>
<td>0.95 [0.21, 1.69]</td>
</tr>
<tr>
<td>Subtotal (95% CI)</td>
<td>134</td>
<td>101</td>
<td>234</td>
<td></td>
<td></td>
<td></td>
<td>46.3%</td>
<td>0.62 [0.46, 0.49]</td>
</tr>
</tbody>
</table>

Heterogeneity: Tau² = 0.15; Chi² = 3.45, df = 3 (P = 0.41); I² = 65%
Test for overall effect: Z = 0.66 (P = 0.51)

1.1.1 Moderate physical activity level

<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>Experimental Mean</th>
<th>Experimental SD</th>
<th>Experimental Total</th>
<th>Control Mean</th>
<th>Control SD</th>
<th>Control Total</th>
<th>Std. Mean Difference IV, Random, 95% CI</th>
<th>Std. Mean Difference IV, Random, 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ardune (2005)</td>
<td>97.82</td>
<td>2.53</td>
<td>23</td>
<td>91.98</td>
<td>6.58</td>
<td>23</td>
<td>11.2%</td>
<td>0.33 [0.05, 1.96]</td>
</tr>
<tr>
<td>Edgier (2009)</td>
<td>98.8</td>
<td>12.2</td>
<td>19</td>
<td>78.6</td>
<td>16</td>
<td>10</td>
<td>11.1%</td>
<td>0.94 [0.03, 1.30]</td>
</tr>
<tr>
<td>Moore-Harison (2000)</td>
<td>65.8</td>
<td>13.6</td>
<td>12</td>
<td>65</td>
<td>15.4</td>
<td>12</td>
<td>9.7%</td>
<td>1.33 [0.45, 2.23]</td>
</tr>
<tr>
<td>State (2007)</td>
<td>30.19</td>
<td>8.75</td>
<td>21</td>
<td>18.1</td>
<td>12.8</td>
<td>8</td>
<td>9.7%</td>
<td>1.18 [0.45, 2.27]</td>
</tr>
<tr>
<td>Subtotal (95% CI)</td>
<td>75</td>
<td>41.8</td>
<td>64</td>
<td></td>
<td></td>
<td></td>
<td>41.8%</td>
<td>1.12 [0.74, 1.49]</td>
</tr>
</tbody>
</table>

Heterogeneity: Tau² = 0.66; Chi² = 3.96, df = 3 (P = 0.39); I² = 6%
Test for overall effect: Z = 0.65 (P = 0.52)

1.1.5 High physical activity level

<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>Experimental Mean</th>
<th>Experimental SD</th>
<th>Experimental Total</th>
<th>Control Mean</th>
<th>Control SD</th>
<th>Control Total</th>
<th>Std. Mean Difference IV, Random, 95% CI</th>
<th>Std. Mean Difference IV, Random, 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vail (2014)</td>
<td>14.43</td>
<td>0.93</td>
<td>30</td>
<td>15.47</td>
<td>1.65</td>
<td>30</td>
<td>11.0%</td>
<td>-0.02 [-1.34, -0.29]</td>
</tr>
<tr>
<td>Subtotal (95% CI)</td>
<td>30</td>
<td>30</td>
<td>60</td>
<td></td>
<td></td>
<td></td>
<td>11.0%</td>
<td>-0.02 [-1.34, -0.29]</td>
</tr>
</tbody>
</table>

Heterogeneity: Not applicable

Test for overall effect: Z = 3.03 (P = 0.002)

Total (95% CI) | 239 | 192 | 100.0% | 0.41 [0.02, 0.79]

Heterogeneity: Tau² = 0.65; Chi² = 52.84, df = 8 (P = 0.00001); I² = 85%
Test for overall effect: Z = 1.61 (P = 0.10)

Test for subgroup differences: Chi² = 35.64, df = 2 (P = 0.0001); I² = 94.0%
1 **Figure 4.** Multitask Activity Level (with low, moderate and high subgroups) versus control on physical performance ADL outcomes

<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>Experimental</th>
<th>Control</th>
<th>Std. Mean Difference</th>
<th>Std. Mean Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean SD Total</td>
<td>Mean SD Total</td>
<td>IV Random, 95% CI</td>
<td>IV Random, 95% CI</td>
</tr>
<tr>
<td>Eric (2002)</td>
<td>-10.2 2.3</td>
<td>29 -9.2 1.2 20</td>
<td>3.0% -6.5[1.17, 0.10]</td>
<td></td>
</tr>
<tr>
<td>Enomoto (2004)</td>
<td>1.377 43.16</td>
<td>39 -4.04 43.61 33</td>
<td>4.7% 6.10[0.99, 6.44]</td>
<td></td>
</tr>
<tr>
<td>Fujihara (2012)</td>
<td>-2.3 0.6</td>
<td>16 -4.9 0.0 18</td>
<td>5.0% 0.00[0.23, 1.70]</td>
<td></td>
</tr>
<tr>
<td>Kallipolitou (2006)</td>
<td>-1.15 1.4</td>
<td>12 -12.1 1.7 10</td>
<td>3.0% 0.37[0.42, 1.22]</td>
<td></td>
</tr>
<tr>
<td>Fltto (2014)</td>
<td>-3.03 0.35</td>
<td>18 -4.24 0.59 17</td>
<td>3.4% 1.00[1.08, 2.10]</td>
<td></td>
</tr>
<tr>
<td>Shinnaka (2008)</td>
<td>-7.6 2.4</td>
<td>5 -14.6 11 8</td>
<td>2.6% 0.72[0.41, 1.92]</td>
<td></td>
</tr>
<tr>
<td>Vasile (2011)</td>
<td>-16.92 3.28</td>
<td>33 -17.65 6.61 15</td>
<td>3.0% 0.16[0.46, 0.77]</td>
<td></td>
</tr>
<tr>
<td>Subtotal (with CI)</td>
<td>-16.06 0.16</td>
<td>142 26.8% 0.45[0.60, 0.05]</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Heterogeneity Test: $\chi^2 = 0.01$, $p = 0.92$, $df = 7$ ($p = 0.00002$), $I^2 = 72$

Test for overall effect: $Z = 1.91$ ($p = 0.60$)

1.1.3 Moderate multitask activity level

<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>Experimental</th>
<th>Control</th>
<th>Std. Mean Difference</th>
<th>Std. Mean Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean SD Total</td>
<td>Mean SD Total</td>
<td>IV Random, 95% CI</td>
<td>IV Random, 95% CI</td>
</tr>
<tr>
<td>Goethe (2015)</td>
<td>-5.23 0.6</td>
<td>59 -5.52 1.03 50</td>
<td>4.0% 0.32[0.07, 0.70]</td>
<td></td>
</tr>
<tr>
<td>Heestra (2011)</td>
<td>-0.75 0.38</td>
<td>15 -7.59 0.62 15</td>
<td>3.0% 1.70[0.03, 3.69]</td>
<td></td>
</tr>
<tr>
<td>Jongers (2013)</td>
<td>0.3 1.3</td>
<td>27 -13.9 5.1 30</td>
<td>4.0% 0.44[0.09, 0.89]</td>
<td></td>
</tr>
<tr>
<td>Knott (2013)</td>
<td>-5.2 0.62</td>
<td>38 -5.6 0.6 15</td>
<td>3.0% 0.59[0.02, 1.1]</td>
<td></td>
</tr>
<tr>
<td>Nagai (2012)</td>
<td>-7.5 1.7</td>
<td>24 -9.2 2.3 24</td>
<td>3.9% 0.88[0.25, 1.79]</td>
<td></td>
</tr>
<tr>
<td>Ni (2014)</td>
<td>-5.05 0.84</td>
<td>24 -7.23 0.38 15</td>
<td>3.7% 2.35[0.01, 1.23]</td>
<td></td>
</tr>
<tr>
<td>Oliveira (2015)</td>
<td>-2.7 1.6</td>
<td>18 -7.4 1.1 16</td>
<td>3.4% 1.58[0.72, 3.38]</td>
<td></td>
</tr>
<tr>
<td>Rodrigues (2016)</td>
<td>-2.9 0.88</td>
<td>27 -22.19 3.96 25</td>
<td>3.0% 0.98[0.38, 1.65]</td>
<td></td>
</tr>
<tr>
<td>Sankaranarayanan (2014)</td>
<td>3.07 0.5</td>
<td>13 -28.6 14.3 10</td>
<td>3.3% 0.06[0.58, 0.12]</td>
<td></td>
</tr>
<tr>
<td>Tideman (2012)</td>
<td>-0.05 2.6</td>
<td>27 -13.6 0.6 25</td>
<td>3.0% 1.02[0.44, 1.82]</td>
<td></td>
</tr>
<tr>
<td>Trinjek (2012)</td>
<td>-20.5 6.8</td>
<td>25 -21.7 30 34</td>
<td>4.2% 0.00[0.41, 1.01]</td>
<td></td>
</tr>
<tr>
<td>Tsing (2015)</td>
<td>-22.10 1.27</td>
<td>42 -22.17 11.7 25</td>
<td>4.2% -0.56[0.3, 0.5]</td>
<td></td>
</tr>
<tr>
<td>Yeo (2016)</td>
<td>4.01 1.11</td>
<td>37 -12.75 40 41</td>
<td>4.2% 0.67[0.01, 0.2]</td>
<td></td>
</tr>
<tr>
<td>Subtotal (with CI)</td>
<td>3.07 0.01</td>
<td>334 43.6% 0.74[0.15, 0.06]</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Heterogeneity Test: $\chi^2 = 0.25$, $p = 0.60$, $df = 12$ ($p = 0.00001$), $I^2 = 45$

Test for overall effect: $Z = 4.00$ ($p = 0.00001$)

1.1.4 High multitask activity level

<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>Experimental</th>
<th>Control</th>
<th>Std. Mean Difference</th>
<th>Std. Mean Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean SD Total</td>
<td>Mean SD Total</td>
<td>IV Random, 95% CI</td>
<td>IV Random, 95% CI</td>
</tr>
<tr>
<td>Eriksen (2012)</td>
<td>-5.55 3.2</td>
<td>39 -52.34 6.56 36</td>
<td>4.2% 0.75[0.29, 1.28]</td>
<td></td>
</tr>
<tr>
<td>Cvetkovic (2015)</td>
<td>0.05 0.2</td>
<td>32 -0.01 6.76 25</td>
<td>2.9% 4.59[0.57, 0.81]</td>
<td></td>
</tr>
<tr>
<td>Ejgio (2009)</td>
<td>-5.2 0.38</td>
<td>19 -53.9 1.7 19</td>
<td>2.1% 1.02[0.24, 1.72]</td>
<td></td>
</tr>
<tr>
<td>Feitl (2009)</td>
<td>-8.3 0.5</td>
<td>39 -5.8 0.5 20</td>
<td>3.7% 1.06[0.04, 1.73]</td>
<td></td>
</tr>
<tr>
<td>Higginson (2015)</td>
<td>-11.7 0.3</td>
<td>27 -23.4 14.5 25</td>
<td>2.6% 1.00[0.47, 1.84]</td>
<td></td>
</tr>
<tr>
<td>McKeown (2016)</td>
<td>-12.36 4.5</td>
<td>44 -12.31 3.38 11</td>
<td>3.4% 0.01[0.57, 0.68]</td>
<td></td>
</tr>
<tr>
<td>Subtotal (with CI)</td>
<td>-11.31 0.01</td>
<td>135 21.5% 1.38[0.46, 2.26]</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Heterogeneity Test: $\chi^2 = 1.31$, $p = 0.92$, $df = 5$ ($p = 0.00001$), $I^2 = 81$

Test for overall effect: $Z = 3.95$ ($p = 0.00001$)

Total (95% CI) 4692 611 100.0% 0.79[0.51, 1.07]

Heterogeneity Test: $\chi^2 = 0.44$, $p = 1.65$, $df = 38$ ($p < 0.00001$), $I^2 = 2.6$

Test for overall effect: $Z = 6.51$ ($p < 0.00001$)

Test for outcome differences: $\chi^2 = 3.32$, $df = 2$ ($p = 0.20$), $I^2 = 37.5$

Test for outcome differences: $\chi^2 = 3.26$, $df = 2$ ($p = 0.20$), $I^2 = 37.5$
Figure 5. Multitask Activity Level (with low, moderate and high subgroups) versus control on self-reported ADL outcomes

<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>Experimental Mean</th>
<th>SD</th>
<th>Total</th>
<th>Control Mean</th>
<th>SD</th>
<th>Total</th>
<th>Weight</th>
<th>Std. Mean Difference IV, Random, 95% CI</th>
<th>Std. Mean Difference IV, Random, 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low multitask activity level</td>
<td>Antunes (2016)</td>
<td>67.82</td>
<td>2.59</td>
<td>23</td>
<td>91.08</td>
<td>0.58</td>
<td>22</td>
<td>12.0%</td>
<td>1.30 {0.69, 1.91}</td>
</tr>
<tr>
<td></td>
<td>Barnett (2002)</td>
<td>73.8</td>
<td>19</td>
<td>20</td>
<td>78.5</td>
<td>18.9</td>
<td>20</td>
<td>12.9%</td>
<td>-0.28 {0.68, 0.37}</td>
</tr>
<tr>
<td></td>
<td>Beavers-Canemaker (2014)</td>
<td>62.22</td>
<td>9.66</td>
<td>22</td>
<td>62.33</td>
<td>0.51</td>
<td>20</td>
<td>13.1%</td>
<td>-0.17 {0.75, 0.42}</td>
</tr>
<tr>
<td></td>
<td>Hoorens-Franken (2006)</td>
<td>65.8</td>
<td>13.6</td>
<td>12</td>
<td>65.8</td>
<td>18.4</td>
<td>12</td>
<td>11.2%</td>
<td>1.33 {0.42, 2.33}</td>
</tr>
<tr>
<td></td>
<td>Subtotal (95% CI)</td>
<td>77</td>
<td>78</td>
<td>50.2%</td>
<td>0.53 {0.34, 1.40}</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Heterogeneity: Tau² = 0.66; CH² = 20.62; df = 3 (P = 0.0002); P = 85% Test for overall effect: Z = 1.20 (P = 0.23)</td>
<td></td>
<td></td>
<td></td>
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</table>

1.5 Moderate multitask activity level

<table>
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<tr>
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<th>SD</th>
<th>Total</th>
<th>Control Mean</th>
<th>SD</th>
<th>Total</th>
<th>Weight</th>
<th>Std. Mean Difference IV, Random, 95% CI</th>
<th>Std. Mean Difference IV, Random, 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Oliveira (2015)</td>
<td>93.4</td>
<td>16.9</td>
<td>16</td>
<td>78.2</td>
<td>22.8</td>
<td>16</td>
<td>12.3%</td>
<td>0.95 {0.21, 1.69}</td>
</tr>
<tr>
<td></td>
<td>Salk (2007)</td>
<td>20.19</td>
<td>9.76</td>
<td>21</td>
<td>19.1</td>
<td>12.9</td>
<td>20</td>
<td>11.2%</td>
<td>1.39 {0.40, 2.37}</td>
</tr>
<tr>
<td></td>
<td>Subtotal (95% CI)</td>
<td>37</td>
<td>24</td>
<td>23.6%</td>
<td>1.12 {0.55, 1.69}</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Heterogeneity: Tau² = 0.63; CH² = 0.83, df = 1 (P = 0.47); P = 62% Test for overall effect: Z = 3.85 (P = 0.0001)</td>
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1.5 High multitask activity level

<table>
<thead>
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<th>Total</th>
<th>Control Mean</th>
<th>SD</th>
<th>Total</th>
<th>Weight</th>
<th>Std. Mean Difference IV, Random, 95% CI</th>
<th>Std. Mean Difference IV, Random, 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ekpe (2009)</td>
<td>98.8</td>
<td>12.2</td>
<td>19</td>
<td>79.8</td>
<td>16</td>
<td>18</td>
<td>12.7%</td>
<td>0.84 {0.32, 1.36}</td>
</tr>
<tr>
<td></td>
<td>Vital (2014)</td>
<td>14.43</td>
<td>0.036</td>
<td>20</td>
<td>15.47</td>
<td>1.98</td>
<td>30</td>
<td>13.4%</td>
<td>-0.02 {0.34, 0.29}</td>
</tr>
<tr>
<td></td>
<td>Subtotal (95% CI)</td>
<td>49</td>
<td>48</td>
<td>26.2%</td>
<td>-0.10 {1.53, 1.22}</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Heterogeneity: Tau² = 0.60; CH² = 11.27, df = 1 (P = 0.0038); P = 91% Test for overall effect: Z = 6.14 (P = 0.0001)</td>
<td></td>
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</tr>
</tbody>
</table>

Total (95% CI)

<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>Experimental Mean</th>
<th>SD</th>
<th>Total</th>
<th>Control Mean</th>
<th>SD</th>
<th>Total</th>
<th>Weight</th>
<th>Std. Mean Difference IV, Random, 95% CI</th>
<th>Std. Mean Difference IV, Random, 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>193</td>
<td>150</td>
<td>100.0%</td>
<td>0.51 {0.11, 1.13}</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Heterogeneity: Tau² = 0.67; CH² = 48.93, df = 7 (P = 0.000001); P = 95% Test for overall effect: Z = 6.12 (P = 0.011)</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Test for subgroups: CH² = 7.99, df = 2 (P = 0.02); P = 35.3%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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</table>
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)
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<td>21. 7 and 17 and 20 (5308)</td>
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<td>2</td>
<td>22. 21 not (letter or editorial or comment or case reports).pt. (4860)</td>
</tr>
<tr>
<td>3</td>
<td>23. limit 22 to english language (4530)</td>
</tr>
<tr>
<td>4</td>
<td>24. remove duplicates from 24 (4447)</td>
</tr>
</tbody>
</table>
Supplementary File 2: References of excluded studies


Beaudart, C., Maquet, D., Mannarino, M., Buckinx, F., Demonceau, M., Crielaard, J. M., et al. (2013). Effects of 3 months of short sessions of controlled whole body vibrations on the risk of falls among nursing home residents. BMC Geriatrics, 13, 42.


vibration training and vitamin D supplementation in institutionalized elderly women.


Running head: PHYSICAL ACTIVITY AND ADL IN OLDER ADULTS

2 exercise or micronutrient supplementation for the wellbeing of the frail elderly? A
4 Chomiuk, T., Folga, A., & Mamcarz, A. (2013). The influence of systematic pulse-limited
5 physical exercise on the parameters of the cardiovascular system in patients over 65
6 years of age. Archives of Medical Science, 9(2), 201-209.
8 (2010). Effects of tai chi exercise on posturography, gait, physical function and
9 quality of life in postmenopausal women with osteopaenia: A randomized clinical
12 people's exercise (HOPE) trial: A pilot randomised controlled trial of a home-based
13 exercise intervention for older people with frailty. Age and Ageing, 43(5) (pp 687-
14 695), Arte Number: afu033.
15 Clemson, L., Fiatarone Singh, M. A., Bundy, A., Cumming, R. G., Manollaras, K.,
16 O'Loughlin, P., et al. (2012). Integration of balance and strength training into daily
17 life activity to reduce rate of falls in older people (the LiFE study): Randomised
18 parallel trial. Bmj, (Online), Arte Number: e4547.
20 LiFE pilot study: A randomised trial of balance and strength training embedded in
21 daily life activity to reduce falls in older adults. Australian Occupational Therapy
22 Journal, 57(1), 42-50.
23 Cochrane, T., Munro, J., Davey, R., & Nicholl, J. (1998). Exercise, physical function and
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strength training in older adults: Intervention gains and tai chi maintenance. Journal of
the American Geriatrics Society, 44(5), 498-506.


## Supplementary File 3: Summary of Individual Intervention Arms

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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

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1 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

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*Note: 1 = little or none required; 2 = a moderate amount required; 3 = a high amount required.*
1  *Completed Scores and Assigned Multitask Level*

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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.