# Systematic review of behaviour change techniques to promote participation in physical activity among people with dementia


## Abstract

**Purpose**. The objective of this study was to systematically review the evidence for the potential promise of behaviour change techniques (BCTs) to increase physical activity among people with dementia (PWD).

**Methods**. PsychINFO, MEDLINE, CINAHL, and the Cochrane Central Register of Controlled Trials databases were searched 01/01/2000 - 01/12/2016. Randomised controlled / quasi-randomised trials were included if they recruited people diagnosed / suspected to have dementia, used at least one BCT in the intervention arm, and had at least one follow-up measure of physical activity / adherence. Studies were appraised using the Cochrane Collaboration risk of bias tool, and BCTs were coded using Michie et al.'s (2013) taxonomy. Intervention findings were narratively synthesised as either 'very promising', 'quite promising', or 'non-promising', and BCTs were judged as having potential promise if they featured in at least twice as many very / quite promising than non-promising interventions (as per Gardner et al., 2016).

**Results**. Nineteen articles from 9 trials reported physical activity findings on behavioural outcomes (2 very promising, 1 quite promising, and 2 non-promising) or intervention adherence (1 quite promising and 4 non-promising). Thirteen BCTs were used across the interventions. While no BCT had potential promise to increase intervention adherence, three BCTs had potential promise for improving physical activity behaviour outcomes: goal setting (behaviour), social support (unspecified), and using a credible source.

**Conclusions**. Three BCTs have potential promise for use in future interventions to increase physical activity among PWD.


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## Introduction

Dementia is a degenerative neurological disease characterised by a chronic, global, and non-reversible loss of cognitive functioning (Butler & Radhakrishnan, 2012). Estimates suggest that 46.8 million people had dementia in 2015 and that this figure will rise to 131.5 million by 2050 (Prince et al., 2015). The majority of people who have dementia are aged 65 and above (90-98%), and the prevalence of dementia increases with age from 65 years (World Health Organization, 2012). It is one of the most burdensome chronic diseases among older people as it gradually impairs memory, executive functioning, and communication (Butler & Radhakrishnan, 2012; Prince et al., 2015). Given the current absence of effective pharmacological treatment for people with dementia (PWD), attention is increasingly drawn to non-pharmacological interventions that may delay the onset of dementia and / or help individuals with the disease retain functioning (Kennedy, Hardman, Macpherson, Scholey, & Pipingas, 2017; Nelson & Tabet, 2015). Physical activity and exercise-based approaches have received considerable attention given their potential to simultaneously address several outcomes (e.g. increase mobility and positive mood), accessibility (e.g. walking around one's neighbourhood), and to also address the problem of widespread physical inactivity particularly among older people (Hallal et al., 2012; McKee, Kearney, & Kenny, 2015). The focus of this paper is on physical activity, where skeletal muscles are contracted resulting in body movement and an increase in energy expenditure (Chodzko-Zajko et al., 2009). This includes exercise, a subtype of physical activity; planned body movement performed in a structured and repetive manner with the purpose of improving or retaining fitness (Chodzko-Zajko et al., 2009).

The evidence for exercise programmes to benefit PWD is limited in both the quality of the evidence and consistency of favourable results (Forbes, Forbes, Blake, Thiessen, & Forbes, 2015). Two systematic reviews have found that while there is promise for exercise to

improve physical functioning, including independence in carrying out activities of daily living, improvement on psychological outcomes among PWD and informal caregiver outcomes are not as promising (Forbes et al., 2015; Potter, Ellard, Rees, & Thorogood, 2011). Other systematic reviews have identified significantly positive effects among PWD of exercise on mobility (Pitkälä, Savikko, Poysti, Strandberg, & Laakkonen, 2013a), depressive symptoms (Barreto Pde, Demougeot, Pillard, Lapeyre-Mestre, & Rolland, 2015), and subjective informal carer burden (Orgeta & Miranda-Castillo, 2014). For PWD living in nursing home settings, while the evidence-base is also limited in quality, there have been consistent reports of exercise to improve dementia symptoms including agitation, mood, and cognition, as well as functional ability and mobility (Brett, Traynor, & Stapley, 2016).

A contributing factor to the current state of inconclusive evidence is the additional challenges of working with PWD to promote physical activity given their cognitive deficits (Butler & Radhakrishnan, 2012; Prince et al., 2015), increased risk for comorbidities (Bunn et al., 2014; Fox et al., 2014; Kosteniuk et al., 2014), and the strong association between such indices of poor health and physical inactivity (Franco et al., 2015; Rhodes et al., 1999; Stubbs et al., 2014; van Alphen, Hortobágyi, & van Heuvelen, 2016; van Stralen et al., 2009). While the current evidence may be limited, in terms of the number of trials conducted and heterogeneity in interventions and outcomes evaluated, PWD are to be encouraged and facilitated to participate in appropriate forms of physical activity as much as the rest of the general population as part of a public health strategy and for PWD to continue to enjoy quality of life (Bowes, Dawson, Jepson, & McCabe, 2013; Ginis et al., 2017; Nyman & Szymczynska, 2016).

Despite the well-known health benefits of physical activity, most adults do not regularly participate in sufficient levels to reap these benefits and physical activity participation declines with age (Hallal et al., 2012; McKee, Kearney, & Kenny, 2015).

Therefore, the promotion of physical activity is inherently a behaviour change problem, and the identifcation of techniques that are more likely to achieve behaviour change is of paramount importance. Systematic reviewers have explored which behaviour change techniques (BCTs) may be associated with effective interventions to increase physical activity participation. However, to date, there is no existing systematic review that has explored the association between BCTs and physical activity intervention effectiveness targeting PWD. In the current study, we undertook for the first time, a systematic review to explore which BCTs were associated with effective interventions targeting physical activity among PWD.

Existing systematic reviews have identified self-regulatory BCTs such as goal-setting and self-monitoring to be particularly effective in increasing physical activity among the general adult population and adults at risk of developing type 2 diabetes (Greaves et al., 2011; McEwan et al., 2016; Michie et al., 2009; Williams & French, 2011). However, another systematic review found self-regulatory BCTs to be associated with both lower levels of physical activity self-efficacy and behaviour among adults aged 60+ (French et al., 2014). This contradictory finding is surprising given the support identified for the use of multi-component goal-setting interventions to increase physical activity (McEwan et al., 2016), and the association of action and coping planning with initiation and maintenance of physical activity respectively among older people (van Stralen, De Vries, Mudde, Bolman, & Lechner, 2009). It follows that different segments of the population may have different general patterns for responsiveness to certain BCTs or clusters of BCTs used to increase physical activity. Therefore, it cannot be assumed that BCTs effective among the general adult population will be effective among PWD. Hence, the need for a novel systematic review to explore which BCTs might be effective in increasing physical activity among PWD.

## Methods

The protocol for this systematic review is available online (Nyman, Howlett, & Adamczewska, 2015). The systematic review was conducted in accordance with the PRISMA statement (Liberati et al., 2009), and a checklist is available in Appendix A (supplementary material).

### *Eligibility criteria*

Studies were eligible if they recruited adults aged 45 and above with a formal diagnosis of dementia or suspected of dementia (self-reported / advised by health professional) (i.e., not people with mild cognitive impairment). A youngest age of 45 was used given that the majority (68%) of all dementia cases below the age of 65 are among those aged 55 and over, and that the risk of dementia increases with age among working age adults so that few cases will be found below the age of 45 (World Health Organization, 2012). We excluded studies that sought to prevent onset of dementia in the healthy population and studies that focused on outcomes among carers of PWD. Studies were included if at least one BCT could be coded from the intervention description using the BCT taxonomy V1 (Michie et al., 2013). All types of comparator groups were included, such as between-group comparisons with active (alternative exposure) and passive (non-exposure) controls. Included outcomes were any measure of participation in physical activity such as measurement of behaviour change (e.g. increase in steps per day / week) or adherence to a physical activity intervention (e.g. class attendance). We included both behavioural and adherence outcomes because of potential differences in effectiveness due to the outcome measure used, and the greater utility of our findings to practitioners interested in either physical activity promotion per se or adherence to a specified programme. Studies that only reported benefits of physical activity (e.g. reduced blood pressure, increased quality of life, etc.) were excluded. We used the Cochrane

Systematic review criteria of only including randomised controlled trials (RCTs) and quasi-randomised trials. Trials must have had at least one follow-up to compare against baseline data (follow-up could be immediately post-intervention). We only included published trials to ensure many of the biases from unpublished and non-RCT designs were controlled.

*Information sources and search strategy*

The following databases were searched by NA (health psychologist) from 01/01/2000 to 01/12/2016 inclusive: PsychINFO, Cinahl, Pubmed (and Medline), and the Cochrane Central Register of Controlled Trials (CENTRAL). The databases were searched from 01/01/2000 because of our use of broad search terms and that existing reviews had identified it was rare for any relevant published work to include people with dementia prior to the year 2000 (e.g. Potter et al. (2011) did not identify any studies prior to the year 2000). Searches were made in title and abstracts of articles and keywords, with the following restrictions: aged 45+, in English language, and articles published in a peer-reviewed journal. The list of search terms and filters used are listed in Appendix B (supplementary material). A researcher (NA) collated the search returns into an Endnote file. After removing duplicates, they initially screened the titles and abstracts against eligibility criteria. Another coder (NH, health psychologist) inspected 218 (20%) of the titles and abstracts that were marked for exclusion, and 10 of the 51 full-text articles marked for exclusion, and confirmed they did not meet the eligibility criteria. In addition to the initial researcher (NA), two other coders (SRN, health psychologist and NH) then screened every remaining full-text article to confirm eligibility. In cases where there were additional articles identified from the reference lists of included trials such as the published trial protocol, these were retrieved and included to supplement the analysis.

*Data extraction*

Characteristics of included studies were recorded by a researcher (NA) and are presented in Table 1. Data was extracted for each study including trial design, country and setting, age, gender, mini-mental state exam (MMSE) score (Folstein, Folstein, & McHugh, 1975), and details of the intervention conditions and treatment effect. In addition, each study was assessed for risk of bias using the tool from the Cochrane Collaboration (Higgins & Green, 2011) to aid interpretation of the findings (see Appendix C, supplementary material). Risk of bias was independently coded by two researchers (SRN and NH). Inter-rater agreement was acceptable across the eight risk of bias domains (Krippendorf's $\alpha = 0.74$), and any disagreements were resolved through discussion to reach consensus. Coding of the BCTs and their potential promise in each study were then independently coded by two reviewers (NA and NH) who had both completed an online training course in using the BCT taxonomy V1 (http://www.bct-taxonomy.com/). Coding BCTs was completed using the BCT taxonomy V1 (Michie et al., 2013). Inter-rater reliability for behaviour change techniques coded in more than one study was good on average (Krippendorf's $\alpha = 0.83$), and any disagreements were resolved through discussion to reach consensus.

For coding potential promise, two independent coders (NA and NH with 100% agreement) used an existing coding framework that was originally developed for exploratory coding of a heterogeneous dataset of sedentary behaviour reduction interventions (Gardner et al., 2016). We used this coding framework rather than a quantitative synthesis (e.g. meta-regression) because the small number of studies and heterogeneity of interventions used prohibited analysis of effectiveness. Rather, an exploratory approach was more appropriate with potential for more rigorous quantitative synthesis in years to come when a larger number of homogenous trials have been conducted.

Potential promise for each intervention was assessed from any significance test on physical activity outcomes, at any follow-up, relative to baseline whether from within-group or between-group analyses. The coding uses three categories of potential: 'very', 'quite', or 'non-promising'. 'Very promising' interventions were those that showed a statistically significant increase in physical activity in the intervention group relative to both baseline (within-group difference) plus at least one comparator group (between-group difference). 'Quite promising' interventions were those that showed either a statistically significant increase in physical activity in the intervention group relative to either baseline (within-group difference) or at least one comparator group (between-group difference), but not both. 'Non-promising' interventions were those that showed no statistically significant increase in physical activity in the intervention group relative to either baseline (within-group difference) or any comparator group (between-group difference). Note, for studies that only reported adherence levels to physical activity interventions, these could only be judged with a maximum score of 'quite promising' (and not 'very promising'), because within-group comparisons would not apply (as participants were as yet to be exposed to the intervention at baseline measurement).

*Analysis*

Given that some included studies reported physical activity outcomes, and others only adherence to physical activity interventions, these studies were separated in the analysis. After coding, the BCTs were tabulated as a function of potential promise (by SRN). Following Gardner et al.'s (2016) approach, we also calculated a 'promise ratio' for each BCT (by SRN). This was calculated by dividing the number of incidences a BCT was identified in an intervention that was very or quite promising by the number of incidences it was identified as non-promising in an intervention. BCTs were interpreted as promising when

they were identified in at least twice as many promising interventions than non-promising interventions (a promise ratio of $\geq$2) and in at least two interventions. For BCTs only identified from very / quite promising interventions, or those only identified from non-promising interventions, ratios were not presented. Instead, these were marked by presenting the number of interventions in which they were reported for very / quite promising interventions and left blank for non-promising interventions. Given the inclusion of trials conducted in both community and long-term care (institutional) settings, an additional ad hoc subgroup analysis, following the procedure outlined above, was conducted by trial setting (by SRN).

## Results

### *Study characteristics*

The initial search identified 1773 database records, of which 19 full-text articles from 9 trials were eligible for inclusion (see Figure 1). Nine trials reporting on nine interventions with 1362 participants were conducted with a mean of 151 participants per study (range 35 - 339). Participants across the trials had a mean age of 79.73 years (mean range 63.15 - 86.9) and there was twice as many women (n = 912) than men (n = 450). Studies were conducted in the USA (n=3), Germany (n=1), the Netherlands (n=1), Sweden (n=1), Finland (n=1), Norway (n=1), and the UK (n=1), using an RCT (n=7) or cluster RCT (n=2) design (see Table 1). The trials took place in community (n=5) and long-term care settings (n=4). The average MMSE score was of moderate severity of dementia symptoms (mean = 16.9), and ranged from severe to mild (8.7 - 21.8). Half the physical activity interventions provided strength and balance training (n=2) alone or in combination with aerobic fitness and / or endurance training (n=2) as well as executive functioning training (n=1). Other interventions provided physical functional training to retain independence with everyday tasks in conjunction with either a range of other activities (n=1) or progressive resistance training (n=1). Others provided a walking programme alone (n=1) or along with lower-limb strength training (n=1). Physical activity tended to be tailored to the individual (6 fully, 2 partially, 1 did not), and was either delivered individually at their place of residence (4), in a class (3), or combination (2). Control groups received either light seated / sham physical activity (light exercise not designed to provide the intended health benefits) (n=3), usual care (n=2), education (n=1), social visits (n=1), a home safety assessment (n=1), or was not described (n=1).

Risk of bias scores are presented in a figure (see Appendix C, supplementary material). Overall, under half of the items were scored as low risk (24 out of 63), with the remaining scored as either high (12 out of 63) or unclear risk (27 out of 63). Because the last

item, 'other bias', was scored as unclear for each trial, when this was removed overall the proportion of low risk scores was higher (24 out of 54, vs. 12 and 18 out of 54 for high and unclear risk respectively). The majority of trials scored low risk on items in relation to blinding of outcome assessment (detection bias) (8 out of 9 trials) and addressing incomplete outcome data (attrition bias) (7 out of 9 trials). However, the majority of trials also scored high risk in relation to blinding of participants and personnel (performance bias) (8 out of 9 trials), because most were single-blind trials due to the nature of the physical activity intervention (participants will know if they are not in the control group unless randomised to a sham physical activity comparator group). In addition, the majority of trials had unclear risk in relation to selective reporting (reporting bias) (7 out of 9 trials) because of unpublished trial protocols to compare against the published outcomes.

*Intervention outcomes*

Although two articles reported on the same intervention (Hauer et al., 2012; Schwenk et al., 2010), both were included separately in the results as they each provided unique data for our analysis on physical activity behaviour and intervention adherence respectively. Therefore, the results that follow include 9 interventions, but one reports behavioural outcomes and intervention adherence in two separate articles, leading to 10 articles in total. The BCTs reported and their potential promise from 10 articles covering the nine interventions are reported in Table 2. Overall outcomes were very promising (n=2), quite promising (n=2), and non-promising (n=6). Thirteen BCTs were used 66 times across the nine interventions.

*Physical activity behaviour.*

Five interventions had mixed results on physical activity behavioural outcomes (2 very promising, 1 quite promising, and 2 non-promising) (see Table 2). Twelve BCTs were used

31 times across the 5 interventions. Three BCTs had potential promise for improving physical activity behaviour outcomes: goal setting (behaviour), social support (unspecified), and using a credible source. The remaining BCTs were either only used once (n=5) or had potential promise ratios below 2 (1.0 - 1.5; n=4) (see Table 3). When divided by setting, only one intervention was conducted with residents in long-term care settings and so no potentially promising BCTs could be identified. The remaining four interventions were conducted with community-dwelling people with dementia, with only goal setting (behaviour) identified as having potential promise for improving physical activity behaviour outcomes (see table in Appendix D, supplementary material).

*Adherence to physical activity interventions.*

Five interventions had mainly negative results on adherence to physical activity interventions. Only 1 intervention was reported to have quite promising results, with the remaining four reported to have non-promising results on adherence (see Table 2). Eleven BCTs were used 35 times across the 5 interventions. No BCT had potential promise for improving adherence to the physical activity interventions included in this review. Three BCTs were either only used once (n=2) or had a potential promise ratio of 1 (n=1). Given the negative findings of the interventions, the remaining BCTs were non-promising, and either only featured in non-promising interventions (n=1) or had potential promise ratios between 0.25 and 0.50 (n=7) (see Table 3). When divided by setting, two interventions were conducted with community-dwelling people with dementia and no potentially promising or non-promising BCTs were identified. The remaining three interventions were conducted with residents in long-term care settings, and six BCTs only featured in non-promising interventions (see table in Appendix E, supplementary material).

## Discussion

To our knowledge, this is the first systematic review to explore the use of BCTs to promote physical activity among PWD and to assess which BCTs were associated with effective interventions. The findings were synthesised for physical activity behavioural outcomes and adherence to physical activity interventions. Three BCTs had potential promise for improving physical activity behaviour in the studies reviewed: goal setting (behaviour), social support (unspecified), and using a credible source. Of studies conducted among community-dwelling PWD, only goal setting (behaviour) remained potentially promising. No BCTs had potential promise for sustaining adherence to physical activity interventions. This means that the combined use of goal (goal-setting (behaviour)), support (social support (unspecified)), and communication (credible source) BCTs could be more effective than other BCTs in increasing physical activity among PWD.

While there are no previous systematic reviews concerning PWD to compare with, the results from this study can be compared with systematic reviews of BCTs used to promote physical activity with other relevant populations. The finding that goal setting (behaviour) had potential promise to increase physical activity among PWD resonates with the results from previous systematic reviews that identified self-regulatory BCTs such as goal-setting and self-monitoring to be particularly effective in increasing physical activity among the general adult population and adults at risk of developing type 2 diabetes (Greaves et al., 2011; McEwan et al., 2016; Michie et al., 2009; Williams & French, 2011). However, this is in contrast to the finding of a systematic review of trials with healthy older adults that found goal setting (behaviour) and other self-regulatory BCTs to be associated with both lower levels of physical activity self-efficacy and behaviour (French et al., 2014). Further research is needed to explore if the discrepancy in findings across these systematic reviews is simply

due to differences in the populations studied or more nuanced factors such as whether goal-setting needs to be self-generated to be effective amongst certain populations like PWD.

Two additional BCTs - social support (unspecified) and using a credible source - were found to be potentially promising for increasing physical activity behaviour among PWD. Evidence has been found for social support BCTs to be effective in promoting healthy behaviours among the general adult population (van Achterberg et al., 2011), and for social support from family and friends to be associated with physical activity among community-dwelling older people (Böhm, Mielke, da Cruz, Ramirez, & Wehrmesister, 2016; Loprinzi & Joyner, 2016; Thanakwang & Soonthorndhada, 2011). Older people have also reported social support to be a facilitator to participation in physical activity (Franco et al., 2015). It appears that social support from family and friends may be more important for initiation of physical activity, but social support from health care providers, sports instructors, and exercise group members may be more important for maintenance of physical activity (van Stralen et al., 2009). For using a credible source, this is among the factors reported by the target patient group as important for determining their engagement with the intervention (Parveen et al., 2016; Redfern et al., 2016). Using a credible source is also often included as part of a BCT strategy in interventions such as for promoting diabetes care and cardiac rehabilitation (Heron et al., 2016; Presseau et al., 2015). Future research could identify which social support BCTs in particular appear to be most effective for PWD and their informal carers and whether this changes as they move from initiation to maintenance of physical activity.

*Limitations and ideas for future research*

The current systematic review was limited in part by the quality of the evidence-base reviewed. Risk of bias scores indicated that less than half the items across the studies could be rated as low risk. With the exception of one trial that had a higher risk of bias, the majority

of the trials had the remaining items scored as unclear risk due to unclear reporting. With greater expectations on authors to publish trial protocols and to follow guidelines in reporting trial protocols and outcomes, we anticipate lower risks of bias in the future.

Given that only mixed evidence was found for increasing physical activity behaviour and non-promising evidence for sustaining adherence to physical activity interventions, there was limited scope in this review to identify promising BCTs. Future research efforts should continue to be made to identify the determinants of physical activity among older people and people with PWD (Koeneman, Verheijden, Chinapaw, & Hopman-Rock, 2011). With only nine interventions that met the inclusion criteria, there were some BCTs that were only used once and so would not meet the criteria for potential promise. Therefore, it is possible that other BCTs not studied in the interventions reviewed are effective in increasing physical activity among PWD but have yet to be evaluated within an RCT. Future research should also focus on maintenance of physical activity among PWD; all the trials included in this review had study durations of up to 6 months and it is possible that different BCTs and other features of interventions enhance long-term participation in physical activity (O'Brien et al., 2015).

We acknowledge the limitations of the current review. With the inclusion of only trials, it is possible that findings from qualitative and non-RCT designs would inform the evidence-base of which BCTs show promise for increasing physical activity among PWD. Likewise, evidence from unpublished studies or those published in non-English languages could also broaden scientific discussion, along with trials published before 2000 that were not captured in our searches. However, 8 of the 9 trials included in our review were published in or after 2009, which would suggest few trials would have been published prior to 2000. The BCT analysis of potential promise for adherence was limited by the fact that studies could not achieve 'very promising'. Nevertheless, as only one study achieved a 'quite promising'

judgement this points towards a general lack of effectiveness on this outcome regardless of this limitation.

*Implications for policy and practice*

PWD are to be encouraged and facilitated to participate in appropriate forms of physical activity as part of a public health strategy and for PWD to continue to enjoy quality of life (Bowes, Dawson, Jepson, & McCabe, 2013; Ginis et al., 2017; Nyman & Szymczynska, 2016). Similar to a previous systematic review of qualitative studies conducted with people with physical impairments and mobility limitations (Williams, Ma, & Martin Ginis, 2017), we found that a combination of goal (goal-setting (behaviour)), support (social support (unspecified)), and communication (using a credible source) strategies would be promising for promotion of physical activity among PWD. This multi-faceted approach to the use of BCTs might be more effective in increasing physical activity. However, only tentative inferences can be made from the current evidence for PWD given the small number of trials conducted to date. Therefore, practitioners could benefit from exploring the potential for BCTs to increase the effectiveness of their physical activity interventions, and in particular, combining the use of goal-setting (behaviour), social support (unspecified), and credible sources.

*Conclusion*

Only nine trials met our inclusion criteria. Nonetheless, there is early evidence to suggest that at least three BCTs have potential promise to promote participation in physical activity among PWD. We encourage behavioural scientists and practitioners to design, implement, and evaluate interventions among PWD to promote physical activity using a BCT taxonomy, which will afford a greater evidence-base going forward.

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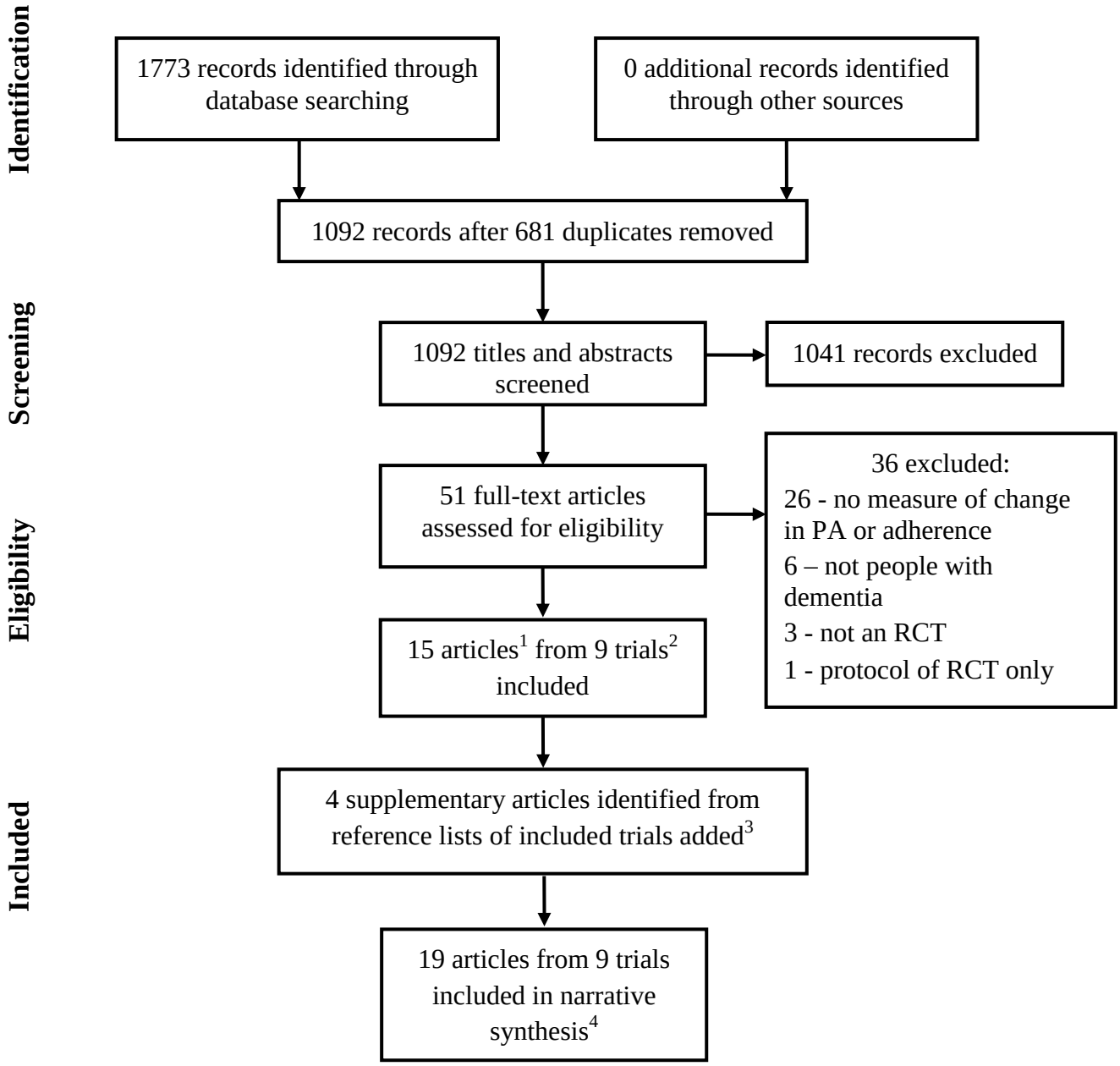
Identification
Screening
Eligibility
Included
1773 records identified through database searching
0 additional records identified through other sources
1092 records after 681 duplicates removed
1092 titles and abstracts screened
1041 records excluded
51 full-text articles assessed for eligibility
36 excluded:
26 - no measure of change in PA or adherence
6 – not people with dementia
3 - not an RCT
1 - protocol of RCT only
15 articles[1] from 9 trials[2] included
4 supplementary articles identified from reference lists of included trials added[3]
19 articles from 9 trials included in narrative synthesis[4]

Figure 1. PRISMA flow diagram of search strategy.

Notes: [1]The following papers were duplications: Bossers et al. (2015b; duplicated Bossers et al. (2015a)), Öhman et al. (2016) and Pertilla et al. (2016; duplicated Pitkälä et al., 2013b); Schwenk et al. (2014; duplicated Hauer et al. (2012) and Schwenk, Zieschang, Oster, & Hauer (2010)), and Telenius et al. (2015b; duplicated Telenius et al. 2015a).

[2]Hauer et al. (2012) and Schwenk et al. (2010) are reports from the same trial; each provided unique data for our analysis on physical activity and intervention adherence respectively.

[3]During data extraction, the following articles identified from the reference lists were obtained to supplement the BCT coding from the included articles: Cerga-Pashoja et al. (2010; trial protocol for Lowery et al. (2014)), Hüger et al. (2009; trial protocol for Hauer et al. (2012)), Pitkälä et al. (2010; 2011; trial protocol and initial findings paper respectively for Pitkälä et al., 2013b)).

[4]The nine trials included in the review are listed in Table 1.

Table 1. Characteristics of studies included in the systematic review

| Author, country, trial design, follow-up | Setting, Mean MMSE score | Male / female (N), Age (range) | Physical activity intervention | Intervention duration, frequency, supervision | Tailoring of the intervention | Comparator group condition | Intervention effect |
|---|---|---|---|---|---|---|---|
| Studies that reported physical activity outcomes | | | | | | | |

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|---|---|---|---|---|---|---|---|
| 1. Galik et al. (2014)<br>USA<br><br>Cluster-RCT, 6 month follow-up | 4 nursing homes<br><br>MMSE: 8.7 ± 4.0 (not reported separately per intervention arm) | 24 / 79 (103)<br><br>Age: 83.7 ± 9.9 (not reported separately per intervention arm) | Nursing home staff were trained to actively engage cognitively impaired residents in functional and physical activities such as walking, ball games, and group exercises. | Nursing home staff encouraged and supervised participants in taking part of physical activities. | Physical activities were personnel-centered and individualised based on the physical and cognitive capability of the resident. | Nursing home staff were only received education in the approach (Function-Focused Care) | IG significantly spent more time doing PA than CG. IG - Significant improvements in amount and intensity of PA and physical function. |

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|---|---|---|---|---|---|---|---|
| 2a. Hauer / Schwenk et al. (2012 / 2010) Germany<br><br>Double-blinded RCT, 6 month follow-up | Geriatric hospital rehabilitation wards of outpatient nursing care services<br><br>MMSE: IG: 21.7 ± 2.8, CG: 21.9 ± 3.2 | IG: 20 / 42, CG: 6 / 44 (112)<br><br>Age: IG: 82.3 ± 6.6, CG: 82.9 ± 7.0 | Progressive resistance training at a submaximal intensity (70–80% of one- repetition maximum (1RM)); Functional training- to perform basic activity of ADL progressing to advanced levels of functional tasks | 2 hours per session, twice a week, over 3 months (24 hours of intervention), 4-6 pps in session supervised by a qualified instructor | The training was individually adjusted for age- and illness-related deficits | Two times a week, 1 hour of sham activities | PA significantly increased in both study groups, with IG showing more-pronounced increase. PA remained elevated in the follow-up period in both groups, but between-group differences disappeared. |

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|---|---|---|---|---|---|---|---|
| 3. Lowery et al. (2014)<br>UK<br><br>Pragmatic, single-blind, parallel-group RCT, 26 week follow-up | Community-dwelling<br><br>MMSE: IG: 16.3 ± 7.4, CG: 14.9 ± 8.7 | IG: 17 / 60, CG: 25 / 39 (141)<br><br>Age: IG: 65.4 ± 14.9 (27–89), G: 60.9 ± 17 (22–88) | Walking programme in and around the home. The therapist progressively withdrew support. | 20-30 min, at least 5 times per week, over 12 weeks (at least 20-30 hours of intervention). Exercised in dyads (pp and carer), supervised by exercise professional | Individually tailored regimen of walking to become progressively more intensive. | No information available | No significant differences between the groups on self-reported walking time at any time point. Prescribed frequency of walks was achieved only by 30.77% of IG. |

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|---|---|---|---|---|---|---|---|
| 4. Steinberg et al. (2009)<br>USA<br><br>RCT, 12 week follow-up | Home dwelling pps recruited from the Department of Psychiatry<br>MMSE: IG: 20.1 ± 5.1, CG: 15.5 ± 5.4 | IG: 4 / 14, CG: 4 / 13 (35)<br><br>Age:<br>IG: 76.5 ± 3.9<br>CG: 74.0 ± 8.1 | Aerobic fitness (brisk walking), strength training targeting major muscle groups; balance and flexibility training (e.g. backward walks, tandem walks) | 6 weeks, participants were given a goal to obtain 6 aerobic points and 4 each of strength and balance per week. One point was given for partially performing task, 2 for completing) Caregivers supervised the activity and gave the points. | None | Home safety assessment | No differences were found in the amount of time spent in vigorous PA. |

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| 5. Teri et al. (2003)<br>USA<br><br>RCT, 24 month follow-up (post-test at 3 months for PA outcome) | Community-dwelling<br><br>MMSE: IG: 17.6 ± 6.8, CG: 15.9 ± 7.4 | IG: 48 / 28, CG: 55 / 45 (176)<br><br>Age: IG: 78 ± 6, CG: 78 ± 8 | Aerobic / endurance activities; strength, balance and flexibility training for 30mins daily exercise. Caregivers instructed on pps' behavioral problems and exercise. | Weeks 1-3: 12 hours per session, twice a week. Weeks 4-7: 12 hours per session, once a week. Weeks 8-11: 12 hours a session, biweekly. Next 3 months: 3 follow ups. | Final three follow-up sessions were to answer questions and consolidate treatment gains. | Routine medical care | 79% of IG and 62% of CG reported exercising 60 min/wk, an improvement of 23% and 6% respectively. Restricted activity days significantly decreased by an average of 0.5 in IG but increased by 0.2 days in CG. |

| Studies that reported adherence to physical activity interventions | | | | | | | |
|---|---|---|---|---|---|---|---|
| 6. Bossers et al. (2015a) Netherlands<br><br>Parallel, three-group, single-blind, RCT (strength and walking group (S&WG), aerobic group (AG), and social group (control, CG), 18 week follow-up | 7 psychogeriatric nursing homes,<br><br>MMSE:<br>S&WG: 15.8 ± 4.3, AG: 15.2 ± 4.8, CG: 15.9 ± 4.2 | S&WG: 8 / 29, AG: 8 / 28, CG: 11 / 25 (109)<br><br>Age: S&WG: 85.7 ± 5.1, AG: 85.4 ± 5.4, CG: 85.4 ± 5.0 | S&WG: lower-limb strengthening and moderate to high intensity walking<br>AG: moderate to high intensity walking | 30 minutes per session,<br>36 sessions over 9 weeks (18 hours of intervention)<br>Each participant supervised by 1 of 18 research assistants | Each participant was supervised and when performed an exercise with ease, exercise intensity was increased by the supervisor | Control group received 30-minute one-to-one social visits at the same frequency as the exercise groups. | Adherence and duration per session were reported but there were no significant differences between groups. |

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| 7. Carlsson et al. (2011)<br>Sweden<br><br>2x2 factorial cluster-RCT (exercise (E) vs. control (C); protein drink (p) vs. placebo (c)), 6 month follow-up | 9 residential care facilities<br><br>MMSE: 17.6 ± 5.1<br>E&p: 16.7 ± 4.9<br>E&c: 18.0 ± 5.0<br>C&p: 18.3 ± 5.4<br>C&c: 17.2 ± 5.1 | 46 / 131 (177)<br>E&p: 9 / 33<br>E&c: 13 / 28<br>C&p: 13 / 34<br>C&c: 11 / 36<br><br>Age: 84.5 ± 6.4 (65-99)<br>E&p: 84.4 ± 6.3<br>E&c: 85.3 ± 5.5<br>C&p: 82.7 ± 6.4<br>C&c: 85.4 ± 7.2 | 1. Exercise in weight-bearing positions, lower limb strength, balance exercises while standing and walking.<br>2. Protein drink | 45 min per session, 29 sessions, over 3 months, (approx. 22 hours of intervention), 3-9 pps in session supervised by two physical therapists | Physical therapists selected exercises for each participant according to their functional deficits | Sitting activities supervised by an occupational therapist | Only attendance was measured and no difference was found. Attendance level was 79% for the IG and 72% for the CG among the 149 pps with both baseline and follow-up data. |

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| 8. Pitkälä et al. (2013)<br>Finland<br><br>RCT of home-based exercise (HIG), vs. group-based exercise (GIG), vs. control (CG), 12 month follow-up | Drug register of the Social Insurance Institution<br><br>MMSE: HIG: 17.8± 6.6, GIG: 18.5 ± 6.3, CG: 17.7 ± 6.2 | HIG: 40 / 70, GIG: 45 / 70, CG: 44 / 70 (339)<br><br>Age: HIG: 77.7 ± 5.4, GIG: 78.3 ± 5.1, CG: 78.1 ± 5.3 | Exercise programme consisted of endurance, balance, and strength training, as well as exercises for improving executive functioning. | Twice a week, over 12 months; HIG: 1 hour (104 hours of intervention)<br>GIG: 4 hours but 1 hour was active (104 hours of intervention), 10 pps per session | HIG: tailored, by a physiotherapist specialised in dementia<br>GIG: not tailored, supervised by 2 physiotherapists specialised in dementia | Usual care, and given advice on nutrition and exercise and the right to physiotherapy. | Attendance was higher in the HIG. Median session participation was HIG: 81 (range, 7-89) and GIG: 75 (range, 7-89), 92.9% of HIG group and 78.6% of GIG group participated in at least half the sessions. |

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|---|---|---|---|---|---|---|---|
| 2b. Hauer / Schwenk et al. (2012 / 2010) Germany<br><br>Double-blinded RCT,<br>12-week follow-up | Geriatric hospital rehabilitation wards of outpatient nursing care services<br><br>MMSE: IG: 21.0 ± 2.9, CG: 21.7 ± 2.9 | IG: 9 / 17, CG: 13 / 22 (61)<br><br>Age: IG: 80 ± 7.1, CG: 82.3 ± 7.9 | Progressive resistance training at a submaximal intensity (70–80% of one- repetition maximum (1RM)); Functional training- to perform basic activity of ADL progressing to advanced levels of functional tasks | 2 hours per session, twice a week, over 3 months (24 hours of intervention), 4-6 pps in session supervised by a qualified instructor | The training was individually adjusted for age- and illness-related deficits | Two times a week, 1 hour of sham activities | Adherence reported but no difference found. Adherence to intervention was high, averaging 91.9% in IG and 94.4% in CG. |

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|---|---|---|---|---|---|---|---|
| 9. Telenius et al. (2015a) Norway<br><br>Single blinded parallel multi centre RCT, 6 month follow up | 18 nursing homes<br><br>IG: 15.5 ± 0.6<br>CG: 15.7 ± 4.9 | IG: 24 / 63, CG: 21/62 (170)<br><br>Age: IG: 87.3 ± 7.0, CG: 86.5 ± 7.7 | Warm-up, at least two strengthening exercises for the muscles of lower limb and two balance exercises. | Twice a week over 12 weeks. 50-60 minutes per session, approximately 24 hours of intervention. Supervised by physiotherapists. | All exercises were individually tailored, instructed and supervised. | Light seated physical activity, reading, playing games etc. | Adherence reported but no difference found. IG attendance was 75%, 7/10 training sessions were performed at high intensity, and only 2% on low. Attendance in CG was 69%. |

Notes: CG: Control group, IG: Intervention group, MMSE: Mini-mental state exam (Folstein et al., 1975), PA: Physical activity, Pps: Participants, RCT: Randomised controlled trial. Hauer et al. (2012) and Schwenk et al. (2010) are reports from the same trial; each provided unique data for our analysis on physical activity and intervention adherence respectively.

Table 2. Behaviour change techniques reported and potential promise of the interventions in the included trials

| Trial | Behaviour change technique reported: Goal setting (behaviour) | Action planning | Monitoring of behaviour by others without feedback | Self-monitoring of behaviour | Self-monitoring of outcome(s) of behaviour | Social support (unspecified) | Social support (emotional) | Instruction on how to perform the behaviour | Demonstration of the behaviour | Behavioural practice/rehearsal | Graded tasks | Credible source | Adding objects to the environment | Potential promise |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Studies that reported physical activity outcomes | | | | | | | | | | | | | | |
| Galik et al. (2014) | ✔ | | | | | ✔ | | ✔ | ✔ | ✔ | | ✔ | | Very promising |
| Hauer / Schwenk et al. (2012 / 2010) | ✔ | | ✔ | | | | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | | Very promising |
| Lowery et al. (2014) | | | | ✔ | ✔ | ✔ | | ✔ | ✔ | ✔ | ✔ | ✔ | | Non-promising |
| Steinberg et al. (2009) | | | | | | | | ✔ | ✔ | ✔ | | | | Non-promising |
| Teri et al. (2003) | ✔ | ✔ | | | | ✔ | | ✔ | ✔ | ✔ | | | | Quite promising |

Studies that reported adherence to physical activity interventions

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bossers et al., (2015a) | | | ✔ | | | | ✔ | | ✔ | ✔ | ✔ | ✔ | | Non-promising |
| Carlsson et al., (2011) | ✔ | ✔ | | | | ✔ | | ✔ | | ✔ | ✔ | ✔ | ✔ | Non-promising |
| Pitkälä et al. (2013b) | ✔ | | | | | ✔ | | ✔ | | ✔ | ✔ | ✔ | ✔ | Quite promising |
| Hauer / Schwenk et al. (2012 / 2010) | ✔ | | ✔ | | ✔ | ✔ | | ✔ | | ✔ | ✔ | ✔ | ✔ | Non-promising |
| Telenius et al. (2015a) | | | ✔ | | | | ✔ | | ✔ | ✔ | | ✔ | ✔ | Non-promising |

Notes: "✔" indicates a BCT was used. Potential promise was graded as very promising, quite promising, or non-promising based on any significance test on physical activity outcomes, at any follow-up, relative to baseline whether from within-group or between-group analyses. For studies that only reported adherence levels to physical activity interventions, these could only be judged with a maximum score of 'quite promising' (and not 'very promising'), because within-group comparisons would not apply (as participants were as yet to be exposed to the intervention at baseline measurement). Hauer et al. (2012) and Schwenk et al. (2010) are reports from the same trial; each provided unique data for our analysis on physical activity and intervention adherence respectively.

Table 3. Behaviour change techniques used as a function of intervention promise

| | Interventions | | | | |
|---|---|---|---|---|---|
| | Studies that reported physical activity outcomes (n=5) | | | | |
| Behaviour change technique | Very promising (2) | Quite promising (1) | Non-promising (2) | All (5) | Promise ratio |
| **1.1: Goal setting (behaviour)** | **2** | **1** | | **3** | **-** |
| 1.4: Action planning | | 1 | | 1 | - |
| 2.1: Monitoring of behaviour by others without feedback | 1 | | | 1 | - |
| 2.3: Self-monitoring of behaviour | | | 1 | 1 | - |
| 2.4: Self-monitoring of outcome(s) of behaviour | | | 1 | 1 | - |
| **3.1: Social support (unspecified)** | **1** | **1** | **1** | **3** | **2** |
| 3.3: Social support (emotional) | 1 | | | 1 | - |
| 4.1: Instruction on how to perform the behaviour | 2 | 1 | 2 | 5 | 1.5 |
| 6.1: Demonstration of the behaviour | 2 | 1 | 2 | 5 | 1.5 |

| | | | | | |
|---|---|---|---|---|---|
| 8.1: Behavioural practice/rehearsal | 2 | 1 | 2 | 5 | 1.5 |
| 8.7: Graded tasks | 1 | | 1 | 2 | 1 |
| **9.1: Credible source** | **2** | | **1** | **3** | **2** |

Studies that reported adherence to physical activity interventions (n=5)

| Behaviour change technique | Very promising (0) | Quite promising (1) | Non-promising (4) | All (5) | Promise ratio |
|---|---|---|---|---|---|
| 1.1: Goal setting (behaviour) | | 1 | 2 | 3 | 0.5 |
| 1.4: Action planning | | | 1 | 1 | - |
| 2.1: Monitoring of behaviour by others without feedback | | | 3 | 3 | - |
| 3.1: Social support (unspecified) | | 1 | 1 | 2 | 1 |
| 3.3: Social support (emotional) | | | 1 | 1 | - |
| 4.1: Instruction on how to perform the behaviour | | 1 | 4 | 5 | 0.25 |
| 6.1: Demonstration of the behaviour | | 1 | 4 | 5 | 0.25 |
| 8.1: Behavioural practice/rehearsal | | 1 | 4 | 5 | 0.25 |
| 8.7: Graded tasks | | 1 | 3 | 4 | 0.33 |
| 9.1: Credible source | | 1 | 4 | 5 | 0.25 |

| | | | |
|---|---|---|---|
| 12.5: Adding objects to the environment | 1 | 1 | - |

Notes: Potential promise ratios highlighted in bold are BCTs that met the criteria for being promising for promoting physical activity among people with dementia (score of ≥2 or used in 2 or more interventions that were only very / quite promising).