REVIEW ARTICLE

International Journal of Geriatric Psychiatry

A systematic review of the effects of physical activity on physical functioning, quality of life and depression in older people with dementia

Rachel Potter, David Ellard, Karen Rees and Margaret Thorogood

Clinical Trials Unit, Warwick Medical School, University of Warwick, UK
Correspondence to: D. Ellard, E-mail: d.r.ellard@warwick.ac.uk

Background: Depression is common in older people with dementia. Physical activity is effective in reducing depression in adults but there is limited evidence about its effectiveness in people with dementia.

Design and Methods: A systematic review and partial meta-analysis of physical activity interventions in people with dementia is reported. We searched eight databases for English language papers and reference lists of relevant papers. Included studies reported a physical activity intervention lasting at least 12 weeks in which participants were older and had a diagnosis of dementia. Studies compared the intervention with a non-active or a no-intervention control and reported at least one outcome related to physical function, quality of life or depression. At least two authors independently assessed each paper for inclusion and for study quality and extracted data.

Results: We included 13 randomised controlled trials with 896 participants. Three of six trials that reported walking as an outcome found an improvement, as did four of the five trials reporting timed get up and go tests. Only one of the four trials that reported depression as an outcome found a positive effect. Both trials that reported quality of life found an improvement.

Conclusions: There is some evidence that physical activity interventions improve physical function in older people with dementia. Evidence for an effect on depression and quality of life is limited.

Key words: physical activity; dementia; older people; quality of life; depression
History: Received 1 June 2010; Accepted 3 September 2010; Published online 6 January 2011 in Wiley Online Library (wileyonlinelibrary.com).
DOI: 10.1002/gps.2641

Introduction

Older people, particularly those who have been diagnosed with dementia, have a high prevalence of depressive symptoms (Hoe *et al*., 2006). Programmes to increase physical activity are a potential intervention that might address this problem. A Cochrane systematic review (Forbes *et al*., 2008) found insufficient evidence to determine whether physical activity programmes were beneficial for people with dementia. However, the review included only one trial reporting the effect of physical activity on depression, which showed a non-significant improvement in depression at both 6 and 12 months (Rolland *et al*., 2007).

The on-going Older Peoples Exercise in Residential and nursing Accommodation trial (OPERA) is evaluating the effectiveness of a physical activity intervention on the prevalence of depression in residential and nursing homes, where many residents have a diagnosis of dementia (NIHR, 2009). In preparing for the OPERA trial we carried out a systematic review of trials of physical activity interventions where participants had a diagnosis of dementia. We had two aims: to develop a synthesis of what is known about physical activity interventions

to address physical functioning, quality of life and depression in people with cognitive impairment or dementia, and to provide information on the content of the physical activity programmes that have been used to inform the development of the intervention used in the OPERA trial. In this paper we report the systematic review and synthesis of available evidence.

Methods

We set wider inclusion criteria than those of the Cochrane review (Forbes *et al*., 2008), and carried out a systematic search for all controlled studies, randomised or not.

Included and excluded studies

We included any trial in which the intervention was some form of physical activity and the target population was people with cognitive impairment or dementia aged 60 and over or described as older, seniors, or older people. Participants could be resident in the community, residential care or hospital. The intervention could take place in any setting, for a minimum of 12 weeks. We excluded trials not published in English (because we had no resources for translation), and trials with no concurrent comparison group (before-and-after studies).

Outcome measures

We were interested in reducing the prevalence of depression, rather than influencing cognition, so we only included studies which either reported an outcome of depression or health related quality of life or which reported outcomes that we believed were indicative of the direct impact of the physical activity, that is, measures of physical function or balance (including reported falls).

Search strategy

We searched the following databases up to February 2009: MEDLINE (from 1966, 2009), EMBASE (from 1988), CINAHL (from 1982), PsycINFO (from 1967), AMED (Allied and Complementary Medicine) (from 1985), the Cochrane Central Register of Controlled Trials, the UK National Research Register, Current Controlled Trials, and checked reference lists of relevant papers. We used as key words dementia, older and physical activity with their synonyms and equivalent MeSH terms.

Identifying relevant studies

After excluding duplicates, all identified titles were checked by two authors for possible relevance. We sought a full copy of all the possibly relevant papers, which were assessed independently for inclusion by two authors. Disagreements were resolved by discussion.

Data extraction and synthesis

Data were extracted from included papers by two authors independently, using a pre-determined proforma. When more than one time point was reported, we used the longest follow-up time. The authors of three trials (Baum *et al*., 2003; Toulotte *et al*., 2003; Santana-Sosa *et al*., 2008) were contacted for additional data and two responded.

Where more than one trial reported the same outcome we carried out a meta-analysis. For the remaining outcomes we have carried out a narrative synthesis.

Meta-analyses

A meta-analysis is reported for four outcomes (TUG, 6-min walk, walking speed and Berg Balance). We entered data into Review Manager (2008) and calculated weighted mean differences (WMD) by subtracting the final from the baseline mean, and 95% confidence intervals for each outcome. We imputed standard deviations of changes where these were not available using the method recommended in the Cochrane handbook (Section 16.1.3.2) (Higgins and Green, 2009). A correlation coefficient of 0.5 was assumed between baseline and follow-up measurements (Follmann *et al*., 1992). We performed a fixed effects meta-analysis unless there was significant heterogeneity in which case we used a random effects model with appropriate cautious interpretation.

Quality assessment

We developed a quality assessment checklist which allowed for both randomised and non-randomised

controlled trials, and was adapted from that recommended in the Cochrane Handbook (Higgins and Green, 2009) The nine criteria chosen briefly were: (1) aims/hypothesis clearly defined. (2) There was definition of included and excluded participants. (3) Randomisation was explicitly explained and truly random. (4) Participants and researchers were unable to foresee group assignment. (5) Groups were similar at baseline. (6) Assessors were blind to assigned treatment when collecting outcome measures. (7) Interventions other than exercise were avoided, controlled or used similarly across comparison groups. (8) Losses to follow-up were less than or equal to 20% and equally distributed between groups. (9) Intention to treat analysis was performed. Rather than calculate an overall score, each paper was coded against each of the criteria as 'Met', 'Not Met' or 'Unclear'.

Results

Outcome of the search strategy

We identified 1553 titles, obtained the text of 110 papers, and excluded 98 after reading the paper (Figure 1). Fifteen papers, relating to 13 randomised controlled trials met our inclusion criteria (Table 1) (Tappen *et al.*, 2000; Cott *et al.*, 2002; Baum *et al.*,

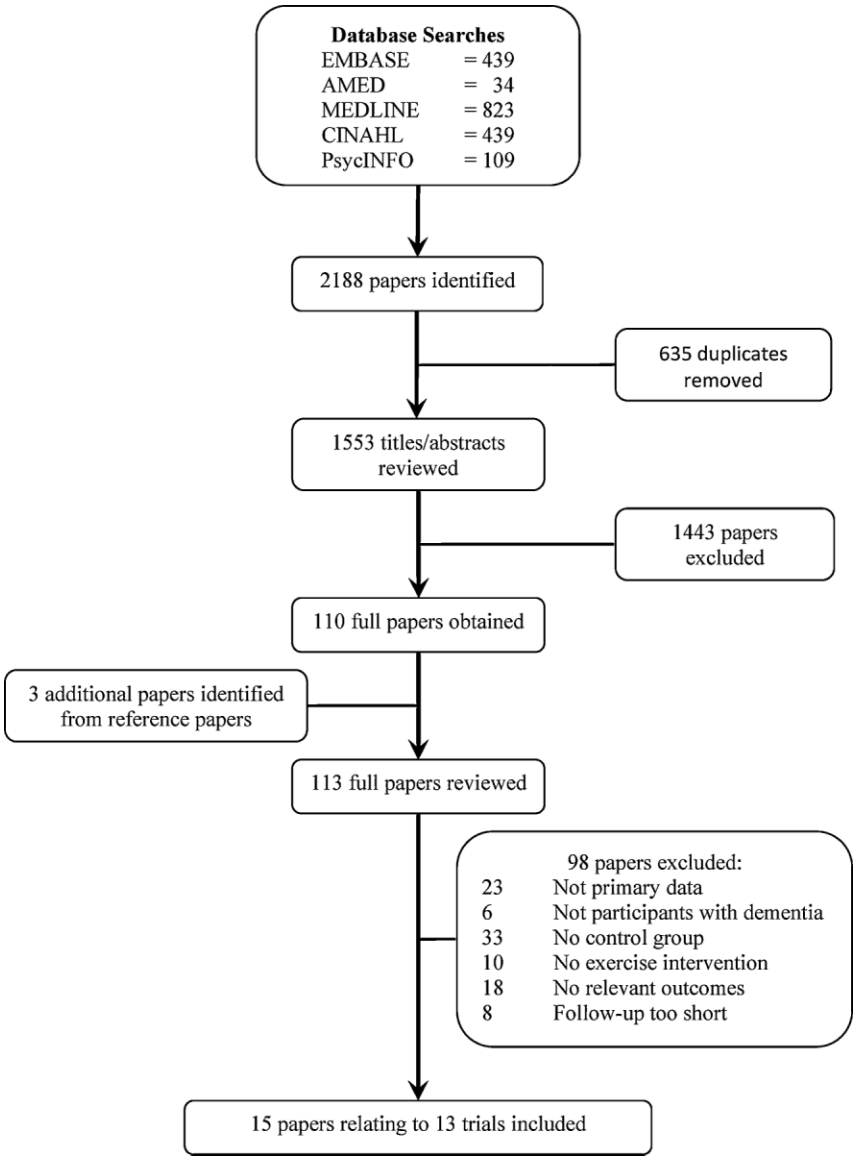

Figure 1 QUOROM figure showing results of the search strategy.

Table 1 Summary of included studies

Author, Country and Location	Number of participants	Mean MMSE	Exercise intervention	Length of sessions (min)	Frequency	Duration	Reported adherence	Quality assessment profile[a]
Baum *et al*. (2003), USA, Care home	20 exercise grp 11 control grp 9	Intervention 21 (10–29), Control 22 (13–29)	Strength and flexibility	60	3× week	6 months	80% exercise, 56% control	1. ☑ 2. ☑ 3. ☑ 4. ? 5. ☑ 6. ? 7. ☑ 8. ☑ 9. ☑
Burgener *et al*. (2008), USA, Community	43 exercise grp 24 control grp 19	Intervention 24.8 (SD 3.5) Control 22.9 (SD 5.2)	Strength and balance Tai Chi classes sitting and standing	60	3× week	40 weeks	75% for 3xweek, 90% for 2xweek	1. ☑ 2. ☑ 3. ? 4. ? 5. ☑ 6. ? 7. ☒ 8. ☒ 9. ☒
Cott *et al*. (2002) Canada Long term care facility	74 walk and talk grp 30 talk only grp 25 control grp19	6 (6)	Walking	30	5× week	16 weeks	Not reported	1. ☑ 2. ☑ 3. ☑ 4. ? 5. ☑ 6. ☑ 7. ? 8. ☑ 9. ☒
Kwak *et al*. (2008), Korea, Community	30 exercise grp 15 control grp 15	Intervention 14.53 (5.34) Control 13.47(7.04)	Strength, stretching and walking	30- 40	3× week	12 months	Not reported	1. ☑ 2. ☑ 3. ☒ 4. ☒ 5. ☑ 6. ? 7. ☑ 8. ? 9. ☑
Netz *et al*. (2007), Israel, Day centre	29 social activity grp 14 exercise grp 15	13.3 (SD 5.83)	Seated exercise class	45	2× week	12 weeks	70%	1. ☑ 2. ☑ 3. ? 4. ? 5. ☒ 6. ? 7. ? 8. ☑ 9. ?
Rolland *et al*. (2007), France, Care home	134 exercise grp 67 control grp 67	8.6 (SD 6.6)	Stretching, walking, strength, flexibility and balance training	60	2× week	40 weeks	19.4% 2/3 sessions, 28.4% 1–2/3 sessions, 41.8% below 1/3 sessions	1. ☑ 2. ☑ 3. ☑ 4. ☑ 5. ☑ 6. ? 7. ☑ 8. ☑ 9. ☒
Rosendahl *et al*. (2006), Sweden, Warden controlled apartments	191 exercise grp 91 control grp 100	17.8 (SD 5.1)	Strength and balance	45	5× week	3 months	76%	1. ☑ 2. ☑ 3. ☑ 4. ☑ 5. ☑ 6. ☒ 7. ☑ 8. ☑ 9. ☑

(*Continues*)

Table 1. (Continued)

Author, Country and Location	Number of participants	Mean MMSE	Exercise intervention	Length of sessions (min)	Frequency	Duration	Reported adherence	Quality assessment profile[a]
Santana-Sosa *et al*. (2008), Spain, Care home	16 exercise grp 8 control grp 8	Intervention 20.1 (2.3) Control 19.9 (1.7)	Strength, flexibility, balance and endurance	75	3× week	12 weeks	98.7%	1. ☑ 2. ☑ 3. ? 4. ? 5. ☑ 6. ? 7. ☑ 8. ☑ 9. ☑
Tappen *et al*. (2000), USA, Care home	71 walking grp 26 conversation grp 24 combined grp 21	10.83	Walking	30	3× week	16 weeks	Walk 57%, Walk and Talk 75%, Conversation 90%	1. ☑ 2. ☑ 3. ? 4. ? 5. ☑ 6. ? 7. ☑ 8. ☑ 9. ☒
Teri *et al*. (2003), USA, Participant's own home	153 exercise grp 76 control grp 77	16.8	Aerobic, endurance, strength, balance and flexibility training	30	2× week reducing to monthly	23 weeks	'quite high'	1. ☑ 2. ☑ 3. ☑ 4. ? 5. ☑ 6. ☑ 7. ? 8. ☒ 9. ☑
Toulotte *et al*. (2003), France, Residential institution	20 exercise grp 10 control grp 10	16.3 (6.5)	Strength, balance, flexibility	45	2× week	16 weeks	Not reported	1. ☑ 2. ☑ 3. ? 4. ? 5. ☑ 6. ☑ 7. ☑ 8. ? 9. ☒
Van de Winckel *et al*. (2004), Belgium, Psychiatric hospital	25 exercise grp 15 control grp 10	10.8 (SD 5.01)	Strength, balance and flexibility	30	7× week	12 weeks	Not reported	1. ☑ 2. ☑ 3. ☑ 4. ☑ 5. ☑ 6. ☑ 7. ☑ 8. ☑ 9. ☑
Williams and Tappen (2007), USA, Nursing home	90 exercise grp 30 supervised walking grp 31 social conversation grp 29	10.37 (SD 7.6)	Strength, balance, flexibility	15 Incr. to 30	5× week	16 weeks	Not reported	1. ☑ 2. ☑ 3. ? 4. ? 5. ☑ 6. ☑ 7. ☑ 8. ☒ 9. ☒

Criteria: ☑ = Met; ☒ = Not Met; ? = Not Clear.

[a]1. Hypothesis/aims, 2. Inclusion/exclusion, 3. Generation of allocation sequence, 4. Concealment of allocation sequence, 5. Baseline assessment, 6. Outcome assessment, 7. Co-interventions, 8. Losses to follow-up, 9. Intention to treat.

2003; Teri *et al*., 2003; Toulotte *et al*., 2003; Van de Winckel *et al*., 2004; Littbrand *et al*., 2006; Rosendahl *et al*., 2006; Netz *et al*., 2007; Rolland *et al*., 2007; Burgener *et al*., 2008; Kwak *et al*., 2008; Santana-Sosa *et al*., 2008; Williams and Tappen, 2007, 2008).

Most trials were small, the 13 trials included a total of 896 participants, (range 16–191 participants), and six trials had less than 20 participants in the intervention group. Only five of the 15 papers included any power calculations for their primary outcomes (Cott *et al*., 2002; Baum *et al*., 2003; Teri *et al*., 2003; Rosendahl *et al*., 2006; Rolland *et al*., 2007). All reported calculations based on 80% power with an α of 0.05 with the exception of Cott *et al*., who expected a large effect size and set α at 0.01. Attrition rates were reported in 10 trials and ranged from 4% at 12 weeks (Van de Winckel *et al*., 2004) to 32% at 2 years (Teri *et al*., 2003).

There were six trials from North America (Tappen *et al*., 2000; Cott *et al*., 2002; Baum *et al*., 2003; Teri *et al*., 2003; Williams and Tappen, 2007; Burgener *et al*., 2008), two of which came from the same group (Tappen *et al*., 2000; Williams and Tappen, 2007). There were also five trials from Europe (Toulotte *et al*., 2003; Van de Winckel *et al*., 2004; Rosendahl *et al*., 2006; Rolland *et al*., 2007; Santana-Sosa *et al*., 2008) and one each from Korea (Kwak *et al*., 2008) and Israel (Netz *et al*., 2007). Eight of the trials were conducted in the institutions in which the patients were resident which were variously described as care homes, institutions or hospitals (Tappen *et al*., 2000; Cott *et al*., 2002; Baum *et al*., 2003; Toulotte *et al*., 2003; Van de Winckel *et al*., 2004; Rolland *et al*., 2007; Williams and Tappen, 2007; Santana-Sosa *et al*., 2008). The other interventions were either delivered in a community facility (Netz *et al*., 2007; Burgener *et al*., 2008; Kwak *et al*., 2008), in the patient's home (Teri *et al*., 2003) or in a sheltered housing complex (Rosendahl *et al*., 2006).

There was considerable variation in the nature of the participants. Mean age ranged from 73 ($\pm$4) years to 88 ($\pm$6.32) years. Most studies had more female participants (Tappen *et al*., 2000; Cott *et al*., 2002; Baum *et al*., 2003; Van de Winckel *et al*., 2004; Rosendahl *et al*., 2006; Williams and Tappen, 2007; Kwak *et al*., 2008; Santana-Sosa *et al*., 2008), and two studies included only female participants (Van de Winckel *et al*., 2004; Kwak *et al*., 2008). One did not report participants' gender (Toulotte *et al*., 2003). The level of cognition of participants varied from a mean MMSE score of 6 ($\pm$6) (Cott *et al*., 2002) to 24.8 ($\pm$ 3.5) (Burgener *et al*., 2008). Dementia was formally diagnosed in eight of the studies (Tappen *et al*., 2000; Cott *et al*., 2002; Teri *et al*., 2003; Van de Winckel *et al*., 2004; Rolland *et al*., 2007; Williams and Tappen, 2007; Burgener *et al*., 2008; Santana-Sosa *et al*., 2008).

Baseline physical ability of participants also varied considerably between trials. Seven studies required participants to be able to stand and walk unaided or with the assistance of one person or a walking aid (Tappen *et al*., 2000; Cott *et al*., 2002; Baum *et al*., 2003; Teri *et al*., 2003; Toulotte *et al*., 2003; Rosendahl *et al*., 2006; Williams and Tappen, 2007), while one trial only included participants able to walk at least 6 m (Rolland *et al*., 2007); in another the majority of participants were wheelchair users, while in one trial participants all had a recent injurious fall (Toulotte *et al*., 2003). In the Korean trial participants were all providing long-term care for someone with dementia (although they too had dementia), indicating they had reasonable functionality (Kwak *et al*., 2008).

Quality assessment

Quality assessment profiles are presented for each paper in Table 1. The methods of randomisation and were clear and adequate in six of the trial with three of these also providing methods of allocation concealment. Eight of the trials provided information about losses to follow-up and six provided information about intention-to-treat analysis.

The physical activity interventions

Most of the interventions included some element of strength, flexibility or balance training (Table 1). Two studies were exclusively walking interventions (Tappen *et al*., 2000; Cott *et al*., 2002) and one study included Tai Chi and Qigong classes (Burgener *et al*., 2008).

Few papers described the intensity or progression of exercise sessions. One trial described a moderate intensity intervention (Teri *et al*., 2003). Netz *et al*. (2007) described a low intensity exercise intervention that progressed later to moderate intensity exercise which was delivered to both the intervention and control group. The number of repetitions of elements of the exercise progressed weekly in one study by Williams and Tappen (2007), while intensity was self-paced in another (Rosendahl *et al*., 2006) but participants were encouraged to exercise at high intensity and both repetition and load were increased. Repetitions and resistance were increased weekly in the study by (Baum *et al*., 2003) and 60% of participants progressed to a heavier grade theraband (resistance

exercise band). Exercise intensity was increased from 30 to 60% of expected maximal oxygen consumption in Kwak *et al*. (2008).

Most trials involved exercise groups; either small groups of 2–9 people (Toulotte *et al*., 2003; Rosendahl *et al*., 2006; Rolland *et al*., 2007; Santana-Sosa *et al*., 2008) or larger groups of 10–15 people (Baum *et al*., 2003; Netz *et al*., 2007). Two trials delivered the interventions to individuals (Tappen *et al*., 2000; Teri *et al*., 2003) one to pairs (Cott *et al*., 2002) and four trials did not specify group's size (Van de Winckel *et al*., 2004; Williams and Tappen, 2007; Burgener *et al*., 2008; Kwak *et al*., 2008). A range of student and qualified health professionals, exercise scientists, activity teachers and research assistants delivered the interventions.

Three trials included both seated and standing exercise (Netz *et al*., 2007; Burgener *et al*., 2008; Kwak *et al*., 2008), while one used only seated exercise (Baum *et al*., 2003). The equipment used was described in two trials (Baum *et al*., 2003; Kwak *et al*., 2008) and included wrist weights, therabands, weighted balls, dumbbells and a Swiss ball (body exercise ball). In three trials exercise sessions were performed to music (Van de Winckel *et al*., 2004; Netz *et al*., 2007; Santana-Sosa *et al*., 2008). The frequency of the exercise sessions ranged from twice a week to every day, lasting between 30 and 75 min duration. Two studies describe a dedicated warming up and cooling down period (Baum *et al*., 2003; Santana-Sosa *et al*., 2008) and one a period of relaxation (Burgener *et al*., 2008).

The majority of exercise sessions were provided for 12–16 weeks. Only four trials provided exercise sessions for 40 weeks or longer (Baum *et al*., 2003; Rolland *et al*., 2007; Burgener *et al*., 2008; Kwak *et al*., 2008).

For those studies that reported adherence to exercise classes, adherence rates ranged from 57% (Tappen *et al*., 2000) to 98.8% (Santana-Sosa *et al*., 2008) (Table 1).

Outcomes assessed using Timed get Up and Go (TUG) tests

A TUG was reported in five papers (Baum *et al*., 2003; Toulotte *et al*., 2003; Netz *et al*., 2007; Rolland *et al*., 2007; Santana-Sosa *et al*., 2008). Four trials demonstrated some improvement in the intervention group, and this was significant in two of the trials (Baum *et al*., 2003; Toulotte *et al*., 2003) (Table 2a). Four trials used a traditional 'timed' version of this test and were pooled (Baum *et al*., 2003; Toulotte *et al*., 2003; Netz *et al*., 2007; Santana-Sosa *et al*., 2008), whilst the remaining trial reports TUG on a five-point scale (from 1 no instability to 5 very abnormal) (Rolland *et al*., 2007). Results were heterogeneous between trials (Figure 2a). Overall there was a reduction in TUG with the intervention (WMD −1.39 s, 95% CI −2.59, 0.19). In a sensitivity analysis removal of the outlier (the Toulotte study) reduced the effect of the intervention on TUG (WMD −0.24 s, 95% CI −0.90, 0.41).

Outcomes assessed using timed walks

Six papers reported results from walking tests (Tappen *et al*., 2000; Cott *et al*., 2002; Toulotte *et al*., 2003; Rosendahl *et al*., 2006; Rolland *et al*., 2007; Kwak *et al*., 2008), (Table 2b). Three of them showed a significant increase in walking speed (Toulotte *et al*., 2003; Rosendahl *et al*., 2006; Rolland *et al*., 2007). One trial (Kwak *et al*., 2008) showed a significant increase in distance walked, while another (Tappen *et al*., 2000) found a decline in distance walked in both the group receiving conversation-only (the control group) and the groups receiving a 30 min assisted walk, but a smaller decline in the group receiving an assisted walk with conversation. One trial (Cott *et al*., 2002) failed to find an effect.

The results of two trials reporting a 6-min walk test (Tappen *et al*., 2000; Kwak *et al*., 2008) were pooled. One trial showed a large improvement (Kwak *et al*., 2008), whereas the other showed no effect (Tappen *et al*., 2000) (Figure 2b). Heterogeneity between the two trials was very high, and the result should be interpreted with caution.

Walking speed, converted to meters per second (m/s), was pooled for four trials (Cott *et al*., 2002; Toulotte *et al*., 2003; Rosendahl *et al*., 2006; Rolland *et al*., 2007) (Figure 2c) and showed a statistically significant improvement in speed (WMD 0.06 m/s (95% CI 0.01, 0.1)).

Outcomes assessed using measures of balance or functional reach

Measures of balance were used to assess outcome in seven trials (Baum *et al*., 2003; Toulotte *et al*., 2003; Rosendahl *et al*., 2006; Rolland *et al*., 2007; Burgener *et al*., 2008; Kwak *et al*., 2008; Santana-Sosa *et al*., 2008), and a further trial (Netz *et al*., 2007) used a measure of functional reach to assess balance and stability. The posturography platform test used by Toulotte *et al*. (2003) required participants to stand on

Table 2 Summary of results

Reference	Test	Result
a) Trials reporting timed get up and go (TUG) tests		
Baum *et al.* (2003)	Timed get up and go	At 6 month: intervention 18 s faster, effect size 0.54 (0.12, 0.95)
Netz *et al.* (2007)	Timed get up and go	At 12 weeks: intervention score increased by 0.3, control score fell by 1.8, difference not significant
Rolland *et al.* (2007)	Get up and go test	At 12 month: intervention speed 3.1(±1.1) min, control speed 3.2(±1.2) min difference not significant
Santana-Sosa *et al.* (2008)	8 foot up and go	At 12 weeks: significant reduction in time for intervention, non-significant increase in time for control
Toulotte *et al.* (2003)	Get up and go test	At 16weeks: intervention increased speed by 41%, slight fall in speed in control group $p < 0.05$
b) Trials reporting a timed walking test		
Cott *et al.* (2002)	2-min walk	At 16 weeks: none of the three groups (walk, walk and talk, control) showed any difference in distance walked.
Kwak *et al.* (2008)	6-min walk	At 12 months: intervention group distance 184 m (± 41), control 99 m (± 45) $p < 0.01$
Rosendahl *et al.* (2006)	Gait speed (m/s), 2.4 m walk	At 6 months: self-paced gait speed: intervention 0.41, control 0.37 (mean difference, 0.05; 95% CI; 0.01–0.08; $p = 0.009$)
Rolland *et al.* (2007)	6 m walking test (m/s)	At 12 months: intervention speed 0.41 (+ 0.16) m/s, control speed 0.36 (+ 0.19) m/s, $p = 0.002$
Tappen *et al.* (2000)	6-min walk	At 16 weeks: all groups showed decline in distance walked but decline less in combined walking and conversation group (conversation 18.8% decline, walking 20.7% decline, combined 2.5% decline)
Toulotte *et al.* (2003)	10 m walk	At 16 weeks: intervention group walking 53% faster, $p = 0.015$
c) Trials reporting measures of balance		
Baum *et al.* (2003)	Berg balance scale	At 6 months: non-significant improvement in intervention group
Burgener *et al.* (2008)	Berg balance scale	At 20 weeks: no difference between groups
Kwak *et al.* (2008)	'ACSM method' (higher score better)	At 12 months intervention grp score 2.73 (+ 0.1), control 1.20 (+ 0.77), $p < 0.05$
Netz *et al.* (2007)	Functional reach	At 12 weeks: no difference between groups
Rolland *et al.* (2007)	One-leg balance test	At 12 months: no difference between groups
Rosendahl *et al*. (2006)	Berg balance scale	At 6 months: intervention grp score 31.0 (SE 0.7) control 29.1 (0.6) $p = 0.05$
Santana-Sosa *et al.* (2008)	Tinetti scale (measures gait and balance)	At 12weeks: no significant difference between groups
Toulotte *et al.* (2003)	Posturography platform (see description above)	At 16 weeks: elliptical area decreased by 40% in intervention group but was unchanged in control group. $p < 0.001$
d) Trials reporting lower limb strength		
Kwak *et al.* (2008)	ACSM measures	At 12 months: exercise grp mean 13.27 kg/W (±3.90), control grp 9.33 kg/W (+3.22) $p < 0.01$
Netz *et al.* (2007)	Sit to stand test	At 12 weeks: no significant differences
Rosendahl *et al.* (2006)	Leg press machine using one-repetition maximum	At 6 months: exercise grp mean 105 kg (SE 3.3) control 94.5(SE 3.3) $p = 0.03$
Santana-Sosa *et al.* (2008)	30-s chair stand test	At 12 weeks: intervention grp 13 stands, control 9 (estimated from bar chart) $p < 0.05$
e) Trials reporting flexibility		
Kwak *et al.* (2008)	ACSM Measure	At 12 months: intervention grp score 2.20 cms (± 0.70), control −2.47 (± 0.11) $p < 0.01$
Santana-Sosa *et al.* (2008)	Chair sit and reach test	At 12 weeks: no significant difference between groups
Toulotte *et al.* (2003)	Chair sit and reach test	At 16 weeks distance between fingers and toes decreased 69% in intervention group, but increased by 44% in control group $p < 0.0002$
f) Trials reporting measures of depressive state or depressive symptoms		
Burgener *et al.* (2008)	Geriatric depression scale (GDS 15)	At 20 weeks: GDS increased (worsened) by 0.4 in intervention and 0.9 in control (difference not significant)
Rolland *et al.* (2007)	Montgomery-Asberg Depression Rating Scale (MADRS)	At 12 months: MADRS13.4 (±8.0) in intervention and 14.8 (±7.2) in control (difference not significant) (NB high score worse)
Van de Winckel *et al.* (2004)	BOP[a]	At 3 months: no significant difference in depressive behaviour subscale
Teri *et al.* (2003)	Cornell scale for depression in dementia	At 2 years: mean difference, 2.14; 95% CI, 0.14–4.17; $p < 0.04$

[a]Beoordelinsschaal voor Oudere Patienten/Evaluation scale for older patients; sub-scale used.

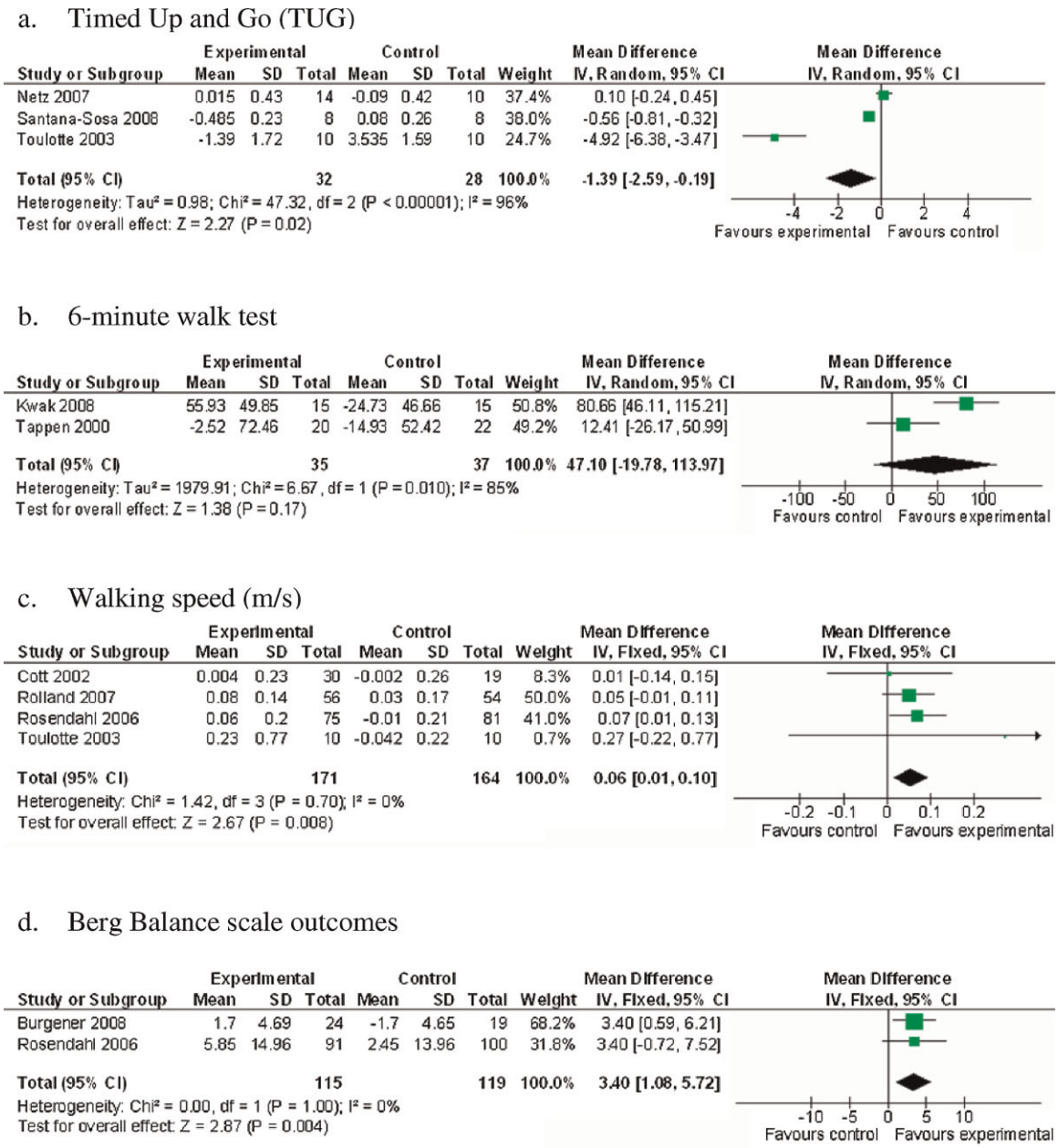

Figure 2 Forest plots of pooled data for four outcomes.

the platform with eyes open while the platform calculates the elliptical area covered by the moving centre of gravity. Only three trails found any improvement in balance (Table 2c).

The results of two trials using the Berg balance scale were pooled (Rosendahl *et al.*, 2006; Burgener *et al.*, 2008), and showed a statistically significant improvement in balance (WMD 3.4 points (95% CI 1.08, 5.72)) (Figure 2d).

Outcomes assessed using measures of lower limb strength

Four trials (Rosendahl *et al.*, 2006; Netz *et al.*, 2007; Kwak *et al.*, 2008; Santana-Sosa *et al.*, 2008) reported changes in lower limb strength, measured using four different tests (Table 2d). Three of them (Rosendahl *et al.*, 2006; Kwak *et al.*, 2008; Santana-Sosa *et al.*, 2008) found a significant improvement.

Table 3 Comparison of affect and mood outcomes across treatment groups (based on table produced in Williams and Tappen (2007)

	Comprehensive exercise	Supervised walking	Social conversation
Adjusted means at 16 weeks (controlled for baseline mood scores. Baseline MMSE, distance walked in 6 min and treatment intensity)			
Affect: OAS 10 min			
Positive	9.61	8.45	9.08
Negative	2.55	4.11	4.78[a]
OAS 2 weeks			
Positive	11.11	9.65	9.14[a]
Negative	3.38	4.81	5.65
Mood: Alzheimer's Mood Scale			
Positive	88.76	80.87	77.20
Negative	46.91	53.04	64.20[a]
Dementia Mood Assessment Scale	19.69	26.49	33.13[a]

OAS, Observed Affect Scale (also called the Lawton OAS).
[a]Indicating significant ($p < 0.05$) difference between comprehensive exercise group and control group that included no physical activity (social conversation). Higher score indicates better (positive) or worse (negative) functioning.

Outcome assessed using measures of flexibility

Three trials (Toulotte *et al*., 2003; Kwak *et al*., 2008; Santana-Sosa *et al*., 2008) reported flexibility as an outcome and two of them (Toulotte *et al*., 2003; Kwak *et al*., 2008) found a significant improvement (Table 2e).

Measures of depressive state or depressive symptoms

Four trials reported measures of depressive state or depressive symptoms (Table 2f), each using a different measure. Three trials did not observe any significant differences. One trial, which included both exercise and behavioural management with 24 month follow-up, found no significant difference at 24 months in the Hamilton depression rating scale, but a significantly lower (better) score on the Cornell scale for depression in dementia. However, the authors report this finding only for those participants who completed an assessment at 24 months (58% of the participants).

Outcomes assessed by measures of quality of life

Two trials reported quality of life. Williams and Tappen (2007) used three measures of health related quality of life: The Observed Affect Scale (OAS) measures quality of life in nursing home residents with dementia, The Dementia Mood Assessment Scale (DMAS), which rates observable mood and functional abilities and the Alzheimer's Mood Scale (AMS) which measures positive and negative mood states. The results are shown in Table 3. All except the AMS showed the most beneficial results in the 'comprehensive exercise group' and the least beneficial results in the social conversation group. In four of the seven measures the difference was significant.

The second trial used the physical role function subscale of the SF-36 to measure health related quality of life (Teri *et al*., 2003). At 3-months an intention to treat analysis showed an improvement of 5.9 points in intervention participants, and a decline of 16.6 points in control participants.

Discussion

We found a large number of potential trials, but many were short-term or had other exclusion criteria (Figure 1). Only 15 papers, relating to 13 trials, were included, all of them carried out in the last 10 years. There was a wide range in the quality of the papers reviewed. In particular, few trials had evidence that they were adequately powered and, whilst all included trials were RCT's, less than half provided clear information about randomisation and only half of those provided information about allocation-concealment.

Walking, getting out of chairs, lower limb strength and flexibility all improved in the majority of the trials that reported these outcomes. There was also limited evidence of improvement in balance. The two studies using the Berg balance scale were pooled and showed a significant effect in favour of the experimental groups. There was some indication from pooled data that the time taken to complete a TUG test can be reduced, but

there was considerable heterogeneity so, this should be interpreted cautiously.

Four of the studies included walking in the intervention, while 11 reported walking in various forms (e.g. timed up-and-go and 10-m walk), as an outcome measure. Pooled analysis of four studies indicated a small but statistically significant increase in walking speed. The three studies included in the meta-analysis, which showed the greatest improvement, all included a high intensity intervention which involved lower limb strengthening (Toulotte *et al*., 2003; Rosendahl *et al*., 2006; Rolland *et al*., 2007). Walking is a normal, enjoyable activity that could be encouraged as a pastime and form of exercise among people with dementia (Marshall and Allen, 2006).

There was little useful information on interventions to address depression or improve quality of life. Only four trials measured depression or depressive symptoms and only one of those showed any positive effect, in only one of the measures used (Teri *et al*., 2003). Only two studies measured quality of life, using disparate measures. One used a sub-scale of a generic measure of quality of life (SF36—Physical role functioning) (Teri *et al*., 2003), whilst the other used a combination of Alzheimer's/dementia specific measures that place emphasise on the affect (mood) of the participants (Williams and Tappen, 2007). Both found some evidence of improvement in quality of life, but even taken together these studies do not provide strong evidence for an improvement in quality of life.

Attendance at sessions was generally high. Littbrand *et al*. (2006) comment that high levels of attendance at groups may be due to studies selectively targeting participants with higher physical abilities, and commented that there are difficulties with high intensity programmes for people with severe dementia (MMSE score of 10 or less) as these people often needed greater assistance and were less physically able. They argued that 'a high intensity functional weight-bearing exercise programme' was applicable for people with dementia but only if they had an MMSE score of 10 or higher.

This systematic review has shown that regular exercise interventions for older people with dementia can include a wide range of exercise modalities, including aerobic, strengthening, flexibility and balance elements, and that exercise groups with increasing intensity of the activity are possible. Older people with dementia can be successfully engaged in activity, and will regularly attend sessions, and undertaking exercise shows some physical benefits. There was not enough evidence to determine an effect on symptoms of depression or quality of life.

Key Points

- Physical activity can improve physical function in older people with dementia;
- There is some evidence that higher intensity interventions including lower limb strengthening are more effective;
- There is no evidence on whether physical activity will prevent or reduce depression in older people with dementia.

Ethics

There is no requirement for this review to have been submitted to an Ethics Committee.

Conflict of interest

None declared.

Acknowledgements

This project benefited from facilities funded through Birmingham Science City Translational Medicine Clinical Research and infrastructure Trials platform, with support from Advantage West Midlands.

References

Baum EE, Jarjoura D, Polen AE, Faur D, Rutecki G. 2003. Effectiveness of a group exercise program in a long-term care facility: a randomized pilot trial. *J Am Med Dir Assoc* **4**: 74–80.

Burgener SC, Yang Y, Gilbert R, Marsh-Yant S. 2008. The effects of a multimodal intervention on outcomes of persons with early-stage dementia. *Am J Alzheimer's Dis Other Dementias* **23**: 382–394.

Cott CA, Dawson P, Sidani S, Wells D. 2002. The effects of a walking/talking program on communication, ambulation, and functional status in residents with Alzheimer disease. *Alzheimer Dis Assoc Disord* **16**: 81–87.

Follmann D, Elliott P, Suh I, Cutler J. 1992. Variance imputation for overviews of clinical trials with continuous response. *J Clin Epidemiol* **45**: 769–773.

Forbes D, Forbes S, Morgan DG, *et al*. 2008. Physical activity programs for persons with dementia. *Cochrane Database Syst Rev* (3): CD006489. : DOI: 10.1002/14651858.CD006489.pub2

Higgins J, Green S (eds). 2009. *Cochrane Handbook for Systematic Reviews of Interventions, Version 5.0.2*. [updated September 2009]. The Cochrane Collaboration, www.cochrane-handbook.org

Hoe J, Hancock G, Livingston G, Orrell M. 2006. Quality of life of people with dementia in residential care homes. *Br J Psychiatr* **188**: 460–464.

Kwak Y, Um S, Son T, Kim D. 2008. Effect of regular exercise on senile dementia patients. *Int J Sport Med* **29**: 471–474.

Littbrand H, Rosendahl E, Lindelof N, *et al*. 2006. A high-intensity functional weight-bearing exercise program for older people dependent in activities of daily living and living in residential care facilities: evaluation of the applicability with focus on cognitive function. *Phys Ther* **86**: 489–498.

Marshall M, Allen K (eds). 2006. *Dementia: Walking not Wandering*. Hawker Publications: London.

Netz Y, Axelrad S, Argov E. 2007. Group physical activity for demented older adults - feasibility and effectiveness. *Clin Rehabil* **21**: 977–986.

NIHR HTA. 2009. Older People's Exercise intervention in Residential and nursing Accommodation (OPERA). Southampton: NIHR Coordinating Centre for Health Technology Assessment (NCCHTA).
Review Manager (RevMan). 2008. *Computer Programme* (Edn 5.0). The Nordic Cochrane Centre, The Cochrane Collaboration: Copenhagen; p. 3.
Rolland Y, Pillard F, Klapouszczak A, *et al*. 2007. Exercise program for nursing home residents with Alzheimer's disease: a 1-year randomized, controlled trial. *J Am Geriatr Soc* **55**: 158–165.
Rosendahl E, Lindelof N, Littbrand H, *et al*. 2006. High-intensity functional exercise program and protein-enriched energy supplement for older persons dependent in activities of daily living: a randomised controlled trial. *Aus J Physiother* **52**: 105–113.
Santana-Sosa E, Barriopedro MI, Lopez-Mojares LM, Perez M, Lucia A. 2008. Exercise training is beneficial for Alzheimer's patients. *Int J Sport Med* **29**: 845–850.
Tappen RM, Roach KE, Applegate EB, Stowell P. 2000. Effect of a combined walking and conversation intervention on functional mobility of nursing home residents with Alzheimer disease. *Alzheimer Dis Assoc Disord* **14**: 196–201.
Teri L, Gibbons LE, McCurry SM, *et al*. 2003. Exercise plus behavioral management in patients with Alzheimer disease: a randomized controlled trial. *J Am Med Assoc* **290**: 2015–2022.
Toulotte C, Fabre C, Dangremont B, Lensel G, Thevenon A. 2003. Effects of physical training on the physical capacity of frail, demented patients with a history of falling: a randomised controlled trial. *Age Ageing* **32**: 67–73.
Van de Winckel A, Feys H, De Weerdt W, Dom R. 2004. Cognitive and behavioural effects of music-based exercises in patients with dementia. *Clin Rehabil* **18**: 253–260.
Williams CL, Tappen RM. 2007. Effect of exercise on mood in nursing home residents with Alzheimer's disease. *Am J Alzheimer Dis Other Dementias* **22**: 389–397.
Williams CL, Tappen RM. 2008. Exercise training for depressed older adults with Alzheimer's disease. *Aging Mental Health* **12**: 72–80.

