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Research

Home-based prescribed exercise improves balance-related activities in people with Parkinson's disease and has benefits similar to centre-based exercise: a systematic review

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KEY WORDS

Parkinson disease
Exercise
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ABSTRACT

Questions: In people with Parkinson's disease, does home-based prescribed exercise improve balance-related activities and quality of life compared with no intervention? Are the effects of home-based exercise similar to those of equivalent centre-based exercise? **Design**: Systematic review and meta-analysis of randomised and quasi-randomised controlled trials. **Participants**: Adults diagnosed with idiopathic Parkinson's disease. **Intervention**: Predominantly home-based prescribed exercise (defined as a minimum of two-thirds of the exercise being completed at home). The intervention had to primarily involve physical practice of exercises targeting gait and/or standing balance compared with either control (ie, usual care only, a sham intervention or no physiotherapy) or equivalent predominantly centre-based exercise. **Outcome measures**: The primary outcome was balance-related activities and the secondary outcomes were gait speed, Berg Balance Scale, Functional Reach test, and quality of life. **Results**: Sixteen trials met the inclusion criteria and all contributed to the meta-analyses. Twelve trials compared home-based prescribed exercise with control, and four trials compared home-based prescribed exercise with equivalent centre-based exercise. Home-based prescribed exercise improved balance-related activities (SMD 0.21, 95% CI 0.10 to 0.32) and gait speed (SMD 0.30, 95% CI 0.12 to 0.49), but not quality of life (SMD 0.11, 95% CI −0.01 to 0.23) compared with control. Home-based and centre-based exercise had similar effects on balance-related activities (SMD −0.04, 95% CI −0.36 to 0.27) and quality of life (SMD −0.08, 95% CI −0.41 to 0.24). **Conclusion**: Home-based prescribed exercise improves balance-related activities and gait speed in people with Parkinson's disease, and these improvements are similar to improvements with equivalent centre-based exercise. **Registration**: PROSPERO CRD 42018107331. **[Flynn A, Allen NE, Dennis S, Canning CG, Preston E (2019) Home-based prescribed exercise improves balance-related activities in people with Parkinson's disease and has benefits similar to centre-based exercise: a systematic review. *Journal of Physiotherapy* 65:189–199]**

Introduction

Parkinson's disease is a chronic, progressive, neurodegenerative disorder. It is the fastest growing neurological disorder in the world; the number of people with Parkinson's disease is projected to double from 6 million in 2015 to 12 million in 2040.[1] Physiotherapy interventions such as balance exercises, treadmill training, cueing and strength exercise have become an integral part of the management of Parkinson's disease.[2] High-quality systematic reviews and randomised controlled trials have shown that exercise improves mobility (gait speed, step length and walking capacity),[3–5] balance[6,7] and quality of life,[3] and can reduce falls.[8,9]

Questions remain, however, about the optimal location, amount of supervision, mode of delivery (individual, group or both), intensity, duration and type of exercise required to achieve these benefits. These questions arise due to the wide range of prescribed exercise used in research, with the location and amount of supervision varying across studies.[10] The prescribed exercise that has been reported includes: individual centre-based or home-based programs; supervised group sessions at a centre; home exercise programs with minimal supervision; and a combination of supervised centre-based sessions and home exercise programs.[10] Given the progressive nature of Parkinson's disease combined with near-normal life expectancy,[11] it is imperative that prescribed exercise programs for people with Parkinson's disease are sustainable and effective over a long period of time. Home-based prescribed exercise, where the exercise is completed in the person's home, is one model of care that has the potential to be sustained over a long period of time with minimal resources. To date, no systematic reviews have specifically investigated the effectiveness of home-based prescribed exercise for people with Parkinson's disease.

A few small randomised controlled trials have aimed to identify if location impacts on the effectiveness of prescribed exercise, by comparing home-based and centre-based interventions of similar

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Box 1. Inclusion criteria.

Design
- Randomised or quasi-randomised controlled trials

Participants
- Adults with Parkinson's disease

Intervention
- Involved predominantly home-based prescribed exercise
- $\geq$ 4 sessions over $\geq$ 2 weeks
- Prescribed by a physiotherapist or health professional with a degree-level qualification in exercise prescription
- Primarily involved physical practice of exercises targeting gait and/or standing balance

Outcome measures
- Balance-related activities
- Quality of life

Comparisons
- Home-based exercise versus a control group receiving no intervention, usual care, or a placebo intervention
- Home-based exercise versus centre-based exercise, where the centre-based exercise is equivalent in terms of dose and type of intervention to that of the home-based prescribed exercise

type and intensity. These studies suggest that centre-based exercises may be superior.[12–15] Two systematic reviews[7,16] have presented subgroup analyses suggesting that location may have an impact on the effect of prescribed exercise. Shen et al[7] reported that compared with no exercise, centre-based exercise resulted in long-term improvements in balance and gait, while home-based exercise did not. Similarly, Klamroth et al[16] reported that home-based exercise did not improve balance compared with no exercise. These results need to be interpreted with caution because neither review explicitly searched for or operationally defined 'home-based exercise' and searches were completed in early 2015.[7,16] Therefore, relevant trials (eg, Caglar et al[17]) and recently published trials (eg, Chivers Seymour et al[18]) were not included. Given that the cost of fully supervised centre-based exercise is unlikely to be sustainable in the context of a neurodegenerative condition, it is crucial to identify whether home-based prescribed exercise is effective.

Therefore, the research questions for this systematic review were:

1. In people with Parkinson's disease, does home-based prescribed exercise improve balance-related activities and quality of life compared with no intervention?
2. Are the effects of home-based exercise similar to those of equivalent centre-based exercise?

Method

Identification and selection of trials

A comprehensive search of the Cochrane Central Register of Controlled Trials (CENTRAL), CINAHL, EMBASE, and Physiotherapy Evidence Database (PEDro) databases was conducted in April 2019. Search terms included words related to: Parkinson's disease, physiotherapy, exercise, home-based therapy, group-based therapy, supervision, gait, mobility, balance, quality of life, randomised and quasi-randomised (see Appendix 1 on the eAddenda for full search strategy). There were no date or language restrictions. Titles and abstracts were screened by two independent reviewers (AF, EP), potential trials identified, and any conflicts resolved by discussion with a third reviewer (SD). Full copies of the relevant trials were retrieved and reviewed by two independent reviewers (AF, EP) against predetermined inclusion and exclusion criteria (Box 1), with any conflicts resolved by discussion with a third reviewer (SD). The reference lists of included trials were also reviewed for potential trials.

Assessment of characteristics of the trials

Quality

The quality of the included trials was assessed using the published PEDro score.[19] The PEDro score is determined by an 11-item scale, which provides information on the internal validity of the trial and the appropriate reporting of statistical information. Each trial is scored out of 10, with a higher rating indicating greater methodological quality. The PEDro score was used to assess and report the quality of the trials but no trials were excluded from the analysis based on the PEDro score.

Participants

Trials involving adults diagnosed with Parkinson's disease were included, while trials involving those with Parkinsonism or Parkinson's plus disorders were excluded.

Intervention

Trials were included if the intervention was exercise that was predominantly home-based, defined as two-thirds of the exercise being conducted at home. To be included, a minimum dose of four sessions over a minimum of 2 weeks, prescribed by a physiotherapist or health professional with a degree-level qualification in exercise prescription, was required. In addition, the exercise had to primarily involve physical practice of exercises targeting gait and/or standing balance. Trials were excluded if the home-based exercise was designed as a sham or control with no potential therapeutic benefit.

Trials were included when the control group received no intervention, usual care, placebo or centre-based exercise. Centre-based exercise was defined as two-thirds of the exercise being provided at a centre, such as hospital outpatient department, private practice, medical centre or community centre. The dose and type of centre-based exercise had to be equivalent to that of the home-based exercise and be prescribed by a physiotherapist or health professional with a degree-level qualification in exercise prescription.

Outcomes

The primary outcome was balance-related activities. Given the range of mobility and balance outcomes, the analysis involved pooling the most comprehensive balance-related activity measure available. This was identified prior to performing the analysis using the following priority order: MiniBESTest;[20] Functional Gait Assessment[21] or Dynamic Gait Index;[22] Berg Balance Scale;[23] Short Physical Performance Battery;[24] Timed Up and Go test;[25] gait speed; turning time; sit to stand time; Functional Reach test;[26] single leg stand time; Pull Test[27] or Push and Release Test;[28] Physical Performance Test;[29] and Sensory Organisation Test.[30] This method has been used in previous systematic reviews reporting mobility and balance outcomes in Parkinson's disease.[7,31] Where a trial reported results for more than one of these outcomes, the outcome with the highest priority was included in the analysis. Individual balance-related outcome measures reported by three or more trials were analysed independently

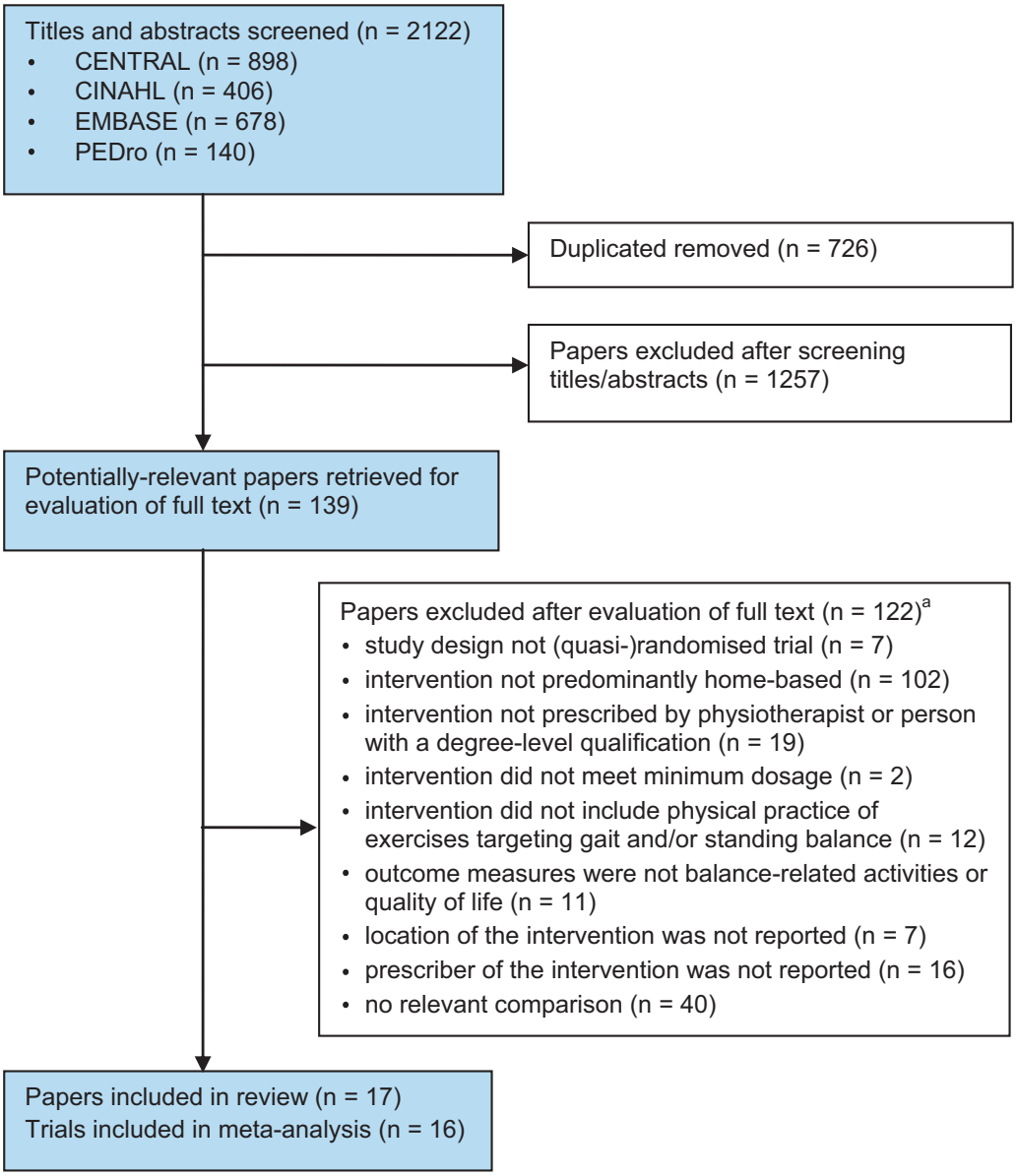

Figure 1. Flow of trials through the review.
[a] Papers may have been excluded for failing to meet more than one eligibility criterion.

as secondary outcomes. Quality of life measured using Parkinson's disease-specific questionnaires or other valid health-related quality of life questionnaires was also reported as a secondary outcome measure.

Data analysis

Data were extracted independently by two reviewers (AF, EP). Authors were contacted where clarification for data extraction was required. To characterise the study participants, data were extracted regarding sample size, age, time since diagnosis, measure of disease severity (eg, Hoehn and Yahr, Unified Parkinson's Disease Rating Scale (UPDRS), UPDRS motor subsection, and the Movement Disorders Society Unified Parkinson's Disease Rating Scale (MDS-UPDRS) Item III) and measures of cognitive ability. Details of the intervention for the home-based prescribed exercise and comparison group were extracted, including: dose and type of exercise; medication state during training (on/off); percentage of exercise delivered at home (home-based prescribed sessions/total prescribed sessions); percentage of sessions supervised by a therapist either in person or via teleconferencing (prescribed supervised sessions/total prescribed sessions); and adherence (the percentage of sessions undertaken/total prescribed sessions). The following information was also extracted: outcomes used, timing of measurements, medication status during measurement (on/off), and result at each time point (mean, standard deviation and number of participants).

Post-intervention scores and scores beyond the intervention were used for the pooled analysis of the effect of home-based prescribed exercise. If the results were reported as median, range and/or interquartile range, the mean and standard deviation were determined using the formula described by Wan et al.[32] If data were only reported in a figure, data were extracted using the software program WebPlotDigitizer.[33] King et al compared home-based prescribed exercise with two centre-based exercise programs: one with individual supervision and one with group supervision.[15] To ensure that participants were not counted twice during the meta-analysis, each pairwise comparison was separately included with the sample size of the home-based prescribed exercise group equally divided. As different outcome measures were used for balance-related activities, gait speed, and quality of life outcomes, data were pooled using Hedges' g standardised mean difference with a 95% confidence interval. A fixed-effect model was used, and each analysis was tested for statistical heterogeneity ($I^2 > 50\%$). If heterogeneity was present, a random-effects model was applied instead of a fixed-effect model. The analyses were performed using RevMan software[a].

Table 1
Characteristics of included studies: home-based prescribed exercise compared with no intervention (n = 12).

Study	Participants[a]	Intervention	Supervision	Adherence (%)	Outcomes[b]
Allen 2010[34]	n = 48 Age *(yr)* = 67 (9) PD *(yr)* = 8 (6) H & Y = N/R UPDRS Motor = 30 (13) MMSE = 29 (1)	Exp = Home-based (92%) Balance and strength 40 to 60 min × 3/wk × 26 wk Con = Usual care	12% supervision 1/mth group session supervised by therapist (centre) 1 to 2 home visits	70	SPPB Preferred gait speed PDQ 39 Timing: 26 wk
Ashburn 2007[35]	n = 140 Age *(yr)* = 72 (9) PD *(yr)* = 8 (6) H & Y = 3.1 (0.6) Cognition[c]	Exp = Home-based (100%) Balance, ROM, strength and walking 60 min[d] × 7/wk × 6 wk Con = Usual care	14% supervision 1/wk session supervised by therapist	N/R	BBS Functional Reach EuroQoL-5D Timing: 8 wk, 26 wk
Caglar 2005[17]	n = 30 Age *(yr)* = 66 (9) PD *(yr)* = 5 (2) H & Y = 2.1 (0.5) Cognition = N/R	Exp = Home-based (98%) Balance, everyday activities, ROM, walking 60 min × 7/wk × 9 wk Con = Usual care	2% supervision 1 initial session supervised by therapist (centre)	100	Time taken to walk 10 m Timing: 9 wk
Canning 2012[36]	n = 20 Age *(yr)* = 62 (8) PD *(yr)* = 6 (4) H & Y[e] UPDRS motor = 19 (9) MMSE = 30 (0.4)	Exp = Home-based (100%) Treadmill walking 30 to 40 min × 4/wk × 6 wk Con = Usual care	29% supervision 7 sessions at home supervised by therapist	78	Preferred gait speed PDQ 39 Timing: 6 wk, 12 wk
Canning 2015[8]	n = 231 Age *(yr)* = 71 (9) PD *(yr)* = 8 (6) H & Y = 2.7 (0.6) UPDRS motor = 26 (10) MMSE = 29 (1)	Exp = Home-based (92%) Balance, cueing and strength 40 to 60 min × 3/wk × 26 wk Con = Usual care	13% supervision 1/mth group session supervised by therapist (centre) 2 to 4 home visits	72	SPPB Fast gait speed PDQ 39 Timing: 26 wk
Chivers Seymour 2019[18]	n = 474 Age *(yr)* = 72 (8) PD *(yr)* = 8 (6) H & Y = 2.6 (0.9) UPDRS motor = 33 (16) MMSE = 29 (2)	Exp = Home-based (100%) Balance, freezing strategies and strength 30 min × 7/wk × 26 wk Con = Usual care	7% supervision 12 sessions at home supervised by therapist	N/R	MiniBESTest PDQ 39 Timing: 26 wk, 52 wk
Goodwin 2011[38] and Fletcher 2012[37]	n = 130 Age *(yr)* = 71 (8) PD *(yr)* = 9 (6) H & Y = 2.5 (0.9) Cognition[f]	Exp = Home-based (67%) Balance and strength 60 min[g] × 3/wk × 10 wk 1/wk centre-based 2/wk home-based Con = Usual care	33% supervision 1/wk group session supervised by therapist	87	BBS TUG EuroQoL-5D Timing:10 wk, 20 wk
Khalil 2017[39]	n = 30 Age *(yr)* = 60 (14) PD *(yr)* = 8 (5) H & Y = 2.3 (0.8) MDS UPDRS III = 48 (18) Cognition[f]	Exp = Home-based (75%) Balance, everyday activities, ROM, strength, and walking 45 min[h] × 4/wk × 8 wk 3/wk exercise sessions 1/wk walking Con = Usual care	25% supervision Wks 1 to 4, 2/wk sessions supervised by therapist Wks 5 to 8, 1/wk telephone call from therapist	77	MiniBESTest Preferred gait speed Timing: 8 wk
Morris 2017[40]	n = 133 Age *(yr)* = 71 (9) PD *(yr)* = N/R H & Y = 2.3 (0.7) MMSE = 28 (2)	Exp = Home-based (100%) Cueing and strength 60 min × 2/wk × 6 wk Con = Placebo: life-skills program 60 min × 2/wk × 6 wk	50% supervision 1/wk session supervised by therapist (home visit)	N/R	PDQ39 Timing: 6 wk, 52 wk
Nieuwboer 2007[41]	n = 153 Age *(yr)* = 67.5 (61.5 to 73) PD *(yr)* = 8 (4 to 11) H & Y = 3 (2.5 to 3) UPDRS motor = 33 (25 to 41) MMSE = 29 (27 to 30)	Exp = Home-based (100%) Cueing during everyday activities 30 min × 3/wk × 3 wk Con = Usual care	100% supervision 3/wk sessions supervised by therapist (home visit)	100	TUG Functional Reach Preferred gait speed PDQ39 Timing: 3 wk
Song 2018[42]	n = 60 Age *(yr)* = 67 (7) PD *(yr)* = 8 (5) H & Y = N/R MDS UPDRS III = 32 (12) MMSE = 29 (2)	Exp = Home-based (100%) Balance 15 min × 3/wk × 12 wk Con = Usual care	8% supervision 2 initial home visits for set up 1 home visit at 6 weeks Telephone call every 2 weeks	86	FGA TUG Timing: 12 wk

Table 1 (*Continued*)

Study	Participants[a]	Intervention	Supervision	Adherence (%)	Outcomes[b]
Stack 2012[43]	n = 47 Age *(yr)* = 74 (6) PD *(yr)* = 8 (6) H & Y = 3.1 (0.8) UPDRS motor = 28 (13) Cognition[i]	Exp = Home-based (100%) Cueing, everyday activities, and strength 60 min × 3/wk × 4 wk Con = No physiotherapy	100% supervision 3/wk sessions supervised by therapist (home visit)	N/R	180 deg turn test Functional Reach HRQoL Timing: 4 wk, 8 wk, 12 wk

BBS = Berg Balance Scale, FGA = Functional Gait Assessment, HRQoL = Health-related quality of life, H & Y = Hoehn and Yahr, MDS UPDRS III = Movement Disorders Society Unified Parkinson's Disease Rating Scale motor subsection, MMSE = Mini-Mental State Examination, MoCA = Montreal Cognitive Assessment, N/R = not reported, PDQ39 = Parkinson's disease Questionnaire 39, ROM = range of motion, SPPB = Short Physical Performance Battery, TUG = Timed Up and Go test, UPDRS motor = Unified Parkinson's Disease Rating Scale motor subsection.

[a] Data are n, mean (SD), or median (IQR).
[b] Outcomes measure and timing of outcome measures used in data analysis.
[c] Inclusion criterion: no gross cognitive impairment.
[d] Duration of intervention reported for home visits only.
[e] Inclusion criterion: mild Parkinson's disease (Hoehn and Yahr stages I to II).
[f] Exclusion criteria: severe/marked cognitive deficit.
[g] Duration of intervention reported for centre-based sessions only.
[h] Duration of intervention reported for walking component of intervention only.
[i] Inclusion criterion: 8/12 on the Middlesex Elderly Assessment of Mental State.

Subgroup analysis

Subgroup analyses were performed to explore the effect of dose and supervision. With respect to dose, interventions were categorised as high dose if they were prescribed for a minimum 150 min/wk for at least 6 weeks. With respect to supervision, the trials that delivered intervention with full (100%) supervision were compared with trials that were not fully supervised.

Results

Flow of trials through the review

The search identified 1396 records (excluding duplicates). After screening the titles and abstracts, the full texts of 139 papers were retrieved. Of these, 17 papers[8,12–15,17,18,34–43] met the inclusion criteria. Two papers reported data from the same trial[37,38] so 16 trials were included in the meta-analysis. See Figure 1 for the flow of trials through the review.

Characteristics of included trials

Twelve trials[8,17,18,34–36,38–43] involving 1496 participants compared home-based prescribed exercise with usual care or a placebo (Table 1). Four trials[12–15] involving 204 participants compared home-based prescribed exercise with centre-based exercise (Table 2). One of these four trials[15] compared home-based prescribed exercise with both centre-based exercise conducted in a group and centre-based exercise conducted individually.

Quality

The mean PEDro score of the trials was 7 (range 4 to 8) (Table 3). All trials reported similar groups at baseline and point estimate variability. The majority of trials (88%) reported random allocation, assessor blinding and a loss to follow-up of $< 15\%$. Concealed allocation occurred in 75% of the trials. Only 50% of trials reported intention-to-treat analysis. Due to the nature of the intervention it was not possible to blind the participants or the therapists to the intervention.

Participants

The mean age of the participants across the trials ranged from 60 to 74 years. The mean time since Parkinson's disease diagnosis across the trials ranged from 5 to 9 years. Fourteen trials reported disease severity using the Hoehn and Yahr Scale and two trials[34,42] used the motor subsection of the UPDRS or MDS-UPDRS. Eight trials[8,18,35,38–41,43] included participants with mild to severe Parkinson's disease (Hoehn and Yahr stage I to IV), seven trials[12–15,17,34,42] included participants with mild to moderate Parkinson's disease (Hoehn and Yahr stage I to III and motor subsection of the UPDRS or MDS-UPDRS) and one trial[36] included participants with mild Parkinson's disease (Hoehn and Yahr stage I to II). Participants with significant cognitive impairment were excluded in all but one trial, which did not report a cognitive criterion for eligibility.[17]

Intervention

All included trials primarily involved exercises targeting gait and/or standing balance. The exercise was prescribed by a physiotherapist in all but one[12] of the studies, where the exercise was prescribed by an exercise physiologist. In 13 trials[8,12–15,17,18,34,35,38–40,43] the exercise program involved multiple components including: balance, cueing, range of movement, strength, walking and everyday activities (eg, sit to stand, turning and stairs). Three trials prescribed one exercise only: Canning et al 2012[36] prescribed walking on a treadmill; Nieubower et al[41] prescribed cue training during everyday activities; and Song et al[42] prescribed balance training using an exergame that required stepping in different directions. Five trials reported that the participants performed the exercise during the 'on' phase, where their Parkinson's disease medication was working optimally,[13–15,36,42] with the remainder not reporting medication status during exercise.

The dose of the interventions varied between the trials. The length of the exercise programs ranged from 3 to 26 weeks, which was reflected in the total number of prescribed sessions ranging from 9 to 182 (median 30.5). The majority of trials (63%) had an intervention duration of between 6 to 10 weeks. Participants completed a minimum of 15 minutes and a maximum of 60 minutes of prescribed exercise per session. Nine trials[8,12,14,17,18,34,35,38,39] prescribed a higher dose of at least 150 minutes of exercise per week for at least 6 weeks. There was a high adherence rate of $\geq 70\%$ (range 70 to 100%) in the ten[8,13,15,17,34,36,38,39,41,42] trials where adherence was reported.

The amount of supervision provided for home-based prescribed exercise ranged from 0 to 100%. Fifteen trials[8,13–15,17,18,34–36,38–43] (93%) provided the participants with at least one supervised session either at home or a centre prior to commencing the home exercise. Types of supervision included individual (one participant and one therapist) sessions at home or a centre, or group-based sessions at a centre. One trial[14] studied supervised home-based sessions using teleconferencing (Skype). Two trials[12,14] reported caregiver supervision to ensure safety of the participants when completing the home-based exercise. All centre-based sessions were supervised.

Outcome measures

Fifteen of the trials reported that the outcome measures were completed during the participants' 'on' phase.[8,12–15,17,34–36,38–43] A measure of balance-related activities immediately after the intervention was reported in 14 trials.[8,12,14,15,17,18,34–36,38,39,41–43] All 14 trials reported data for a least one of the comprehensive measures of balance-related activity listed in the priority order determined a priori. For the meta-analysis, the following outcome measures were

Table 2
Characteristics of included studies: home-based prescribed exercise compared with centre-based exercise (n = 4).

Study	Participants[a]	Intervention	Supervision	Adherence (%)	Outcomes[b]
Atterbury 2017[12]	n = 40 Age *(yr)* = 65 (8) PD *(yr)* = 5 (7) H & Y = 2.5 (0.5) MDS UPDRS III = 34 (13) MoCA = 26 (2)	Home-based (100%) Balance 40 to 60 min × 3/wk × 8 wk	0% supervision DVD with instructions and safety guidelines Assisted by caregiver for safety	N/R	FGA Timing: 8 wk
		Centre-based Balance exercises 40 to 60 min × 3/wk × 8 wk	100% supervision 3/wk sessions supervised by therapist (group) 4 to 8 people per group	N/R	
Dereli 2010[13]	n = 30 Age *(yr)* = 64 (11) PD *(yr)* = 7 (4) H & Y = 2.1 (0.7) UPDRS motor = 17 (7) MMSE = 27 (2)	Home-based (97%) Balance, breathing, relaxation, ROM and walking 45 min × 3/wk × 10 wk	3% supervision 1 × participant education session 1/wk telephone call from therapist	100	PDQLQ Timing: 10 wk
		Centre-based Balance, breathing, relaxation, ROM and walking 45 min × 3/wk × 10 wk	100% supervision 1 × participant education session 3/wk sessions supervised by a therapist (individual)	100	
Gandolfi 2017[14]	n = 76 Age *(yr)* = 69 (8) PD *(yr)* = 7 (4) H & Y = 2.5 (2.5 to 3.0) UPDRS = 47 (24) MMSE = 28 (4)	Home-based (95%) Balance 50 min × 3/wk × 7 wk	100% supervision 1 × explanation of intervention in centre 3/wk sessions supervised by therapist, using Skype Caregiver present to provide safety	N/R	DGI Fast gait speed PDQ8 Timing: 8 wk, 12 wk
		Centre-based Balance 50 min × 3/wk × 7 wk	100% supervision 3/wk sessions supervised by therapist (individual)	N/R	
King 2015[15]	n = 58 Age *(yr)* = 64 (7) PD *(yr)* = 6 (6) H & Y = 2.4 (0.5) UPDRS motor = 37 (13) MoCA = 26 (4)	Home-based (92%) Balance and walking 60 min × 3/wk × 4 wk	8% supervision 1 × session to receive home exercise program	85	MiniBESTest PDQ39 Timing: 4 wk
		Centre-based individual Balance and walking 60 min × 3/wk × 4 wk	100% supervision 3/wk sessions supervised by therapist (individual)	97	
		Centre-based group Balance and walking 60 min × 3/wk × 4 wk	100% supervision 3/wk sessions supervised by therapist (group)	95	

DGI = Dynamic gait index, FGA = Functional Gait Assessment, H & Y = Hoehn and Yahr, MDS UPDRS III = Movement Disorders Society Unified Parkinson's Disease Rating Scale motor subsection, MMSE = Mini-Mental State Examination, MoCA = Montreal Cognitive Assessment, N/R = not reported, PDQLQ = Parkinson's Disease Quality of Life Questionnaire, PDQ8 = Parkinson's disease questionnaire 8, PDQ39 = Parkinson's disease Questionnaire 39, ROM = Range of motion, UPDRS = Unified Parkinson's Disease Rating Scale, UPDRS motor = Unified Parkinson's Disease Rating Scale motor subsection.
[a] Data are n, mean (SD), or median (IQR).
[b] Outcomes measure and timing of outcome measures used in data analysis.

used: MiniBESTest,[15,18,39] Functional Gait Assessment,[12,42] Dynamic Gait Index,[14] Berg Balance Scale,[35,38] Short Physical Performance Battery,[8,34] preferred gait speed,[17,36] turning time,[43] and Timed Up and Go test.[41] Gait speed, Functional Reach test and Timed Up and Go test were the only balance-related activity outcome measures reported in three or more trials with data available at the end of the intervention only.

Four trials measured preferred gait speed,[34,36,39,41] one trial measured fast gait speed[8] and one trial measured time taken to walk 10 m.[17] Three trials reported Functional Reach[35,41,43] and three trials reported Timed Up and Go test.[38,41,42]

Quality of life was measured in 12 trials.[8,13–15,18,34–36,38,40,41,43] Some trials used Parkinson's disease-specific measures: Parkinson's disease Questionnaire 39 (PDQ 39),[44] Parkinson's disease questionnaire 8 (PDQ8),[45] and Parkinson's Disease Quality of Life Questionnaire (PDQLQ).[46] Other trials used generic quality of life measures: EuroQoL-5D[47] and a generic health-related quality of life measure.[48]

Seven trials[14,18,35,36,38,40,43] reported measures beyond the intervention period, with the follow-up period ranging from 4 to 46 weeks (median 10 weeks).

Effect of home-based prescribed exercise compared with usual care or a placebo

Balance-related activities

The effect of home-based prescribed exercise on balance-related activities immediately after the intervention was determined by pooling 11 trials totalling 1220 participants, with a mean PEDro score of 7.2 indicating good quality. Overall, there was an SMD of 0.21 (95% CI 0.10 to 0.32, I^2 = 0%) in favour of home-based prescribed exercise (Figure 2a, see also Figure 3a on the eAddenda for detailed forest plot).

The effect of home-based prescribed exercise on balance-related activities beyond the intervention period was determined by pooling five trials totalling 541 participants, with a mean PEDro score of 7.2 indicating good quality. The length of time after the exercise intervention ranged from 4 to 26 weeks. One trial reported follow-up data at both 4 and 8 weeks beyond the exercise, so the values for the longest follow-up period (8 weeks) were used in the meta-analysis. Overall, there was no difference between home-based prescribed exercise and usual care or a placebo beyond the intervention, with an SMD of 0.12 (95% CI −0.05 to 0.29, I^2 = 0%) (Figure 2b, see also Figure 3b on the eAddenda for detailed forest plot).

The effect of home-based prescribed exercise on gait speed immediately after the intervention was determined by pooling six trials totalling 482 participants, with a mean PEDro score of 7.2 indicating good quality. The overall effect was an SMD of 0.30 (95% CI 0.12 to 0.49, I^2 = 3%) in favour of home-based prescribed exercise (Figure 4, see also Figure 5 on the eAddenda for detailed forest plot). This translates to a mean increase in gait speed of 0.12 m/s (0.01 to 0.20) when results are back converted using the largest, least-biased and most representative study of those included in the analysis.[8] Only one trial compared the effect of home-based prescribed exercise on

Table 3
PEDro criteria and scores for included trials (n = 16).

Study	Random allocation	Concealed allocation	Groups similar at baseline	Participant blinding	Therapist blinding	Assessor blinding	< 15% dropouts	Intention -to-treat analysis	Between-group Difference reported	Point estimate and Variability reported	Total (0 to 10)
Allen (2010)[34]	Y	Y	Y	N	N	Y	Y	Y	Y	Y	8
Ashburn (2007)[35]	Y	Y	Y	N	N	Y	Y	Y	Y	Y	8
Atterbury (2017)[12]	Y	N	Y	N	N	N	N	N	Y	Y	4
Caglar (2005)[17]	N	N	Y	N	N	Y	Y	N	Y	Y	5
Canning (2012)[36]	Y	Y	Y	N	N	Y	Y	Y	Y	Y	8
Canning (2015)[8]	Y	Y	Y	N	N	Y	Y	Y	Y	Y	8
Chivers Seymour (2019)[18]	Y	Y	Y	N	N	Y	Y	Y	Y	Y	8
Dereli (2010)[13]	N	N	Y	N	N	Y	Y	N	Y	Y	5
Gandolfi (2017)[14]	Y	N	Y	N	N	Y	Y	N	Y	Y	6
Goodwin (2011)[38]	Y	Y	Y	N	N	N	Y	Y	Y	Y	7
Khalil (2017)[39]	Y	Y	Y	N	N	Y	Y	N	Y	Y	7
King (2015)[15]	Y	Y	Y	N	N	Y	Y	N	Y	Y	7
Morris (2017)[40]	Y	Y	Y	N	N	Y	Y	Y	Y	Y	8
Nieuwboer (2007)[41]	Y	Y	Y	N	N	Y	Y	N	Y	Y	7
Song (2018)[42]	Y	Y	Y	N	N	Y	Y	Y	Y	Y	8
Stack (2012)[43]	Y	Y	Y	N	N	Y	N	N	N	Y	5

gait speed beyond the intervention, so a meta-analysis could not be performed.

There was no effect of home-based prescribed exercise on the Functional Reach test when pooling three trials totalling 315 participants, with a mean PEDro score of 6.7 indicating good quality (MD 0.66 cm, 95% CI −0.84 to 2.16, I^2 = 0%). There was also no effect on the Timed Up and Go test when pooling three trials totalling 330 participants, with a mean PEDro score of 7.3 indicating good quality (MD 0.07 seconds, 95% CI −0.65 to 0.79, I^2 = 28%).

Quality of life

The effect of home-based prescribed exercise on quality of life immediately after the intervention was determined by pooling nine trials with a total of 1119 participants, with a mean PEDro score of 7.4 indicating good quality. Overall, there was a trend for home-based prescribed exercise to improve quality of life when compared with usual care or a placebo with an SMD of 0.11 (95% CI −0.01 to 0.23, I^2 = 11%) but the data were also consistent with the possibility of an effect close to no effect (Figure 6a, see also Figure 7a on the eAddenda for detailed forest plot).

The effect of home-based prescribed exercise on quality of life beyond the intervention was reported in six trials with the length of time after the intervention ranging from 6 to 46 weeks. When pooling data from the six trials with a total of 582 participants, with a mean PEDro score of 7.3 indicating good quality, there was an SMD of 0.23 (95% CI 0.06 to 0.39, I^2 = 22%) in favour of home-based prescribed exercise (Figure 6b, see also Figure 7b on the eAddenda for detailed forest plot).

Subgroup analyses

Subgroup analyses were conducted for the primary outcome of balance-related activities regarding dose and supervision. The effect of dose on balance-related activities was determined by pooling data from seven trials[8,17,18,34,35,38,39] that delivered a high dose of intervention, totalling 964 participants, with a mean PEDro score of 7.3 indicating good quality; and by pooling data from four trials[36,41–43] that delivered a low dose of intervention, totalling 256 participants, with a mean PEDro score of 7.0 indicating good quality. When trials were grouped according to dose, high-dose home-based prescribed exercise[8,17,18,34,35,38,39] was more effective than usual care or a placebo (SMD 0.24, 95% CI 0.11 to 0.36, I^2 = 0%), and low-dose home-based prescribed exercise[36,41–43] was no more effective than usual care or a placebo (SMD 0.11, 95% CI −0.14 to 0.36, I^2 = 0%) (Figure 8, see also Figure 9 on the eAddenda for detailed forest plot).

The effect of supervision on balance-related activities was determined by pooling data from nine trials[8,17,18,34–36,38,39,42] that examined minimally supervised exercise, totalling 1035 participants, with a mean PEDro score of 7.4 indicating good quality; and by pooling data from two trials[41,43] that examined fully supervised exercise, totalling 185 participants, with a mean PEDro score of 6.0 indicating good quality. When trials were grouped according to supervision, minimally supervised (median 13% supervised sessions, range 2 to 33) home-based prescribed exercise[8,17,18,34–36,38,39,42] was more effective than usual care or a placebo (SMD 0.23, 95% CI 0.11 to 0.35, I^2 = 0%), and fully supervised home-based prescribed exercise[41,43] was no more effective than usual care or a placebo (SMD 0.11, 95% CI −0.18 to 0.40, I^2 = 0%) (Figure 10, see also Figure 11 on the eAddenda for detailed forest plot).

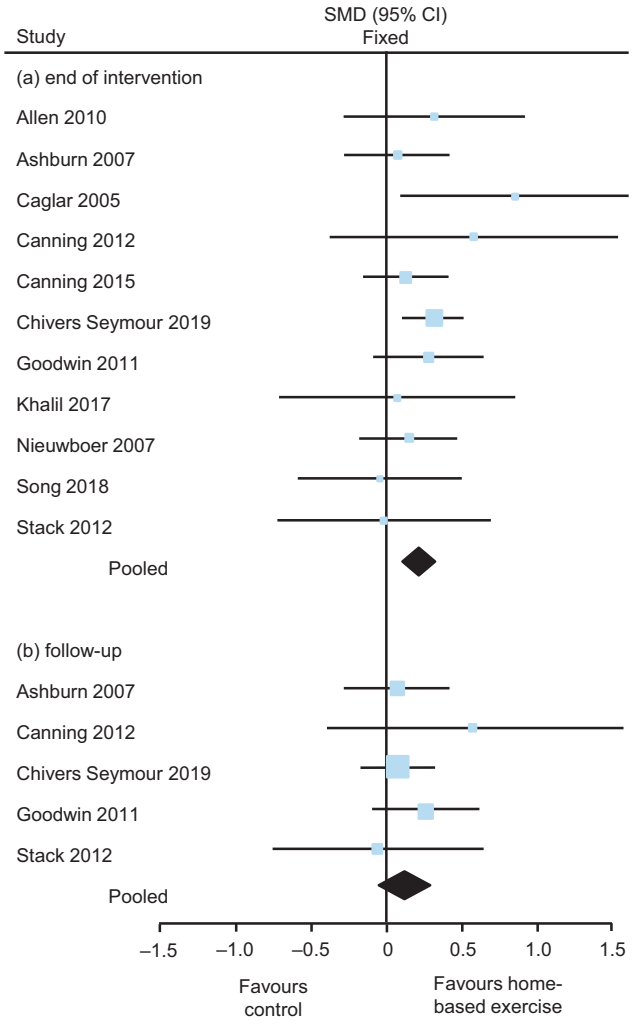

Figure 2. a. Standardised mean difference (95% CI) of effect of home-based prescribed exercise versus control on balance-related activities immediately after the intervention. **b.** Standardised mean difference (95% CI) of effect of home-based prescribed exercise versus control on balance-related activities beyond the intervention period.

Effect of home-based prescribed exercise compared with equivalent centre-based exercise

Balance-related activities

The effect of home-based prescribed exercise on balance-related activities immediately after the intervention when compared with equivalent centre-based exercise was determined by pooling three trials[12,14,15] totalling 166 participants, with a mean PEDro score of 5.7 indicating fair quality. Overall, there was no effect on balance-related activities for home-based prescribed exercise when compared with centre-based exercise (SMD −0.04, 95% CI −0.36 to 0.27, I^2 = 0%) (Figure 12, see also Figure 13 on the eAddenda for detailed forest plot). There were no individual mobility and balance outcome measures reported by three or more trials.

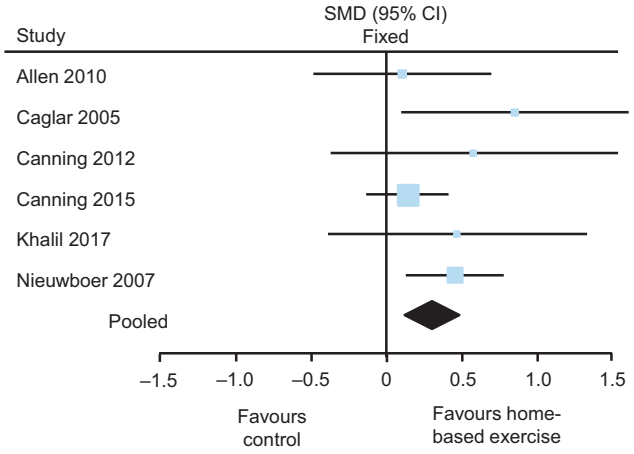

Figure 4. Standardised mean difference (95% CI) of effect of home-based prescribed exercise versus control on gait speed immediately after the intervention.

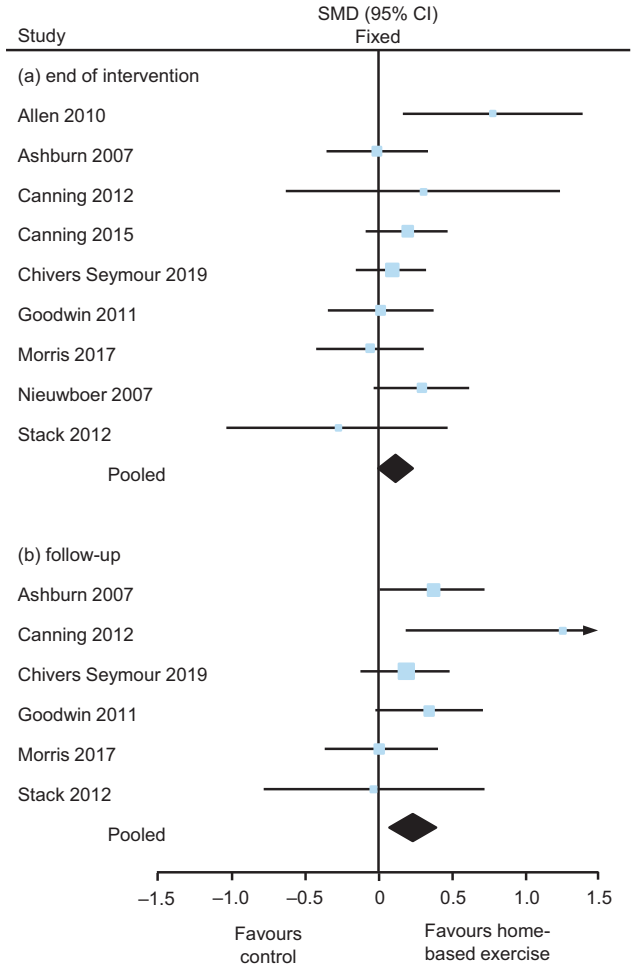

Figure 6. a. Standardised mean difference (95% CI) of effect of home-based prescribed exercise versus control on quality of life immediately after the intervention. **b.** Standardised mean difference (95% CI) of effect of home-based prescribed exercise versus control on quality of life beyond the intervention period.

Quality of life

The effect of home-based prescribed exercise on quality of life immediately after the intervention when compared with equivalent centre-based exercise was determined by pooling three trials[13–15] totalling 157 participants, with a mean PEDro score of 6.0 indicating good quality. Overall, there was no effect on quality of life for home-based prescribed exercise when compared with centre-based exercise (SMD −0.08, 95% CI −0.41 to 0.24, I^2 = 5%) (Figure 14, see also Figure 15 on the eAddenda for detailed forest plot).

Discussion

This systematic review provides evidence that home-based prescribed exercise improves balance-related activities and gait speed in people with mild to moderate Parkinson's disease without substantial cognitive deficit. These improvements were not sustained beyond the intervention period. There is also a trend for home-based prescribed exercise to improve quality of life for this population. When comparing centre-based exercise with home-based prescribed exercise, neither model of care was superior to the other for balance-

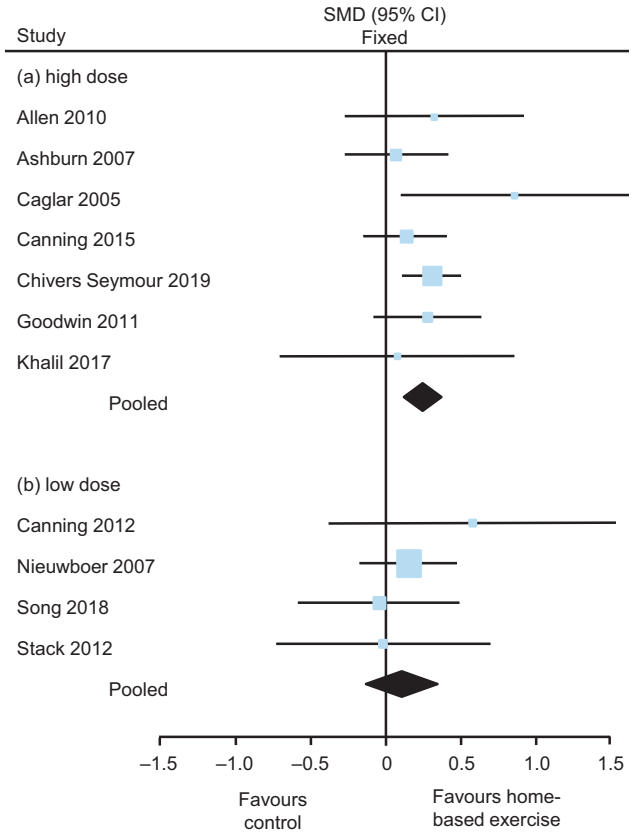

Figure 8. Subgroup analysis by dose on the effect of home-based prescribed exercise versus control on balance-related activities immediately after the intervention.

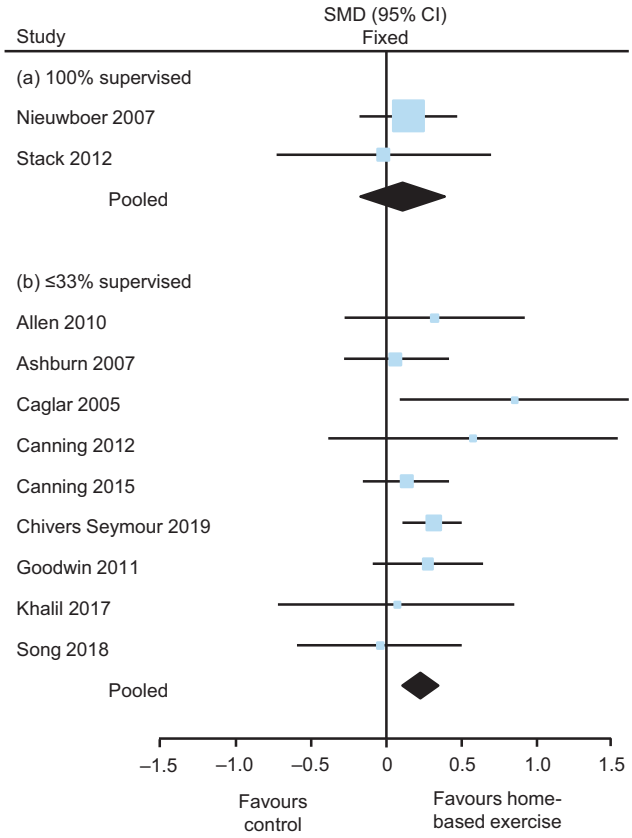

Figure 10. Subgroup analysis by supervision on the effect of home-based prescribed exercise versus control on balanced-related activities immediately after the intervention.

related activities or quality of life. The majority of the trials (75%) included in the meta-analysis were of high quality, which supports the credibility of these findings.

This is the first systematic review to specifically investigate the effectiveness of home-based prescribed exercise in people with Parkinson's disease. The small positive effect in balance-related activities is consistent with previous systematic reviews[7,16,31] investigating the effect of exercise, irrespective of the location. Furthermore, the finding that the benefits on balance-related activities gained from home-based prescribed exercise were not sustained beyond the intervention in this review is also consistent with a subgroup analysis conducted by Shen et al,[7] who reported no long-term effect on balance and gait when exercise was home-based.

Home-based prescribed exercise improved gait speed. When converted from an SMD to m/s, the increase in gait speed (0.12 m/s) was greater than previously reported in systematic reviews: Allen et al[31] reported an increase of 0.05 m/s, and Tomlinson et al[4] reported an increase of 0.04 m/s. Both Allen et al and Tomlinson et al included studies of low methodological quality, whereas five of the six trials in the current review were of good quality. Furthermore, four trials included in the current meta-analysis had a specific focus on walking, compared with the previous reviews, which included a greater range of interventions, including dance, Tai Chi and cueing strategies. This suggests that the greater increase in gait speed could be, in part, due to the specificity of the training. This increase in gait speed could also be considered clinically significant, given it is well above the 0.06 m/s reported by Hass et al to be a small clinically important difference in people with Parkinson's disease.[49]

The lack of difference in quality of life immediately after the intervention extends the previous work conducted by Tomlinson et al,[4] which reported that physiotherapy did not have an effect on quality of life. One explanation for this could be that the home-based exercise focused primarily on addressing the motor impairments of Parkinson's disease; however, non-motor impairments (such as depression) have been shown to have a greater effect on quality of life than motor impairments.[50] Nevertheless, the improvement in quality of life beyond the intervention period reflects some ongoing benefit of home-based exercise.

The subgroup analysis by dose indicates that the amount of the intervention is important when prescribing home-based exercise for people with Parkinson's disease, as high-dose interventions (minimum 150 min/wk for at least 6 weeks) improved balance-related activities while low-dose interventions did not. This is the first meta-analysis to show that dose influences outcomes of exercise programs in people with Parkinson's disease, and differs from the only other meta-analysis considering dose.[7] This difference may have been due to the definition of high dose used in the current analysis, where dose was defined by both duration and frequency (ie, 150 min/wk over a minimum of 6 weeks) compared with Shen et al who considered dose based on the number of hours completed.[7] The current results suggest that prescribed exercise should be sustained

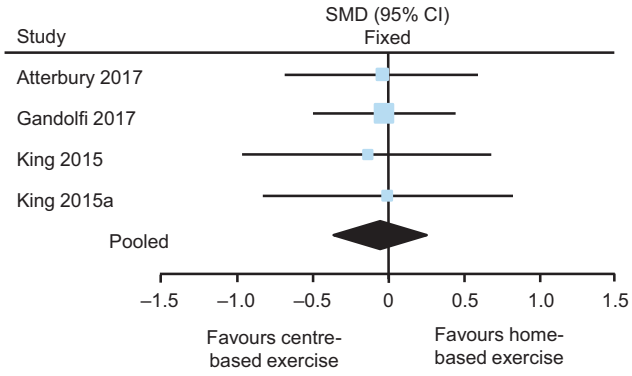

Figure 12. Standardised mean difference (95% CI) of effect of home-based prescribed exercise versus centre-based exercise on balance-related activities immediately after the intervention.

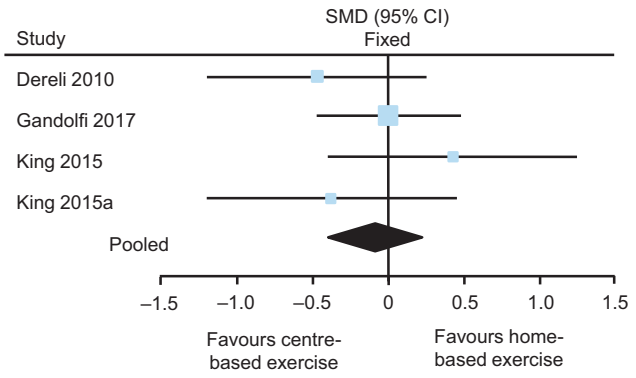

Figure 14. Standardised mean difference (95% CI) of effect of home-based prescribed exercise versus centre-based exercise on quality of life immediately after the intervention.

for a minimum of 150 min/wk for 6 weeks, and that if prescribed exercises are not ongoing, the improvements in balance-related activities will not be maintained. The ongoing need for prescribed exercise is supported by Wallen et al, who showed that improvements in balance were only maintained up to 6 months beyond the intervention in people with Parkinson's disease.[51] Importantly, a high dose of home-based prescribed exercise was provided with minimal supervision, which did not impact the effectiveness of the intervention. This indicates that prescribed exercise for people with Parkinson's disease can be provided in a sustainable manner over the long term.

The subgroup analysis by supervision found no effect of fully supervised home-based exercise programs, while programs with minimal supervision improved balance-related activities. However, the home-based exercise programs included in the fully supervised trials were of low dose (ie, an average of 135 minutes of exercise a week for an average of 3.5 weeks) compared with the home-based exercise programs included in the minimally supervised trials (ie, an average of 208 minutes of exercise a week for an average of 14 weeks). Furthermore, the trials with high dose had the lowest amount of supervision, with the average supervision over the seven trials being 15%. It is possible that the requirement for an exercise program to be fully supervised at home negatively influences the dose that can be achieved due to resource constraints. Given that Parkinson's disease is a chronic progressive condition, it is vital that effective exercise programs can be delivered and monitored without requiring full supervision.

The second question in this review was to determine if home-based prescribed exercise improves balance-related activities and quality of life when compared with centre-based exercise in people with Parkinson's disease. Our results indicate that when exercise type and dose are equivalent, the effects on balance-related activities and quality of life are similar between centre-based and home-based prescribed exercise immediately after the intervention. Our review included four trials that directly compared home-based prescribed exercise and centre-based exercise of equivalent type and dose, ensuring that the results can be attributed primarily to location. These results should be applied cautiously because the overall quality of these trials was fair. Any differences beyond the intervention period could not be determined due to insufficient data.

This review has clinical implications for physiotherapists working with people with Parkinson's disease. Importantly, home-based prescribed exercise is effective in people with mild to moderate Parkinson's disease without substantial cognitive impairment, and that effect is likely to be similar in magnitude to centre-based exercise. This allows clinicians to consider the best location for intervention based on the preference of the person with Parkinson's disease and the resources available. It is important to note that all the home-based exercise programs were prescribed by a physiotherapist or health professional with a degree-level qualification in exercise prescription, and the majority of the home-based exercise programs incorporated therapist support and/or direct supervision using a variety of methods, including: home visits by the therapist, occasional group-based sessions at a centre, telephones calls and Skype. In nine of the 12 trials, where home-based prescribed exercise was compared with usual care or a placebo, it included a minimum of one home visit. These strategies enable the therapist to provide feedback and progress the exercises to ensure that they remained appropriate and challenging.

The results of this review support minimally supervised, home-based exercise to improve balance-related activities in people with mild to moderate Parkinson's disease without substantial cognitive impairment. However, three fall-prevention trials suggest that this type of exercise may increase falls in those with more advanced Parkinson's disease,[8,18,35] cognitive impairment and freezing of gait.[18] Therefore, minimally supervised, home-based exercise is not recommended for people with more advanced Parkinson's disease, especially in the presence of cognitive impairment and freezing of gait.

This review had some limitations, including the use of post-intervention data as opposed to change scores and the use of an SMD, which is less clinically meaningful than a mean difference. For the analysis examining the effect of home-based prescribed exercise compared with usual care or a placebo beyond the intervention, there were few trials and the follow-up period was highly variable, so these results should be applied cautiously. When comparing home-based prescribed exercise with centre-based exercise, the few available trials all had small sample sizes, which could have led to small sample bias. The reporting of adherence to the intervention also needs to be considered, as the trials with minimal supervision relied on self-reporting and no trials reported if adherence was calculated using capped (ie, capped data, restricting adherence to a maximum of 100%) or uncapped (ie, uncapped data, allowing > 100% adherence) methods. As expected, there was a wide range of balance-related activity measures reported; greater consistency of outcome measures would facilitate future research.[52] The use of a predefined priority order was an effective method of addressing this concern.

In conclusion this review provides evidence that home-based prescribed exercise can improve balance-related activities and gait speed in people with mild to moderate Parkinson's disease without substantial cognitive deficit. Furthermore, these improvements are likely to be similar to improvements obtained by equivalent centre-based exercise. This suggests that home-based prescribed exercise may be an effective strategy for delivering high-quality exercise to people with Parkinson's disease in health services where resources are limited.

What was already known on this topic: In people with Parkinson's disease, specific exercise-based interventions improve mobility, balance and quality of life. Given the progressive nature of the disease and its near-normal life expectancy, exercise programs must be sustainable. Home-based prescribed exercise has the potential to be sustained over a long period of time with minimal resources.

What this study adds: Home-based prescribed exercise improves balance and gait speed in people with Parkinson's disease. Home-based and centre-based exercise were found to have similar effects on balance-related activities and quality of life.

Footnotes: [a] RevMan 5.3 software, The Nordic Cochrane Centre, Copenhagen, Denmark.

eAddenda: Figures 3, 5, 7, 9, 11, 13 and 15, and Appendix 1 can be found online at https://doi.org/10.1016/j.jphys.2019.08.003.

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References

1. Dorsey E, Sherer T, Okun MS, Bloem BR. The emerging evidence of the parkinson pandemic. *J Parkinson's Dis*. 2018;8:S3–S8.
2. Keus S, Munneke M, Graziano M, Paltamaa J, Pelosin E, Domingos J, et al. European physiotherapy guideline for Parkinson's disease. *The Netherlands: KNGF/ParkinsonNet*; 2014.
3. Goodwin VA, Richards SH, Taylor RS, Taylor AH, Campbell JL. The effectiveness of exercise interventions for people with Parkinson's disease: a systematic review and meta analysis. *Mov Disord*. 2008;23:631–640.
4. Tomlinson CL, Patel S, Meek C, Herd CP, Clarke CE, Stowe R, et al. Physiotherapy versus placebo or no intervention in Parkinson's disease. *Cochrane Database Syst Rev*. 2013;9:CD002817.
5. Mehrholz J, Kugler J, Storch A, Pohl M, Hirsch K, Elsner B. Treadmill training for patients with Parkinson's disease. *Cochrane Database Syst Rev*. 2015;9:CD007830.
6. Conradsson D, Löfgren N, Nero H, Hagströmer M, Ståhle A, Lökk J, et al. The effects of highly challenging balance training in elderly with Parkinson's disease: a randomized controlled trial. *Neurorehabil Neural Repair*. 2015;29:827–836.
7. Shen X, Wong-Yu ISK, Mak MKY. Effects of exercise on falls, balance, and gait ability in Parkinson's disease: a meta-analysis. *Neurorehabil Neural Repair*. 2016;30:512–527.
8. Canning C, Sherrington C, Lord S, Close JC, Heritier S, Heller GZ, et al. Exercise for falls prevention in Parkinson disease: a randomized controlled trial. *Neurology*. 2015;84:304–312.
9. Morris ME, Menz HB, McGinley JL, Watts JJ, Huxham FE, Murphy AT, et al. A randomized controlled trial to reduce falls in people with Parkinson's disease. *Neurorehabil Neural Repair*. 2015;29:777–785.
10. Allen NE, Sherrington C, Suriyarachchi GD, Paul SS, Song J, Canning CG. Exercise and motor training in people with Parkinson's disease: a systematic review of participant characteristics, intervention delivery, retention rates, adherence, and adverse events in clinical trials. *Parkinsons Dis*. 2012;2012:954328.
11. Backstrom D, Granasen G, Domellof ME, Linder J, Mo SJ, Riklund K, et al. Early predictors of mortality in parkinsonism and Parkinson disease: A population-based study. *Neurology*. 2018;91:e2045–e2056.
12. Atterbury E, Welman K. Balance training in individuals with Parkinson's disease: therapist-supervised vs. home-based exercise programme. *Gait Posture*. 2017;55:138–144.
13. Dereli EE, Yaliman A. Comparison of the effects of a physiotherapist-supervised exercise programme and a self-supervised exercise programme on quality of life in patients with Parkinson's disease. *Clin Rehabil*. 2010;24:352–362.
14. Gandolfi M, Geroin C, Dimitrova E, Boldrini P, Waldner A, Bonadiman S, et al. Virtual reality telerehabilitation for postural instability in Parkinson's disease: a multicenter, single-blind, randomized, controlled trial. *Biomed Res Int*. 2017;2017:7962826.
15. King LA, Wilhelm J, Chen Y, Blehm R, Nutt J, Chen Z, et al. Effects of group, individual, and home exercise in persons with Parkinson disease: a randomized clinical trial. *J Neurol Phys Ther*. 2015;39:204–212.
16. Klamroth S, Steib S, Devan S, Pfeifer K. Effects of exercise therapy on postural instability in Parkinson disease: a meta-analysis. *J Neurol Phys Ther*. 2016;40:3–14.
17. Caglar AT, Gurses HN, Mutluay FK, Kiziltan G. Effects of home exercises on motor performance in patients with Parkinson's disease. *Clin Rehabil*. 2005;19:870–877.
18. Chivers Seymour K, Pickering R, Rochester L, Roberts HC, Ballinger C, Hulbert S, et al. Multicentre, randomised controlled trial of PDSAFE, a physiotherapist-delivered fall prevention programme for people with Parkinson's. *J Neurol Neurosurg Psychiatry*. 2019;90:774–782.
19. Maher CG, Sherrington C, Herbert RD, Moseley AM, Elkins M. Reliability of the PEDro scale for rating quality of randomized controlled trials. *Phys Ther*. 2003;83:713–721.
20. Godi M, Franchignoni F, Caligari M, Giordano A, Turcato AM, Nardone A. Comparison of reliability, validity, and responsiveness of the mini-BESTest and Berg Balance Scale in patients with balance disorders. *Phys Ther*. 2013;93:158–167.
21. Leddy AL, Crowner BE, Earhart GM. Functional gait assessment and balance evaluation system test: reliability, validity, sensitivity, and specificity for identifying individuals with Parkinson disease who fall. *Phys Ther*. 2011;91:102–113.
22. Huang S-L, Hsieh C-L, Wu R-M, Tai C-H, Lin C-H, Lu W-S. Minimal detectable change of the timed up & go test and the dynamic gait index in people with Parkinson disease. *Phys Ther*. 2011;91:114–121.
23. Qutubuddin AA, Pegg PO, Cifu DX, Brown R, McNamee S, Carne W. Validating the Berg Balance Scale for patients with Parkinson's disease: a key to rehabilitation evaluation. *Arch Phys Med Rehabil*. 2005;86:789–792.
24. Guralnik JM, Simonsick EM, Ferrucci L, Glynn RJ, Berkman LF, Blazer DG, et al. A short physical performance battery assessing lower extremity function: association with self-reported disability and prediction of mortality and nursing home admission. *J Gerontol*. 1994;49:M85–M94.
25. Morris S, Morris ME, Iansek R. Reliability of measurements obtained with the Timed Up & Go test in people with Parkinson disease. *Phys Ther*. 2001;81:810–818.
26. Duncan PW, Weiner DK, Chandler J, Studenski S. Functional reach: a new clinical measure of balance. *J Gerontol*. 1990;45:M192–M197.
27. Visser M, Marinus J, Bloem BR, Kisjes H, van den Berg BM, van Hilten JJ. Clinical tests for the evaluation of postural instability in patients with Parkinson's disease. *Arch Phys Med Rehabil*. 2003;84:1669–1674.
28. Jacobs JV, Horak FB, Van Tran K, Nutt JG. An alternative clinical postural stability test for patients with Parkinson's disease. *J Neurol*. 2006;253:1404–1413.
29. Reuben DB, Siu AL. An objective measure of physical function of elderly outpatients: the Physical Performance Test. *J Am Geriatr Soc*. 1990;38:1105–1112.
30. Cohen H, Heaton LG, Congdon SL, Jenkins HA. Changes in sensory organization test scores with age. *Age Ageing*. 1996;25:39–44.
31. Allen NE, Sherrington C, Paul SS, Canning CG. Balance and falls in Parkinson's disease: A meta-analysis of the effect of exercise and motor training. *Mov Disord*. 2011;26:1605–1615.
32. Wan X, Wang W, Liu J, Tong T. Estimating the sample mean and standard deviation from the sample size, median, range and/or interquartile range. *BMC Med Res Methodol*. 2014;14:135.
33. Rohatgi A. WebPlotDigitizer website. https://automeris.io/WebPlotDigitizer. Accessed November 13, 2018.
34. Allen N, Canning C, Sherrington C, Lord SR, Latt MD, Close JC, et al. The effects of an exercise program on fall risk factors in people with Parkinson's disease: a randomized controlled trial. *Mov Disord*. 2010;25:1217–1225.
35. Ashburn A, Fazakarley L, Ballinger C, Pickering R, McLellan L, Fitton C. A randomised controlled trial of a home based exercise programme to reduce the risk of falling among people with Parkinson's disease. *J Neurol Neurosurg Psychiatry*. 2007;78:678–684.
36. Canning C, Allen N, Dean C, Goh L, Fung V. Home-based treadmill training for individuals with Parkinson's disease: a randomized controlled pilot trial. *Clin Rehabil*. 2012;26:817–826.
37. Fletcher E, Goodwin VA, Richards SH, Campbell JL, Taylor RS. An exercise intervention to prevent falls in Parkinson's: an economic evaluation. *BMC Health Serv Res*. 2012;12:426.
38. Goodwin V, Richards S, Henley W, Ewings P, Taylor A, Campbell J. An exercise intervention to prevent falls in people with Parkinson's disease: a pragmatic randomised controlled trial. *J Neurol Neurosurg Psychiatry*. 2011;82:1232–1238.
39. Khalil H, Busse M, Quinn L, Nazzal M, Batyha W, Alkhazaleh S, et al. A pilot study of a minimally supervised home exercise and walking program for people with Parkinson's disease in Jordan. *Neurodegener Dis Manag*. 2017;7:73–84.
40. Morris ME, Taylor NF, Watts J, Evans A, Horne M, Kempster P, et al. A home program of strength training, movement strategy training and education did not prevent falls in people with Parkinson's disease: a randomised trial. *J Physiother*. 2017;63:94–100.
41. Nieuwboer A, Kwakkel G, Rochester L, Jones D, van Wegen E, Willems AM, et al. Cueing training in the home improves gait-related mobility in Parkinson's disease: the RESCUE trial. *J Neurol Neurosurg Psychiatry*. 2007;78:134–140.
42. Song J, Paul SS, Caetano MJD, Smith S, Dibble LE, Love R, et al. Home-based step training using videogame technology in people with Parkinson's disease: a single-blinded randomised controlled trial. *Clin Rehabil*. 2018;32:299–311.
43. Stack E, Roberts H, Ashburn A. The PIT SToPP trial: a feasibility randomised controlled trial of home-based physiotherapy for people with Parkinson's disease using video-based measures to preserve assessor blinding. *Parkinsons Dis*. 2012;2012:360231.
44. Peto V, Jenkinson C, Fitzpatrick R, Greenhall R. The development and validation of a short measure of functioning and well being for individuals with Parkinson's disease. *Qual Life Res*. 1995;4:241–248.
45. Jenkinson C, Fitzpatrick R, Peto V, Greenhall R, Hyman N. The PDQ-8: development and validation of a short-form Parkinson's disease questionnaire. *Psychol Health*. 1997;12:805–814.
46. De Boer A, Wijker W, Speelman J, De Haes J. Quality of life in patients with Parkinson's disease: development of a questionnaire. *J Neurol Neurosurg Psychiatry*. 1996;61:70–74.
47. EuroQol Group. EuroQol-a new facility for the measurement of health-related quality of life. *Health Policy*. 1990;16:199–208.
48. Haapaniemi T, Sotaniemi K, Sintonen H, Taimela E. The generic 15D instrument is valid and feasible for measuring health related quality of life in Parkinson's disease. *J Neurol Neurosurg Psychiatry*. 2004;75:976–983.
49. Hass CJ, Bishop M, Moscovich M, Stegemöller EL, Skinner J, Malaty IA, et al. Defining the clinically meaningful difference in gait speed in persons with Parkinson disease. *J Neurol Phys Ther*. 2014;38:233–238.
50. van Uem JM, Marinus J, Canning C, van Lummel R, Dodel R, Liepelt-Scarfone I, et al. Health-related quality of life in patients with Parkinson's disease a systematic review based on the ICF model. *Neurosci Biobehav Rev*. 2016;61:26–34.
51. Wallann MB, Hagstromer M, Conradsson D, Sorjonen K, Franzen E. Long-term effects of highly challenging balance training in Parkinson's disease – a randomized controlled trial. *Clin Rehabil*. 2018;32:1520–1529.
52. Bloem BR, Marinus J, Almeida Q, Dibble L, Nieuwboer A, Post B, et al. Measurement instruments to assess posture, gait, and balance in Parkinson's disease: Critique and recommendations. *Mov Disord*. 2016;31:1342–1355.