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[Intervention Review]

Physical exercise for people with Parkinson's disease: a systematic review and network meta-analysis

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Editorial note: Key results from the network meta-analysis are also available as an interactive summary of findings table, produced in collaboration with MAGIC.

ABSTRACT

Background

Physical exercise is effective in managing Parkinson's disease (PD), but the relative benefit of different exercise types remains unclear.

Objectives

To compare the effects of different types of physical exercise in adults with PD on the severity of motor signs, quality of life (QoL), and the occurrence of adverse events, and to generate a clinically meaningful treatment ranking using network meta-analyses (NMAs).

Search methods

An experienced information specialist performed a systematic search for relevant articles in CENTRAL, MEDLINE, Embase, and five other databases to 17 May 2021. We also searched trial registries, conference proceedings, and reference lists of identified studies up to this date.

Selection criteria

We included randomized controlled trials (RCTs) comparing one type of physical exercise for adults with PD to another type of exercise, a control group, or both.

Data collection and analysis

Two review authors independently extracted data. A third author was involved in case of disagreements.

We categorized the interventions and analyzed their effects on the severity of motor signs, QoL, freezing of gait, and functional mobility and balance up to six weeks after the intervention using NMAs. Two review authors independently assessed the risk of bias using the risk of bias 2 (RoB 2) tool and rated the confidence in the evidence using the CINeMA approach for results on the severity of motor signs and QoL. We consulted a third review author to resolve any disagreements.

Due to heterogeneous reporting of adverse events, we summarized safety data narratively and rated our confidence in the evidence using the GRADE approach.

Main results

We included 156 RCTs with a total of 7939 participants with mostly mild to moderate disease and no major cognitive impairment. The number of participants per study was small (mean 51, range from 10 to 474). The NMAs on the severity of motor signs and QoL included data from 71 (3196 participants), and 55 (3283 participants) trials, respectively. Eighty-five studies (5192 participants) provided safety data. Here, we present the main results.

We observed evidence of beneficial effects for most types of physical exercise included in our review compared to a passive control group. The effects on the severity of motor signs and QoL are expressed as scores on the motor scale of the Unified Parkinson Disease Rating Scale (UPDRS-M) and the Parkinson's Disease Questionnaire 39 (PDQ-39), respectively. For both scales, higher scores denote higher symptom burden. Therefore, negative estimates reflect improvement (minimum clinically important difference: -2.5 for UPDRS-M and -4.72 for PDQ-39).

Severity of motor signs
The evidence from the NMA (71 studies; 3196 participants) suggests that dance has a moderate beneficial effect on the severity of motor signs (mean difference (MD) -10.32, 95% confidence interval (CI) -15.54 to -4.96; high confidence), and aqua-based, gait/balance/functional, and multi-domain training might have a moderate beneficial effect on the severity of motor signs (aqua-based: MD -7.77, 95% CI -13.27 to -2.28; gait/balance/functional: MD -7.37, 95% CI -11.39 to -3.35; multi-domain: MD -6.97, 95% CI -10.32 to -3.62; low confidence). The evidence also suggests that mind-body training and endurance training might have a small beneficial effect on the severity of motor signs (mind-body: MD -6.57, 95% CI -10.18 to -2.81; endurance: MD -6.43, 95% CI -10.72 to -2.28; low confidence). Flexibility training might have a trivial or no effect on the severity of motor signs (MD 2.01, 95% CI -4.82 to 8.98; low confidence). The evidence is very uncertain about the effects of strength/resistance training and "Lee Silverman Voice training BIG" (LSVT BIG) on the severity of motor signs (strength/resistance: MD -6.97, 95% CI -11.93 to -2.01; LSVT BIG: MD -5.49, 95% CI -14.74 to 3.62; very low confidence).

Quality of life
The evidence from the NMA (55 studies; 3283 participants) suggests that aqua-based training probably has a large beneficial effect on QoL (MD -14.98, 95% CI -23.26 to -6.52; moderate confidence). The evidence also suggests that endurance training might have a moderate beneficial effect, and that gait/balance/functional and multi-domain training might have a small beneficial effect on QoL (endurance: MD -9.16, 95% CI -15.68 to -2.82; gait/balance/functional: MD -5.64, 95% CI -10.04 to -1.23; multi-domain: MD -5.29, 95% CI -9.34 to -1.06; low confidence). The evidence is very uncertain about the effects of mind-body training, gaming, strength/resistance training, dance, LSVT BIG, and flexibility training on QoL (mind-body: MD -8.81, 95% CI -14.62 to -3.00; gaming: MD -7.05, 95% CI -18.50 to 4.41; strength/resistance: MD -6.34, 95% CI -12.33 to -0.35; dance: MD -4.05, 95% CI -11.28 to 3.00; LSVT BIG: MD 2.29, 95% CI -16.03 to 20.44; flexibility: MD 1.23, 95% CI -11.45 to 13.92; very low confidence).

Adverse events
Only 85 studies (5192 participants) provided some kind of safety data, mostly only for the intervention groups. No adverse events (AEs) occurred in 40 studies and no serious AEs occurred in four studies. AEs occurred in 28 studies. The most frequently reported events were falls (18 studies) and pain (10 studies). The evidence is very uncertain about the effect of physical exercise on the risk of adverse events (very low confidence).

Across outcomes, we observed little evidence of differences between exercise types.

Authors' conclusions

We found evidence of beneficial effects on the severity of motor signs and QoL for most types of physical exercise for people with PD included in this review, but little evidence of differences between these interventions. Thus, our review highlights the importance of physical exercise regarding our primary outcomes severity of motor signs and QoL, while the exact exercise type might be secondary. Notably, this conclusion is consistent with the possibility that specific motor symptoms may be treated most effectively by PD-specific programs. Although the evidence is very uncertain about the effect of exercise on the risk of adverse events, the interventions included in our review were described as relatively safe. Larger, well-conducted studies are needed to increase confidence in the evidence. Additional studies recruiting people with advanced disease severity and cognitive impairment might help extend the generalizability of our findings to a broader range of people with PD.

PLAIN LANGUAGE SUMMARY

Physical exercise for people with Parkinson's disease: what type of exercise works best?

Background

Parkinson's disease (PD) is a progressive disorder of the nervous system that mostly affects people over 60. Symptoms begin gradually and include movement issues, such as trembling, stiffness, slowness of movement and balance, and coordination issues. People with PD can also have emotional and mood problems, fatigue, sleep problems, and thinking difficulties. The disorder cannot be cured, but the symptoms can be relieved, for example, with medicine or surgery. Moreover, people with PD may benefit from physiotherapy or other forms of physical exercise, such as dancing. But it remains unclear if some of these exercise types work better than others.

What was our aim?

We wanted to find out what type of physical exercise works best to improve movement and quality of life for people with PD. We also wanted to find out what type of exercise causes the least unwanted effects.

What did we do?

We searched for studies that compared physical exercise with no physical exercise or with another physical exercise type. We compared and summarized their short-term results, and rated our confidence in the evidence, based on factors such as study methods and number of people included. We only studied short-term results.

What did we find?

We found 156 studies on different physical exercise types for people with PD. The studies included a total of 7939 people. The smallest study was conducted with 10 people and the biggest with 474 people. The average participant age was between 60 and 74 years. The studies were conducted in countries around the world, with the highest number (34) in the USA. Of the included studies, 71 (3196 people) provided information on movement; 55 (3283 people) provided information on quality of life, and 85 (5192 people) provided information on unwanted effects.

What are the key results?

Many types of physical exercise worked well for people with PD compared to no physical exercise.

Dance has a moderate beneficial effect on movement. Aqua-based training, gait/balance/functional training, and training that consists of several exercise types (i.e. multi-domain training) might have a moderate beneficial effect on movement. Mind-body (e.g. tai chi or yoga) and endurance training might have a small beneficial effect on movement. Flexibility training might have little to no effect on movement. We are very uncertain about the effects of strength/resistance training and the PD-specific physical therapy "Lee Silverman Voice training BIG" (LSVT BIG) on movement.

Aqua-based training probably has a large beneficial effect on quality of life. Endurance training might have a moderate, and gait/balance/functional and multi-domain training might have a small beneficial effect on quality of life. We are very uncertain about the effects of mind-body training, gaming, strength/resistance training, dance, LSVT BIG, and flexibility training on quality of life.

Our confidence in the effects ranged from high to very low. When our confidence was reduced, it was often because of two reasons. First, not all of the studies provided information on movement or quality of life from all the people who participated. Second, studies were very small.

Only 85 studies provided some information about unwanted effects, and mostly only for the physical exercise groups, not the groups who did not do exercise. No unwanted effects were reported in 40 studies. No serious unwanted effects were reported in four studies. Unwanted effects were reported in 28 studies. The unwanted effects reported most frequently were falls (18 studies) and pain (10 studies). We could not say what type of exercise causes the least unwanted effects because studies did not provide information about everything we needed. That is why we are very uncertain about the results on unwanted effects.

What does this mean?

We found that many types of physical exercise can help improve movement and quality of life for people with PD. We found scant evidence that certain exercise types work better than others. Therefore, for movement and quality of life, we think physical exercise is important, but the exact exercise type might be less important. Still, it is possible that some symptoms may be relieved best with specific types of training made for people with PD. The types of training we included seemed to be quite safe.

Larger, well-designed studies are needed to increase our confidence in the evidence. Also, more research is required to understand the features that influence the effects of exercise. More studies involving people who have worse symptoms could help extend the results to more people with PD.

How up to date is this review?

The evidence is up to date to May 2021.

SUMMARY OF FINDINGS

Summary of findings 1. Network estimates of effects and confidence in the evidence for physical exercise in people with Parkinson's disease on the severity of motor signs

Patient or population: people with Parkinson's disease
Interventions: physical exercise including: aqua-based training, dance, endurance training, flexibility training, gait/balance/functional training, gaming, LSVT BIG, mind-body training, multi-domain training, and strength/resistance training
Comparison: passive control group (mean [median] UPDRS-M score = 21.34 [19.80])*
Outcome: severity of motor signs, reported as UPDRS-M scores, scale from 0 to 108 (worse)
Settings: inpatient and outpatient care

Total studies: 71 RCTs **Total participants:** 3196	**Estimated absolute effects on severity of motor signs (SMD and 95% CI)**	**Estimated absolute effects on severity of motor signs (MD and 95% CI), MCID for improvement/worsening: -2.5/2.5****	**Confidence in the evidence (CINeMA)**	**Interpretation*****
Dance (5 RCTs; 169 participants)	-0.77 (-1.16 to -0.37)	-10.32 (-15.54 to -4.96)	⊕⊕⊕⊕ High	Dance has a moderate beneficial effect on the severity of motor signs.
Aqua-based training (2 RCTs; 30 participants)	-0.58 (-0.99 to -0.17)	-7.77 (-13.27 to -2.28)	⊕⊕◯◯[a,d] Low	Aqua-based training might have a moderate beneficial effect on the severity of motor signs.
Gait/balance/functional training (3 RCTs; 137 participants)	-0.55 (-0.85 to -0.25)	-7.37 (-11.39 to -3.35)	⊕⊕◯◯[a,d] Low	Gait/balance/functional training might have a moderate beneficial effect on the severity of motor signs.
Multi-domain training (7 RCTs; 271 participants)	-0.52 (-0.77 to -0.27)	-6.97 (-10.32 to -3.62)	⊕⊕◯◯[a,d] Low	Multi-domain training might have a moderate beneficial effect on the severity of motor signs.
Strength/resistance training (2 RCTs; 52 participants)	-0.52 (-0.89 to -0.15)	-6.97 (-11.93 to -2.01)	⊕◯◯◯[a,d,e] Very low	The effect of strength/resistance training might have a moderate beneficial effect on the severity of motor signs, but the evidence is very uncertain.
Mind-body training (10 RCTs; 323 participants)	-0.49 (-0.76 to -0.21)	-6.57 (-10.18 to -2.81)	⊕⊕◯◯[a,d] Low	Mind-body training might have a small beneficial effect on the severity of motor signs.
Endurance training (5 RCTs; 227 participants)	-0.48 (-0.8 to -0.17)	-6.43 (-10.72 to -2.28)	⊕⊕◯◯[b,d] Low	Endurance training might have a small beneficial effect on the severity of motor signs.
LSVT BIG (1 RCT; 39 participants)	-0.41 (-1.1 to 0.27)	-5.49 (-14.74 to 3.62)	⊕◯◯◯[b,c] Very low	LSVT BIG might have a small beneficial effect on the severity of motor signs, but the evidence is very uncertain.

Flexibility training (No direct evidence, indirect evidence only)	0.15 (-0.36 to 0.67)	2.01 (-4.82 to 8.98)	⊕⊕◯◯[c,f,g] Low	Flexibility training might have a trivial or no effect on the severity of motor signs.
Gaming (No direct or indirect evidence)	Not applicable****	Not applicable****	Not applicable****	Not applicable****

CI: confidence interval; **MCID:** minimal clinically important difference; **MD:** mean difference; **PI:** prediction interval; **SD:** standard deviation; **SMD:** standardized mean difference; **UPDRS-M:** Unified Parkinson Disease Rating Scale - motor scale

CINeMA grades of evidence (derived from the GRADE Working Group grades of evidence)
High confidence: we are very confident that the true effect lies close to that of the estimate of the effect.
Moderate confidence: we are moderately confident in the effect estimate: the true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different.
Low confidence: our confidence in the effect estimate is limited: the true effect may be substantially different from the estimate of the effect.
Very low confidence: we have very little confidence in the effect estimate: the true effect is likely to be substantially different from the estimate of the effect.

* We calculated scores based on mean UPDRS-M scores (post-intervention), reported in 23 studies (317 participants) included in the network meta-analysis.
** We rescaled scores from SMDs to MDs of the UPDRS-M using an SD of 13.4 (Shulman 2010). Minimal clinically important difference for improvement: -2.5 (Shulman 2010).
*** We based the classification of effect sizes on the SMDs following Cohen 1988 (i.e. small, unimportant: < 0.2; small, important: 0.2 to 0.5; moderate: 0.5 to 0.8; large: > 0.8).
**** None of the studies provided data on the effect of gaming on the severity of motor signs.
[a]Large contribution of studies at high risk of bias and inconsistency between results of primary analysis and sensitivity analysis limited to studies at low risk of bias (downgraded by 1 level for risk of bias).
[b]Large contribution of studies with at least some concerns regarding risk of bias; no sensitivity analysis limited to studies at low risk of bias available (downgraded by 1 level for risk of bias).
[c]CI includes effects in both directions (downgraded by 2 levels for imprecision).
[d]While CI includes effect in favor of the intervention (i.e. aqua-based, endurance, gait/balance/functional, mind-body, multi-domain, and strength/resistance training), PI includes effects in both directions (i.e. PI extends beyond range of equivalence on the opposite side of line of no effect favoring the passive control group) (downgraded by 1 level for heterogeneity).
[e]While CI of direct estimate includes effect in favor of strength/resistance training, CI of indirect estimate extends into range of equivalence across line of no effect (downgraded by 1 level for incoherence).
[f]Estimates are based on indirect evidence only and global approach to assess incoherence is significant, $P < 0.05$, $I^2 = 58.4\%$ (downgraded by 2 levels for incoherence).
[g]The overall level of confidence was downgraded by no more than 2 levels in order to avoid downgrading more than once for related concerns (i.e. imprecision, heterogeneity, and incoherence).
Additionally, we present key results from the network meta-analysis in an interactive summary of findings table.

Summary of findings 2. Network estimates of effects and confidence in the evidence for physical exercise in people with Parkinson's disease on quality of life

Patients or population: people with Parkinson's disease
Interventions: physical exercise including aqua-based training, dance, endurance training, flexibility training, and gait/balance/functional training, gaming, LSVT BIG, mind-body training, multi-domain training, and strength/resistance training
Comparison: passive control group (mean [median] PDQ-39 score = 32.72 [29.50])*

Outcome: quality of life, reported as PDQ-39 scores, scale from 0 to 100 (worse)

Settings: inpatient and outpatient care

Total studies: 55 RCTs **Total participants:** 3283	**Estimated absolute effects on quality of life (SMD and 95% CI)**	**Estimated absolute effects on quality of life (MD and 95% CI), MCID for improvement/worsening: -4.72/4.22****	**Confidence in the evidence (CINeMA)**	**Interpretation*****
Aqua-based training (1 RCT; 18 participants)	-0.85 (-1.32 to -0.37)	-14.98 (-23.26 to -6.52)	⊕⊕⊕O[a] Moderate	Aqua-based training probably has a large beneficial effect on quality of life.
Endurance training (3 RCTs; 90 participants)	-0.52 (-0.89 to -0.16)	-9.16 (-15.68 to -2.82)	⊕⊕OO[a,e] Low	Endurance training might have a moderate beneficial effect on quality of life.
Mind-body training (5 RCTs; 155 participants)	-0.50 (-0.83 to -0.17)	-8.81 (-14.62 to -3.00)	⊕OOO[b,e] Very low	Mind-body training might have a moderate beneficial effect on quality of life, but the evidence is very uncertain.
Gaming (No direct evidence, indirect evidence only)	-0.40 (-1.05 to 0.25)	-7.05 (-18.50 to 4.41)	⊕OOO[b,c,g,h] Very low	Gaming might have a small beneficial effect on quality of life, but the evidence is very uncertain.
Strength/resistance training (3 RCTs; 87 participants)	-0.36 (-0.70 to -0.02)	-6.34 (-12.33 to -0.35)	⊕OOO[a,e,f,h] Very low	Strength/resistance training might have a small beneficial effect on quality of life, but the evidence is very uncertain.
Gait/balance/functional training (5 RCTs; 745 participants)	-0.32 (-0.57 to -0.07)	-5.64 (-10.04 to -1.23)	⊕⊕OO[a,e] Low	Gait/balance/functional training might have a small beneficial effect on quality of life.
Multi-domain training (7 RCTs; 575 participants)	-0.30 (-0.53 to -0.06)	-5.29 (-9.34 to -1.06)	⊕⊕OO[a,e] Low	Multi-domain training might have a small beneficial effect on quality of life.
Dance (4 RCTs; 130 participants)	-0.23 (-0.64 to 0.17)	-4.05 (-11.28 to 3.00)	⊕OOO[b,d] Very low	Dance might have a small beneficial effect on quality of life, but the evidence is very uncertain.
LSVT BIG (No direct evidence, indirect evidence only)	0.13 (-0.91 to 1.16)	2.29 (-16.03 to 20.44)	⊕OOO[a,c,g,h] Very low	LSVT BIG might have a trivial or no effect on quality of life, but the evidence is very uncertain.
Flexibility training (No direct evidence, indirect evidence only)	0.07 (-0.65 to 0.79)	1.23 (-11.45 to 13.92)	⊕OOO[b,c,g,h] Very low	Flexibility training might have a trivial or no effect on quality of life, but the evidence is very uncertain.

CI: confidence interval; **MCID:** minimal clinically important difference; **MD:** mean difference; **PDQ-39:** Parkinson's Disease Questionnaire 39; **PI:** prediction interval; **SD:** standard deviation; **SMD:** standardized mean difference

CINeMA grades of evidence (derived from the GRADE Working Group grades of evidence)

High confidence: we are very confident that the true effect lies close to that of the estimate of the effect.
Moderate confidence: we are moderately confident in the effect estimate: the true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different.
Low confidence: our confidence in the effect estimate is limited: the true effect may be substantially different from the estimate of the effect.
Very low confidence: we have very little confidence in the effect estimate: the true effect is likely to be substantially different from the estimate of the effect.

* We calculated scores based on mean PDQ-39 scores (post-intervention) reported in 21 studies (642 participants) included in the network meta-analysis.
** We rescaled scores from SMDs to MDs of the PDQ-39 using an SD of 17.62 (Peto 2001). Minimal clinically important difference for improvement/worsening: -4.72/4.22 (Horvath 2017).
*** We based the classification of effect sizes on the SMDs following Cohen 1988 (i.e. small, unimportant: < 0.2; small, important: 0.2 to 0.5; moderate: 0.5 to 0.8; large: > 0.8).
[a]High risk of bias in measurement of the outcome due to the nature of self-reported questionnaires (i.e. the subjectivity of the assessment) (downgraded by 1 level for risk of bias).
[b]Large contribution of studies at high risk of bias even when considering only domains that are not affected by the subjectivity of the assessment (downgraded by 2 levels for risk of bias).
[c]CI includes effects in both directions (downgraded by 2 levels for imprecision).
[d]Estimate favors dance and CI extends into range of equivalence across line of no effect (downgraded by 1 level for imprecision).
[e]While CI includes effect in favor of the intervention (i.e. endurance, gait/balance/functional, mind-body, multi-domain, and strength/resistance training), PI includes effects in both directions (i.e. PI extends beyond range of equivalence on the opposite site of line of no effect favoring the passive control group) (downgraded by 1 level for heterogeneity).
[f] While CI of direct estimate includes effect in favor of strength/resistance training, CI of indirect estimate includes effects in favor of both interventions (i.e. CI extends beyond range of equivalence on the opposite side of line of no effect favoring the passive control group) (downgraded by 2 levels for incoherence).
[g]Estimates are based on indirect evidence only and global approach to assess incoherence is significant, $P < 0.05$, $I^2 = 60.0\%$ (downgraded by 2 levels for incoherence).
[h]The overall level of confidence was very low even when avoiding downgrading more than once for related concerns (i.e. imprecision, heterogeneity, and incoherence).
Additionally, we present key results from the network meta-analysis in an interactive summary of findings table.

Summary of findings 3. Estimates of effects and confidence in the evidence for physical exercise in people with Parkinson's disease on adverse events

Patient or population: people with Parkinson's disease
Interventions: physical interventions including aqua-based training, dance, endurance training, flexibility training, gait/balance/functional training, gaming, LSVT BIG, mind-body training, multi-domain training, and strength/resistance training
Comparison: passive control group

Outcome: adverse events (number of participants with any adverse event)

Settings: inpatient and outpatient care

Outcome	Impact	Number of participants (studies)	Confidence in the evidence (GRADE)	Interpretation
Adverse events	Among 156 studies, only 85 provided some kind of safety data (i.e. occurrence or absence of events mostly described as adverse events). Most studies reported events for the intervention groups only. No adverse events occurred in 40 studies. No serious or major adverse events occurred in four studies. Adverse events occurred in 28 studies. The most frequently reported events were falls (18 studies) and pain (10 studies).	5192 (85)	⊕○○○[a,b] Very low	The evidence is very uncertain about the effect of physical exercise on the risk of adverse events.

GRADE Working Group grades of evidence

High confidence: we are very confident that the true effect lies close to that of the estimate of the effect.
Moderate confidence: we are moderately confident in the effect estimate: the true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different.
Low confidence: our confidence in the effect estimate is limited: the true effect may be substantially different from the estimate of the effect.
Very low confidence: we have very little confidence in the effect estimate: the true effect is likely to be substantially different from the estimate of the effect.

[a]Reporting of adverse events was highly heterogeneous and frequently incomplete (downgraded by 2 levels for risk of bias).
[b]Effects could not be estimated using quantitative analysis (downgraded by 1 level for imprecision).

BACKGROUND

Description of the condition

Parkinsonian syndromes include idiopathic Parkinson's disease (PD) and atypical Parkinsonian syndromes, the latter of which are rare diseases and comprise only 5% to 7% of all types of parkinsonism (Bower 1997; Rajput 1984). PD is the second most common neurodegenerative disease for people over 60 years of age (De Lau 2006).

PD is associated with loss of dopaminergic neurons in the substantia nigra and the presence of Lewy bodies (Damier 1999). The precise mechanisms of neurodegeneration are unclear but most likely involve both genetic and environmental factors (Ascherio 2016). PD is primarily characterized by progressive motor symptoms, including bradykinesia, muscular rigidity, rest tremor, and postural instability (Hughes 1992). These features cause impairment in various aspects of mobility, such as gait, transfers, balance, and posture (Keus 2007). Furthermore, non-motor symptoms such as anxiety, depression, fatigue, sleep disturbance, and sensory symptoms (Shulman 2001), frequently occur in people with PD, as well as cognitive dysfunctions which can potentially occur at any disease stage and range from mild cognitive impairment to PD dementia (Aarsland 2021; Muslimović 2005). Motor and non-motor symptoms cause substantial functional limitations and a reduction in the quality of life (QoL) of people with PD and their caregivers (Aarsland 2021; Martinez-Martin 2011). There has been a vast discussion about different subtypes of the disease; however, so far there has been no final conclusion about distinct subtypes and their potential respective courses of symptomatology (Bloem 2021). PD remains a clinical diagnosis typically based on the presence of a combination of cardinal motor features, associated and exclusionary symptoms, and response to dopaminergic treatment (Postuma 2015).

Incidence rates of PD based on prospective population-based studies range from 8 to 18 per 100,000 person-years. Incidence of PD is rare before 50 years of age and increases sharply after 60 years of age (De Lau 2006). Epidemiological studies suggest that men have a higher risk than women of developing PD (De Lau 2006; Moisan 2016). In most people with PD, life expectancy is not severely reduced (Bäckström 2018).

The European Union-wide burden for PD is estimated to be 70 disability-adjusted life years (Deuschl 2020). There is also a huge health economic burden, with mean annual costs of 20,095 euros (EUR) per person with PD in Germany (Winter 2010). With approximately 6.1 million people with PD worldwide, the global burden of the disease has more than doubled over the past generation, and it is likely to increase further due to demographic change (Dorsey 2018).

Description of the intervention

Pharmacological agents, such as levodopa, dopamine agonists, and monoamine oxidase B inhibitors, have been central to the treatment of motor symptoms in PD (Rizek 2016). When the disease progresses, the efficacy of levodopa can decline and fluctuate throughout the day, which is referred to as switching between the 'on'- (i.e. symptoms are controlled) and 'off'- (i.e. symptoms worsen) medication state (Ramirez-Zamora 2014). Surgical treatment, especially deep brain stimulation, is another widely investigated intervention that is demonstrated to be effective for some people with PD (Aum 2018).

Recently, an increasing number of studies has been investigating the potential of non-pharmacological and non-surgical interventions, including primarily physiotherapy, but also other types of physical exercise, in managing motor and non-motor symptoms in PD. In systematic reviews and clinical guidelines, physical exercise interventions for people with PD are defined as interventions that focus on the enhancement of muscle strength, aerobic capacity, balance, gait, and functional mobility by means of cueing, cognitive movement strategies, and physical exercises (e.g. Keus 2014; Tomlinson 2013).

Positive effects of a variety of types of physical exercise in people with PD have been observed in systematic reviews. These include short-term benefits of physiotherapy on motor impairment and activities of daily living (Tomlinson 2013), positive effects of Nordic walking on motor and non-motor symptoms (Bombieri 2017), and improved balance and well-being through tai chi training (Ćwiękała-Lewis 2017). Additionally, more recent systematic reviews have demonstrated the potential to improve outcomes, such as severity of motor signs, quality of life, freezing of gait, or functional mobility and balance, for people with PD through several types of physical exercise. These include, for example, aquatic therapy (Cugusi 2019; Gomes Neto 2020), dance (Carapellotti 2020; Chen 2020), mind-body training (Jin 2019), physiotherapy (Consentino 2020), exercises targeted at freezing of gait (Gilat 2021), and strength/resistance and endurance training (Gamborg 2022).

Evidence of beneficial effects of physical exercise for people with PD was also provided by recent systematic reviews with network meta-analyses (NMAs). Álvarez-Bueno and colleagues analyzed the effects of nine types of exercise (namely, endurance, resistance, combined, balance, dance, alternative exercises such as yoga or tai chi, body weight supported, and sensorimotor interventions including or not including endurance exercise) on motor symptoms, using an NMA (Álvarez-Bueno 2021). They identified evidence of positive effects on the severity of motor signs for dance, endurance, resistance, and sensorimotor training with or without endurance exercise compared with a control group, but no evidence of differences between the interventions. The authors concluded that interventions "including more complex and demanding activities seem to be the most effective [...]" (Álvarez-Bueno 2021). In another NMA that was part of a review of exercise interventions comprising tai chi, qigong, resistance training, aerobic exercise, multimodal exercise training, dance, tango, and yoga, the authors found evidence of beneficial effects on the severity of motor signs for dance and tango, and evidence of beneficial effects on functional mobility and balance for dance, tango, multimodal exercises, and tai chi (Tang 2019). The only evidence of differences between the interventions was observed in comparisons including a single study each (e.g. superiority in the effect of tango on severity of motor signs compared to tai chi). Tang and colleagues concluded by highlighting tango as an effective option to improve the functional mobility of people with PD. Kwok and colleagues conducted a systematic review with NMA on behavioral interventions, including obstacle training, gait training on a treadmill, and action observation training, for the management of freezing of gait (Kwok 2022). They provided evidence of statistically significant effects on freezing of gait compared to usual care or no treatment

for obstacle training, gait training with a treadmill, and general exercise, and further beneficial effects for action observation training and conventional physiotherapy after controlling for the baseline severity of freezing of gait (Kwok 2022). Similar to the results of Tang and colleagues (Tang 2019), little evidence of differences between the interventions was observed in the Kwok 2022 review: only comparisons involving obstacle training (for which only a single study provided data) indicated superiority on freezing of gait over the effects of most other interventions (Kwok 2022).

Investigations of the long-term effects of different types of physical exercise (including multimodal physical therapy, progressive resistance training, aerobic training, gait and balance training, tai chi, and dance) found that these interventions modify long-term motor symptoms and physical functioning in people with PD, with balance training having the longest carry-over effects, followed by gait and tai chi training (Mak 2017).

Physical exercise appears to be relatively safe. Although data on adverse events were rare in most studies included in previous systematic reviews on physical exercise for PD, studies that provided data on this outcome reported either no, or no serious, adverse events (Bombieri 2017; Ćwiękała-Lewis 2017; Tomlinson 2013). Mak and colleagues conducted a review of long-term effects of exercise and physical activity for PD that included 46 studies (Mak 2017). They reported that adverse events were reported in 25 studies, of which 10 reported injuries that were sustained during training; 28 studies noted falls and minor injuries that did not require medical attention. Further adverse events reported were hypotension, lightheadedness or dizziness, joint pain or muscle soreness, injury-induced shoulder pain, fatigue, and discomfort due to devices (i.e. due to the harness of a robotic gait trainer in one study). Given the total number of participants in the 25 studies (792 participants), the authors regarded the overall risk of adverse events as low and the interventions as safe and well tolerated (Mak 2017).

Nevertheless, it has to be noted that adverse events may have occurred in studies without being recorded or reported, potentially leading to an overestimation of the safety of physical exercise.

How the intervention might work

There is a vast amount of evidence that physical exercise substantially induces neuroplasticity and enhances brain health in both motor and cognitive circuits in PD. Neuroplasticity is the brain's ability to modify existing neural networks; for example, by adding or reorganizing synapses.

Evidence from a systematic review on studies in humans suggests that physical exercise may lead to changes in various markers of neuroplasticity, as indicated by changes in brain function and brain structure (Johansson 2020).

Evidence from studies in both animals and humans suggests that physical activity may induce specific structural and functional brain changes relevant for people with PD (Bonavita 2020; Voss 2013).

In rodent models of PD, forced or voluntary physical exercises have neuroprotective effects as the release of neurotrophic factors (e.g. brain-derived neurotrophic factor, glial-derived neurotrophic factor) increases (Cohen 2003). These animal models also showed compensatory changes in dopaminergic neurons of the basal ganglia. For example, dopamine neurotransmission increases through enhanced vesicular release and decreasing dopamine clearance in the synaptic cleft due to reduced dopamine reuptake (Petzinger 2007). Furthermore, the efficacy of neurotransmission increases because of enhanced dopamine D2 receptor expression in remaining dopaminergic neurons and their targets (Yin 2009).

Integrating findings from neuroimaging studies on healthy-aging adults and people with PD and focusing on the beneficial effects of exercise on mobility and cognition, Bonavita hypothesizes that exercise-induced prefrontal activation may drive improvements in cognitive performances and gait control (Bonavita 2020). Also, it is suggested that resistance training may facilitate neuroplasticity in the basal ganglia and corticomotor networks associated with gait performance (Bonavita 2020).

In addition to the evidence of neurobiological changes induced by exercise, several systematic reviews documented the positive impact of exercise programs on measures of functional and related capabilities, such as physical functioning, balance, gait, strength, and activities of daily living (Goodwin 2008; Mak 2017; Radder 2020; Wu 2021). Focusing on long-term effects of exercise, Mak and colleagues observed that, by sustained training, some of these effects may persist for up to 12 months after completing training (Mak 2017).

Finally, people with PD may benefit not only from the functional effects of exercise, but also from the opportunities for social interaction during group or partnered exercise programs.

Why it is important to do this review

The increasing number of trials assessing physical exercise demonstrates the growing interest in non-pharmacological and non-surgical interventions for the treatment of PD. There are several systematic reviews and meta-analyses focusing on one type (e.g. Bombieri 2017; Ćwiękała-Lewis 2017; Dockx 2016; Dos Santos 2017), as well as some that focus on several types of physical exercise (e.g. Tomlinson 2013; Tomlinson 2014). Moreover, recent systematic reviews have investigated the comparative efficacy of different types of exercise for people with PD using network meta-analyses (NMAs) and demonstrated the potential of several exercise programs to improve outcomes for people with PD (Álvarez-Bueno 2021; Kwok 2022; Tang 2019). However, two of these reviews focused on only one outcome domain (Álvarez-Bueno 2021; Kwok 2022), and none of them performed safety analyses. Furthermore, some reviews provided only limited information on the methods used (e.g. statistical analyses (Tang 2019); methods used to account for trial design when combining RCTs and non-randomized studies (Álvarez-Bueno 2021); whether all relevant steps were performed in duplicate by independent reviewers (Tang 2019); detailed information on the assessments of risk of bias (Álvarez-Bueno 2021; Kwok 2022; Tang 2019); or the confidence in the evidence (Álvarez-Bueno 2021; Kwok 2022)); did not assess the confidence in the evidence (Tang 2019); or had other methodological limitations (e.g. addressing a limited number of interventions, and limiting the study selection to English articles (Tang 2019)). Thus, the relative benefit of a broad range of exercise programs in improving several core outcomes – including the severity of motor signs, QoL, and the risk of adverse events – in people with PD remains unclear.

We conducted a comprehensive systematic review comparing all types of physical exercise in a network meta-analysis

combining direct and indirect evidence. When the methodological assumptions are met, network meta-analyses allow the estimation of metrics for all possible comparisons in the same model and enable analyses of direct and indirect evidence simultaneously. Such analyses potentially enable ranking of different treatments for specific outcomes. Such ranking could be highly relevant for people with PD and clinicians when making clinical decisions on non-pharmacological and non-surgical PD treatment, and when people with PD wish to integrate more physical training in their daily life.

OBJECTIVES

To compare the effects of different types of physical exercise in adults with Parkinson's disease (PD) on the severity of motor signs, quality of life (QoL) and the occurrence of adverse events, and to generate a clinically meaningful treatment ranking using network meta-analyses (NMAs).

METHODS

Criteria for considering studies for this review

Types of studies

We included randomized controlled trials (RCTs). We included both full-text and abstract publications as long as they provided sufficient information on study design, characteristics of participants, and interventions. We included trials with participants performing physical exercise in at least one treatment arm. In the case of cross-over trials, we analyzed only the first period of the trial. We imposed no limitations with respect to length of follow-up.

We excluded cluster-RCTs in order to preserve as much methodological homogeneity across trials as possible. We also excluded non-randomized trials, case reports, and clinical observations.

Types of participants

We included trials involving adults (≥ 18 years of age) with a confirmed diagnosis of idiopathic Parkinson's disease (at least 90% of the sample with idiopathic Parkinson's disease). We included participants of all cognitive stages (without cognitive impairment, with mild cognitive impairment, with dementia). We did not impose any restrictions regarding sex or educational level of the participants.

We excluded trials involving participants with atypical parkinsonism (e.g. drug-induced parkinsonism, vascular parkinsonism).

We assume that participants who fulfilled the inclusion criteria were equally eligible to be randomized to any of the interventions we compared.

Types of interventions

We included trials comparing different types of physical exercise with each other, with a control group, or both.

We included trials involving physical training as one main component of the intervention. Interventions needed to comprise structured exercise. Interventions may have included various training content, have been delivered in various environments, and have incorporated diverse training devices (e.g. treadmill, physiotherapy, aerobic exercises, qigong, bicycle exercises, strength training, Lee Silverman Voice Training BIG (LSVT BIG), Nordic walking, virtual reality exercises, dance, balance training, gait training, aqua-based exercises, yoga, tai chi). We included interventions: conducted in either a group or an individual setting; lasting for at least five sessions under direct (i.e. excluding remote) supervision; and consisting of either continuous training or interval training. We included combined interventions only when physical training was the main component of the intervention. Concomitant supportive treatment should not have differed between study arms.

We grouped similar interventions based on an adaptation of the ProFaNE taxonomy (a naming and classification system developed for falls-prevention interventions; Lamb 2011). As recommended by authors of a Cochrane Review who applied the taxonomy to categorize exercise interventions for falls prevention (Sherrington 2019), we have provided information on our operationalization of the taxonomy in Appendix 1. Please note that the type of exercise or control group derived from this taxonomy was pivotal in determining the eligibility of a study for inclusion in our review. For example, we included a study if it compared two different interventions categorized as the same exercise type.

Two review authors (ME, AF, RG, EL, JCV) categorized the interventions based on all available information describing the interventions' characteristics (e.g. exercise components and their relative proportion, intensity, setting). We categorized interventions according to the dominant exercise category. We assigned all study arms to one of the ten possible exercise categories or one of the two possible categories of control groups, regardless of how study authors labeled the study arms. As a result, we may have assigned a study arm that was designated as a control arm to an exercise category (e.g. we may have assigned a study arm with an intervention comprising stretching exercises to the flexibility training category, although it was designated as a control arm to study the efficacy of tai chi). When we were unable to reach a consensus about category assignment, we consulted a third review author (ME, AF) for the final decision.

Our decision set included all interventions that used structured exercise. We assigned them to the following categories:

- aqua-based training;
- dance;
- endurance training;
- flexibility training;
- gait/balance/functional training;
- gaming;
- LSVT BIG;
- mind-body training;
- multi-domain training; and
- strength/resistance training.

For more details on the interventions, please see Appendix 1.

We expected that many studies would use an active or a passive control group as comparators against the interventions included in our decision set. We included these interventions in our supplementary set in order to improve inference among the

interventions in the decision set, as described in Chapter 11 of the *Cochrane Handbook for Systematic Reviews of Interventions* (Chaimani 2022).

We defined 'active control' groups as groups receiving a structured, supervised, non-physical intervention (e.g. communication training). We defined 'passive control' groups as groups not receiving a structured, supervised intervention (e.g. wait-list, no treatment, usual care, advice only, unstructured physical activity).

When no direct evidence from RCTs existed, and we considered the trials sufficiently similar with respect to the participant population to ensure the transitivity assumption of network meta-analysis, we obtained indirect estimates of intervention effects via the network calculations.

Types of outcome measures

We included all trials fulfilling our inclusion criteria, irrespective of whether they reported the outcomes of interest listed below (Primary outcomes; Secondary outcomes). These outcomes are consistent with a proposed consensus set of outcomes for people with Parkinson's disease (De Roos 2017).

We estimated the relative ranking of the competing interventions according to the outcomes described below. We produced network plots for each outcome displaying the amount of evidence.

We only considered outcomes measured using standardized and validated instruments. When studies reported multiple outcome measures, we gave preference according to the order in which they are listed below.

Primary outcomes

- Severity of motor signs (measured, for example, with: the Movement Disorder Society-Sponsored Revision of the Unified Parkinson's Disease Rating Scale (MDS-UPDRS-M, motor score, Goetz 2008); the Unified Parkinson's Disease Rating Scale (UPDRS-M, motor score, designed to assess motor impairment and disability in Parkinson's disease, Fahn 1987); the Hoehn and Yahr scale (used to describe how symptoms of Parkinson's disease progress, Hoehn 1967); the Webster Rating Scale (assessment of severity of disease and clinical impairment against 10 items, Webster 1968); or the Columbia University Rating Scale (assessment of motor impairment and activities of daily living against 13 items, Yahr 1969); or other validated scales.
- Quality of life (QoL; measured, for example, with: the Parkinson's Disease Questionnaire 39 (PDQ-39, a Parkinson's disease-specific health-related QoL questionnaire containing 39 items divided among eight domains, Jenkinson 1997b; Peto 1995); Parkinson's Disease Questionnaire 8 - short-form of the PDQ-39, Jenkinson 1997a); EuroQol (EQ-5D), a generic QoL questionnaire containing five items, EuroQol Group 1990); or other validated instruments).

Secondary outcomes

- Freezing of gait (measured with the Freezing of Gait Questionnaire (FOG-Q, Giladi 2000) or the New Freezing of Gait Questionnaire (NFOG-Q, Nieuwboer 2009). Both measure the freezing of gait in people with Parkinson's disease).
- Functional mobility and balance (measured with the Timed Up and Go (TUG), which measures the time taken in seconds for a person to get up from a chair, walk a certain distance (usually three meters), turn around, and walk back to the chair and sit down, Podsiadlo 1991).
- Adverse events (number of participants with any adverse event).

Timing of outcome assessment

We evaluated outcomes assessed shortly (≤ six weeks) after the intervention. When multiple assessments within this interval were reported, we evaluated the assessment closest to the end of the intervention. We gave preference to data on the severity of motor signs assessed during the on-medication state.

We evaluated adverse events measured at any time after initiation of the intervention.

Search methods for identification of studies

Electronic searches

We adapted search strategies as suggested in Chapter 4 of the *Cochrane Handbook for Systematic Reviews of Interventions* (Lefebvre 2020). We applied no language restrictions to reduce language bias. We used medical subject headings (MeSH) or equivalent and text word terms.

We conducted searches tailored to each of the following databases and trial registries:

- CENTRAL via The Cochrane Register of Studies Online (inception to 17 May 2021) (Appendix 2);
- MEDLINE via OvidSP (inception to 17 May 2021) (Appendix 3);
- Embase via OvidSP (inception to 17 May 2021) (Appendix 4);
- CINAHL via EBSCO (inception to 17 May 2021) (Appendix 5);
- SPORTDiscus via EBSCO (inception to 17 May 2021) (Appendix 6);
- AMED (Allied and Complementary Medicine) via OvidSP (inception to 17 May 2021) (Appendix 7);
- REHABDATA via www.naric.com/?q=en/rehabdata (18 May 2021) (Appendix 8);
- PEDro (Physiotherapy Evidence Database) via www.pedro.org.au (18 May 2021) (Appendix 9);
- EU Clinical Trials Register via www.clinicaltrialsregister.eu/ctr-search/search (20 May 2021) (Appendix 10);
- World Health Organization International Clinical Trials Registry Platform via www.who.int/ictrp/search/en (20 May 2021) (Appendix 10);
- ClinicalTrials.gov via www.clinicaltrials.gov (20 May 2021) (Appendix 10);
- ISRCTN registry via www.isrctn.com (20 May 2021) (Appendix 10).

These searches were complemented by a handsearch of abstracts covering the following conferences (2019, 2020):

- International Congress of Parkinson's Disease & Movement Disorders;
- American Academy of Neurology;
- European Academy of Neurology;
- International Association of Parkinsonism and Related Disorders.

Searching other resources

We handsearched references of all identified trials, relevant review articles, and current treatment guidelines for further literature. We contacted authors of relevant studies for unpublished material or further information on ongoing studies.

Data collection and analysis

Selection of studies

One review author (ME) screened the results and removed titles that clearly did not satisfy the inclusion criteria. Following this initial screening, two review authors (ME, AF) independently screened the remaining results for eligibility by reading the abstracts, and obtained full-text copies of potentially eligible studies. In the case of disagreement or when it was unclear whether we should include an abstract or not, we assessed the full-text publication for further discussion. If we were still unable to reach consensus, a third author (MR) would have adjudicated.

We did not anonymize the studies before assessment. We include a Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow chart that shows the status of identified studies (Moher 2009), as recommended in Chapter 3 of the *Cochrane Handbook for Systematic Reviews of Interventions* (Page 2020a). We report the review in accordance with the PRISMA extension for network meta-analysis (Hutton 2015).

We included studies in the Characteristics of included studies table irrespective of whether measured outcome data were reported in a 'usable' way. There were no language restrictions, and articles were translated if not published in English. Volunteers recruited via Cochrane's TaskExchange platform translated seven articles: six of these were published in Chinese (Gu 2013; Guan 2016; Wang 2017; Wang 2018; Zhang 2018; Zhu 2011), and one was published in Persian (Taheri 2011). We included five of these studies in this review (Gu 2013; Guan 2016; Taheri 2011; Wang 2017; Zhu 2011).

We recorded excluded studies in the Characteristics of excluded studies table.

Data extraction and management

Two review authors (ME, AF, RG, EL, JCV) extracted data using a standardized data extraction form. When authors were unable to reach a consensus, we consulted a third review author (ME, AF) for the final decision. If required, we contacted the authors of specific studies for supplementary information (Li 2020). After reaching an agreement, we entered data into Review Manager Web (RevMan Web; RevMan Web 2022).

We extracted the following information:

- general information: author, title, source, publication date, country, language, duplicate publication;
- quality assessment: sequence generation, allocation concealment, blinding (participants, personnel, outcome assessors), incomplete outcome data, selective outcome reporting, other sources of bias;
- study characteristics: trial design, setting, source of participants, statistical methods (power calculations, subgroup analysis), treatment cross-overs, compliance with assigned treatment, discontinuation, time point of randomization, length of follow-up;
- participant characteristics: participant details (baseline demographics such as age, sex), number of participants recruited, allocated, or evaluated, participants lost to follow-up, disease severity, cognitive stage, physical capability;
- intervention: type, frequency, setting, supervision;
- outcomes: motor outcomes (motor function, freezing of gait, functional mobility and balance), QoL, adverse events;
- notes: sponsorship or funding for trial and notable conflicts of interest of authors, trial registry record information (e.g. NCT numbers).

We collated multiple reports of the same study, so that each study rather than each report was the unit of interest in the review. We collected characteristics of the included studies in sufficient detail to populate a table of Characteristics of included studies in the full review. For the outcomes, when both effect sizes with standard deviations (SDs) or standard errors (SEs) and raw data were reported, we collected the effect sizes with SDs or SEs originally reported by the authors of the trial. We evaluated the impact of potential effect modifiers (see Subgroup analysis and investigation of heterogeneity section).

Assessment of risk of bias in included studies

We used the Cochrane Risk of Bias 2 tool (RoB 2; beta version 7; Sterne 2019) to assess risk of bias for the severity of motor signs and QoL.

We assessed the effect of assignment to intervention (the intention-to-treat effect).

The tool implements signaling questions for each domain, leading to 'low', 'high', or 'some concerns' for risk of bias. The answers to these signaling questions are available in a supplementary file (see Risk of bias in included studies). Additionally, we created plots visualizing the judgments using the robvis tool (McGuinness 2020).

We addressed the following domains covering all types of bias that can affect results of randomized trials:

- bias arising from the randomization process;
- bias due to deviations from intended interventions;
- bias due to missing outcome data;
- bias in measurement of the outcome;
- bias in selection of the reported result.

For adverse events, retrieving effect estimates for a network meta-analysis and conducting a formal assessment of risk of bias was not feasible. Therefore, we made an informal judgment of the risk of bias for this outcome.

Two review authors (ME, AF) independently assessed risk of bias for each outcome. If we were unable to reach a consensus, we consulted a third review author for a final decision.

Measures of treatment effect

Relative treatment effects

We gave preference to intention-to-treat data to calculate treatment effects. For continuous outcomes, we calculated mean differences (MDs), including 95% confidence intervals (CIs), when assessed with the same instrument; otherwise we calculated standardized mean differences (SMDs), including 95% CIs. For the

continuous outcomes included in the summary of findings tables and analyzed using network meta-analyses (i.e. the severity of motor signs and quality of life), we also calculated 95% prediction intervals (PIs) that were considered among CIs in the assessment of the confidence in the evidence. For these outcomes, we also converted SMDs back to MDs on the most frequently reported scale and interpreted findings with respect to a minimum clinically important difference (MCID) on the respective scale (e.g. 2.5 points on the UPDRS-M (Shulman 2010)). For the remaining outcomes (i.e. freezing of gait and functional mobility and balance), we also presented the results along with the MCID on the most frequently reported scale, or, when the MCID was not retrievable, the minimum detectable change (i.e. 3.5 seconds on the TUG (Huang 2011)).

Relative treatment ranking

We obtained a treatment hierarchy using P-scores (Rücker 2015). P-scores allow ranking treatments on a continuous 0 to 1 scale in a frequentist network meta-analysis. Since ranking according to P-scores is a probability ranking, we report not only P-scores but also network estimates along with corresponding 95% CIs. The use of P-scores allows us, separately for each outcome of interest, to answer the question of which treatment has the highest proportion of competitors that it beats (Salanti 2021).

Unit of analysis issues

Studies with multiple treatment groups

As recommended in Chapter 23.3.4 of the *Cochrane Handbook for Systematic Reviews of Interventions* (Higgins 2020a), for studies with multiple treatment groups, we combined arms as long as they could be regarded as subtypes of the same intervention type. When arms could not be pooled this way, we included multi-arm trials using a network meta-analysis approach that accounts for the within-study correlation between the effect sizes by reweighting all comparisons of each multi-arm study (Rücker 2012; Rücker 2014).

Dealing with missing data

As suggested in Chapter 10 of the *Cochrane Handbook for Systematic Reviews of Interventions* (Deeks 2020), we took the following steps to deal with missing data. Whenever possible, we contacted the original investigators to request relevant missing data. When the number of participants evaluated for a given outcome was not reported, we used the number of participants randomized per treatment arm as the denominator. When estimates for means and SDs were missing, we calculated these statistics from reported data whenever possible, using approaches described in Chapter 10 of the *Cochrane Handbook for Systematic Reviews of Interventions* (Deeks 2020). When data were not reported numerically but graphically, two review authors (ME, JCV) independently estimated missing data from figures. We addressed the potential impact of missing data on findings of the review in the Discussion section.

We did not need to calculate SDs according to a validated imputation method (Furukawa 2006), as these statistics were either available or retrievable based on other statistics (e.g. standard errors).

We imputed data as follows.

- For one study reporting data on functional mobility and balance (Hackney 2009, 61 participants), we imputed missing SDs of mean change scores based on SDs of pre and post mean scores, as described in Chapter 6 of the *Cochrane Handbook for Systematic Reviews of Interventions* (6.5.2.8 (2); Higgins 2020b). Imputation was conducted using a correlation coefficient of r = 0.5.
- For two studies reporting data on QoL (Schmitz-Hubsch 2006) or functional mobility and balance (Nieuwboer 2007), for which we received individual patient data from the study authors, we calculated post mean scores and SDs for each group and we imputed missing data for one participant each using the last observation carried forward method.

We estimated data from figures as data were not reported numerically from: five studies reporting the severity of motor signs (Colgrove 2012, 13 participants; De Assis 2018, 12 participants; Reuter 2011, 90 participants; Ridgel 2019, 16 participants; Shen 2021, 30 participants), one study each reporting QoL (Poliakoff 2013, 30 participants), and freezing of gait (Duncan 2012, 52 participants); and two studies reporting functional mobility and balance (Corcos 2013, 38 participants; Ridgel 2019, 16 participants).

Assessment of heterogeneity

Assessment of clinical and methodological heterogeneity within treatment comparisons

To evaluate the presence of clinical heterogeneity, we generated summary statistics for the important clinical and methodological characteristics across all included studies. Within each pairwise comparison, we assessed the presence of clinical heterogeneity by visually inspecting the similarity of these characteristics (see Effects of interventions).

Assessment of transitivity across treatment comparisons

To check if the assumption of transitivity held, we assessed whether the included interventions were similar when they were evaluated in RCTs with different designs. Furthermore, we compared the distribution of the potential effect modifiers across the different pairwise comparisons. For each set of studies, grouped by treatment comparison, we created a table of important clinical and methodological characteristics (e.g. age, sex, and cognitive stage of participants, length of intervention, disease duration, disease severity, physical capability; see Effects of interventions). We visually inspected the similarity of these factors, including the inclusion and exclusion criteria of every trial in the network. Despite the diversity of the investigated interventions in the network, we assumed transitivity across our treatment comparisons based on predefined, narrow inclusion criteria, similarity of inclusion and exclusion criteria of the included studies, and balanced distribution of clinical and methodological characteristics across comparisons.

Assessment of statistical heterogeneity and inconsistency

To evaluate the presence of heterogeneity and inconsistency in the entire network, we report the generalised heterogeneity statistic Q_{total} and the generalised I^2 statistic as described in Schwarzer 2015. We used the decomp.design command in the R package netmeta version 1.0-1 or decomposition of the heterogeneity statistic into a Q statistic for assessing the heterogeneity between studies with the same design (netmeta 2021; R), and a Q statistic for assessing the designs' inconsistency to identify the amount of heterogeneity or inconsistency within as well as between designs. To evaluate the presence of inconsistency locally,

we compared direct and indirect treatment estimates of each treatment comparison. This can serve as a check for consistency of a network meta-analysis (Dias 2010). For this purpose, we used the netsplit function in the R package netmeta version 1.0-1, which enabled us to split the network evidence into direct and indirect contributions (netmeta 2021; R). For each treatment comparison, we present direct and indirect treatment estimates plus the network estimate using forest plots. In addition, for each comparison, we report the Z value and P value of the test for disagreement (direct versus indirect). We considered a P value of less than 0.05 significant for this test. However, it should be noted that in a network of evidence there may be many loops, and with multiple testing there is an increased likelihood that we might find an inconsistent loop by chance. Therefore, we were cautious when deriving conclusions from this approach.

When finding substantive heterogeneity or inconsistency, we reviewed the evidence base, reconsidered inclusion criteria, and discussed the potential role of unmeasured effect modifiers to identify further sources.

We interpreted I^2 values according to Chapter 9.5.2 of the *Cochrane Handbook for Systematic Reviews of Interventions* as follows (Deeks 2020):

- 0% to 40% might not be important;
- 30% to 60% may represent moderate heterogeneity;
- 50% to 90% may represent substantial heterogeneity;
- 75% to 100% represents considerable heterogeneity.

We used the P value of the Chi^2 test only for describing the extent of heterogeneity and not for determining statistical significance. In addition, we report Tau^2, the between-study variance in random-effects meta-analysis. In the event of excessive heterogeneity that was unexplained by subgroup analyses, we did not report outcome results as the pooled effect estimate of the network meta-analysis but provided a narrative description of the results of each study.

Assessment of reporting biases

In pairwise comparisons with at least 10 trials, we examined the presence of small-study effects graphically by generating funnel plots. We used linear regression tests to test for funnel plot asymmetry (Egger 1997). We considered a P value of less than 0.1 significant for this test (Page 2020b). We additionally considered comparison-adjusted funnel plots and the accompanying regression test to assess selection bias. We examined the presence of small-study effects for the primary outcomes only. Moreover, we searched study registries to identify completed but not published trials.

Data synthesis

Methods for direct treatment comparisons

Pairwise comparisons are part of the NMA; thus, we did not perform additional pairwise meta-analyses.

Methods for indirect and mixed comparisons

As the data were considered sufficiently similar to be combined, we performed an NMA using the frequentist weighted least-squares approach described by Rücker 2012. We used a random-effects model, taking into account the correlated treatment effects in multi-arm studies. We assumed a common estimate for the heterogeneity variance across the different comparisons. To evaluate the extent to which treatments are connected, we provide a network plot for our outcomes. For each comparison, we report the estimated treatment effect along with its 95% CI. We graphically present the results using forest plots, with the passive control group as reference treatment. We used the R package netmeta version 1.0-1 for statistical analyses (netmeta 2021; R).

Subgroup analysis and investigation of heterogeneity

We planned to perform subgroup analyses using the following characteristics, which might have an effect on the outcomes:

- age (< 50 years, ≥ 50 years);
- sex (male, female);
- cognitive stage (participants without cognitive impairment, participants with cognitive impairment);
- length of intervention (< 12 weeks, ≥ 12 weeks).

Given the distribution of these characteristics across studies, we were only able to perform subgroup analyses by the length of intervention. We conducted these for all outcomes included in the NMAs (i.e. the severity of motor signs, QoL, freezing of gait, and functional mobility and balance).

Sensitivity analysis

We performed sensitivity analyses to test the robustness of our results by analyzing trial results at low overall risk of bias, as judged by using the RoB 2 tool only (Sterne 2019). We conducted sensitivity analyses for the primary outcomes included in the NMAs (i.e. the severity of motor signs and QoL).

Summary of findings and assessment of the certainty of the evidence

Confidence in the evidence

Two review authors (ME, AF) independently rated their confidence in the evidence in the results of the network meta-analyses using the Confidence in Network Meta-Analysis (CINeMA) approach (Nikolakopoulou 2020).

CINeMA identifies six domains to be judged:

- within-study bias;
- reporting bias;
- indirectness;
- imprecision;
- heterogeneity;
- incoherence.

We considered the judgments for all domains and avoided downgrading by more than two levels for related concerns (i.e. imprecision, heterogeneity, and incoherence).

We rated our confidence in the evidence in the results on adverse events, which we reported narratively, using the GRADE approach (Schünemann 2022).

Summary of findings tables

We included summary of findings tables to present the main findings in a transparent and simple tabular format for outcomes

prespecified at protocol stage (Roheger 2021). In particular, we included key information concerning the confidence in the evidence, the magnitude of effect of the interventions examined, and the sum of available data on the severity of motor signs (Summary of findings 1), QoL (Summary of findings 2), and adverse events (Summary of findings 3). Additionally, we created an interactive summary of findings table using the MATCH-IT tool (MATCH-IT) to present key results from the network meta-analyses.

Quality of life

Due to the nature of self-reported questionnaires and the corresponding subjectivity of the assessment, we judged all study results on QoL to be at high risk of bias (i.e. due to high risk of bias in measurement of the outcome as assessed by domain 4 of the RoB 2 tool; Sterne 2019). Therefore, when assessing the confidence in the evidence for QoL, by default, we downgraded by one level for risk of bias for all comparisons. Additionally, we downgraded by another level for risk of bias when the effect estimates were highly affected by studies that we judged to be at high risk of bias when considering only domains not affected by self-reporting of the outcome (i.e. excluding domain 4 of the RoB 2 tool).

RESULTS

Description of studies

Results of the search

Our literature search yielded 21,965 potentially relevant references. Additionally, we identified 16 references via handsearching reference lists and review articles, and one reference of a study awaiting classification during the peer review process, resulting in 21,982 records in total.

At the initial screening stage, we removed 2556 duplicates, and one author (ME) excluded 16,129 references due to lack of conformity with the inclusion criteria, leaving 3297 records. Two review authors (ME, AF) independently screen these and excluded another 2854 records not meeting the inclusion criteria.

We further evaluated the remaining 314 studies (443 references), either as full-text publications or, if not available, as abstract publications or study registry entries. This led to the exclusion of 32 studies. In addition, we identified 58 ongoing studies which may be completed by 2024. Sixty-eight studies are awaiting classification, including one identified during the peer review process.

We finally included 156 studies, with a total of 7939 participants, which evaluated physical exercise for people with Parkinson's disease (PD) in this systematic review. We included 109 of these studies, providing data on 4394 participants, in our network meta-analyses (NMAs).

We report the overall numbers of references identified, screened, selected, excluded, and included in a PRISMA flow diagram (see Figure 1).

Figure 1.

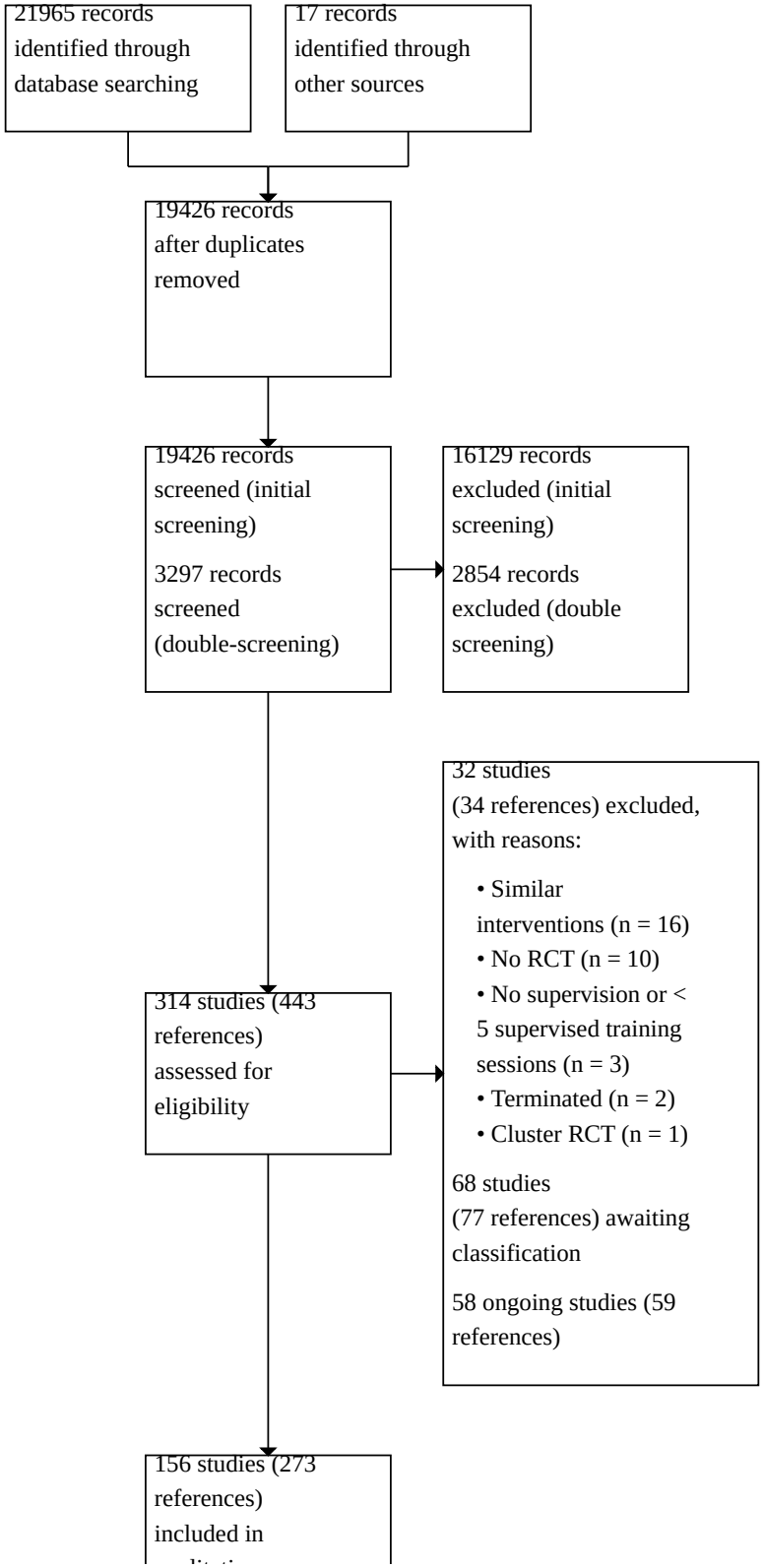
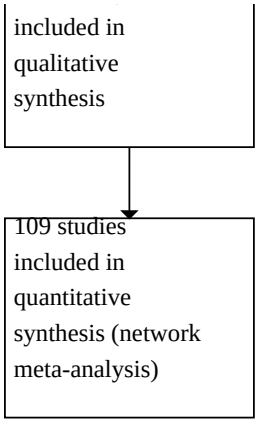


Figure 1. (Continued)



Included studies

For a detailed description of the studies, see the Characteristics of included studies table. Here we provide a brief overview of the included studies.

Published full-text articles were available for all of the 156 included studies. We included 151 studies whose full-text articles were published in English. We also included five studies not published in English: four were published in Chinese (Gu 2013; Guan 2016; Wang 2017; Zhu 2011), and one in Persian (Taheri 2011). Volunteers recruited via Cochrane's TaskExchange platform translated these studies' articles.

We contacted study authors of 51 studies for additional information. We received a response including additional trial information or outcome data from the authors of 23 studies (Bridgewater 1996; Burini 2006; Capato 2020a; Carroll 2018; Ebersbach 2010; Gobbi 2021; Goodwin 2011; Hackney 2009; Johansson 2018; King 2020; Mak 2021; Morris 2009; Nieuwboer 2007; Paul 2014; Pérez de la Cruz 2017; Pohl 2013; Pohl 2020; Santos 2017a; Santos 2017b; Schenkman 2012; Schmitz-Hubsch 2006; Terrens 2020; Yuan 2020). We received no response from authors of 28 studies (Agosti 2016; Arfa-Fatollahkhani 2019; Cheng 2017; Cheung 2018; Claesson 2018; Corcos 2013; Daneshvar 2019; Dashtipour 2015; Dipasquale 2017; Ferrazzoli 2018; Ferreira 2018; Harvey 2019; Hubble 2018; Liu 2016; Pazzaglia 2020; Pedreira 2013; Picelli 2016; Reuter 2011; Ribas 2017; Santos 2019; Shanahan 2017; Shen 2021; Smania 2010; Sparrow 2016; Stack 2012; Sujatha 2019; Szefler-Derela 2020; Volpe 2013).

Design

We included data from 156 randomized controlled trials (RCTs) (Agosti 2016; Allen 2010; Almeida 2012; Amano 2013; Arfa-Fatollahkhani 2019; Ashburn 2007; Ashburn 2018; Avenali 2021; Bridgewater 1996; Burini 2006; Cakit 2007; Canning 2012; Canning 2015; Capato 2020a; Carroll 2018; Carvalho 2015; Chaiwanichsiri 2011; Cheng 2017; Cherup 2021; Cheung 2018; Choi 2013; Cholewa 2013; Claesson 2018; Colgrove 2012; Conradsson 2015; Corcos 2013; Cugusi 2015; Daneshvar 2019; Dashtipour 2015; da Silva Rocha Paz 2019; De Assis 2018; De Moraes Filho 2020; Dipasquale 2017; Duncan 2012; Ebersbach 2010; Ellis 2005; Feng 2019; Ferraz 2018; Ferrazzoli 2018; Ferreira 2018; Fietzek 2014; Fil-Balkan 2018; Fisher 2008; Frazzitta 2012; Frazzitta 2014; Frazzitta 2015; Ganesan 2014; Gao 2014; Gobbi 2021; Goodwin 2011; Gu 2013; Guan 2016; Hackney 2007; Hackney 2009; Harvey 2019; Hass 2012; Hirsch 2003; Hubble 2018; Johansson 2018; Kanegusuku 2017; King 2013; King 2020; Kunkel 2017; Kurt 2018; Kurtais 2008; Kwok 2019; Landers 2016; Lee HJ 2018; Lehman 2005; Li 2012; Liao 2015; Liu 2016; Mak 2008; Mak 2021; Martin 2015; Medijainen 2019; Michels 2018; Miyai 2000; Miyai 2002; Morris 2009; Morris 2015; Morris 2017; Muller 1997; Mulligan 2018; Myers 2020; Nadeau 2014; Ni 2016; Nieuwboer 2007; Ortiz-Rubio 2018; Palmer 1986; Park 2014; Paul 2014; Pazzaglia 2020; Pedreira 2013; Peloggia Cursino 2018; Pérez de la Cruz 2017; Picelli 2016; Pohl 2013; Pohl 2020; Poier 2019; Poliakoff 2013; Protas 2005; Qutubuddin 2013; Reuter 2011; Ribas 2017; Ridgel 2019; Rios Romenets 2015; Santos 2017a; Santos 2017b; Santos 2017c; Santos 2019; Schaible 2021; Schenkman 1998; Schenkman 2012; Schenkman 2018; Schilling 2010; Schlenstedt 2015; Schmitz-Hubsch 2006; Sedaghati 2016; Shahmohammadi 2017; Shanahan 2017; Shen 2021; Shulman 2013; Silva 2019; Silva-Batista 2018; Silveira 2018; Smania 2010; Solla 2019; Sparrow 2016; Stack 2012; Stozek 2016; Sujatha 2019; Szefler-Derela 2020; Szymura 2020; Taheri 2011; Terrens 2020; Tollar 2018; Tollar 2019; Toole 2000; Van Puymbroeck 2018; Vergara-Diaz 2018; Vivas 2011; Volpe 2013; Volpe 2014; Volpe 2017a; Volpe 2017b; Wan 2021; Wang 2017; Winward 2012; Wong-Yu 2015; Yang 2010; Yen 2011; Youm 2020; Yuan 2020; Zhang 2015; Zhu 2011). Ten of these trials had a cross-over design (Burini 2006; Ellis 2005; Fietzek 2014; Gobbi 2021; King 2020; Martin 2015; Miyai 2000; Nieuwboer 2007; Sparrow 2016; Yuan 2020).

The number of trial arms per study that were relevant to this review ranged between two and four. The majority (127 studies) included two relevant arms (Agosti 2016; Allen 2010; Amano 2013; Arfa-Fatollahkhani 2019; Ashburn 2007; Ashburn 2018; Avenali 2021; Bridgewater 1996; Burini 2006; Cakit 2007; Canning 2012; Canning 2015; Carroll 2018; Cherup 2021; Cheung 2018; Choi 2013; Cholewa 2013; Claesson 2018; Colgrove 2012; Conradsson 2015; Corcos 2013; Cugusi 2015; Daneshvar 2019; Dashtipour 2015; da Silva Rocha Paz 2019; De Assis 2018; De Moraes Filho 2020; Dipasquale 2017; Duncan 2012; Ellis 2005; Feng 2019; Ferrazzoli 2018; Ferreira 2018; Fietzek 2014; Fil-Balkan 2018; Frazzitta 2012; Frazzitta 2014; Frazzitta 2015; Gao 2014; Goodwin 2011; Gu 2013; Guan 2016; Hackney 2007; Harvey 2019; Hass 2012; Hirsch 2003; Hubble 2018;

Johansson 2018; Kanegusuku 2017; King 2013; King 2020; Kunkel 2017; Kurt 2018; Kurtais 2008; Kwok 2019; Lee HJ 2018; Lehman 2005; Liu 2016; Mak 2021; Martin 2015; Medijainen 2019; Michels 2018; Miyai 2000; Miyai 2002; Morris 2009; Morris 2017; Muller 1997; Mulligan 2018; Myers 2020; Nieuwboer 2007; Ortiz-Rubio 2018; Palmer 1986; Park 2014; Paul 2014; Pazzaglia 2020; Pedreira 2013; Pérez de la Cruz 2017; Picelli 2016; Pohl 2013; Pohl 2020; Poier 2019; Poliakoff 2013; Protas 2005; Qutubuddin 2013; Ribas 2017; Ridgel 2019; Rios Romenets 2015; Santos 2017a; Santos 2017b; Santos 2017c; Schaible 2021; Schenkman 1998; Schenkman 2012; Schilling 2010; Schlenstedt 2015; Schmitz-Hubsch 2006; Shahmohammadi 2017; Shanahan 2017; Shen 2021; Silva 2019; Smania 2010; Solla 2019; Sparrow 2016; Stack 2012; Stozek 2016; Sujatha 2019; Szefler-Derela 2020; Szymura 2020; Taheri 2011; Toole 2000; Van Puymbroeck 2018; Vergara-Diaz 2018; Vivas 2011; Volpe 2013; Volpe 2014; Volpe 2017a; Volpe 2017b; Wan 2021; Wang 2017; Winward 2012; Wong-Yu 2015; Yang 2010; Youm 2020; Yuan 2020; Zhang 2015; Zhu 2011). Twenty-eight studies included three arms (Almeida 2012; Capato 2020a; Carvalho 2015; Chaiwanichsiri 2011; Cheng 2017; Ebersbach 2010; Ferraz 2018; Fisher 2008; Ganesan 2014; Gobbi 2021; Li 2012; Liao 2015; Mak 2008; Morris 2015; Nadeau 2014; Ni 2016; Peloggia Cursino 2018; Reuter 2011; Santos 2019; Schenkman 2018; Sedaghati 2016; Shulman 2013; Silva-Batista 2018; Silveira 2018; Terrens 2020; Tollar 2018; Tollar 2019; Yen 2011), and two studies included four arms of interest (Hackney 2009; Landers 2016).

Sample sizes

The number of randomized participants ranged between 10 in Miyai 2000 to 474 in Ashburn 2018, with a mean number of 51 participants randomized per study. For the studies included in the network meta-analysis, data were provided for a mean number of 21 participants per trial arm, ranging from between four participants in Michels 2018 to 115 participants in Canning 2015 per trial arm.

Location

Most studies were conducted in the USA (34 studies: Amano 2013; Cherup 2021; Cheung 2018; Colgrove 2012; Corcos 2013; Dashtipour 2015; Duncan 2012; Fisher 2008; Hackney 2007; Hackney 2009; Hass 2012; Hirsch 2003; King 2013; King 2020; Landers 2016; Lehman 2005; Li 2012; Michels 2018; Myers 2020; Ni 2016; Palmer 1986; Park 2014; Protas 2005; Qutubuddin 2013; Ridgel 2019; Schenkman 1998; Schenkman 2012; Schenkman 2018; Schilling 2010; Shulman 2013; Sparrow 2016; Toole 2000; Van Puymbroeck 2018; Vergara-Diaz 2018), followed by Italy (17 studies: Agosti 2016; Avenali 2021; Burini 2006; Cugusi 2015; Dipasquale 2017; Ferrazzoli 2018; Frazzitta 2012; Frazzitta 2014; Frazzitta 2015; Pazzaglia 2020; Picelli 2016; Smania 2010; Solla 2019; Volpe 2013; Volpe 2014; Volpe 2017a; Volpe 2017b), Brazil (15 studies: Carvalho 2015; da Silva Rocha Paz 2019; De Assis 2018; De Moraes Filho 2020; Ferraz 2018; Ferreira 2018; Gobbi 2021; Kanegusuku 2017; Pedreira 2013; Peloggia Cursino 2018; Ribas 2017; Santos 2017b; Santos 2019; Silva 2019; Silva-Batista 2018), China (11 studies: Feng 2019; Gao 2014; Gu 2013; Guan 2016; Liu 2016; Shen 2021; Wan 2021; Wang 2017; Wong-Yu 2015; Zhang 2015; Zhu 2011), Australia (10 studies: Allen 2010; Bridgewater 1996; Canning 2012; Canning 2015; Hubble 2018; Morris 2009; Morris 2015; Morris 2017; Park 2014; Terrens 2020). Eight studies each were conducted in Germany (Ebersbach 2010; Fietzek 2014; Muller 1997; Poier 2019; Reuter 2011; Schaible 2021; Schlenstedt 2015; Schmitz-Hubsch 2006) and the UK (Ashburn 2007; Ashburn 2018; Goodwin 2011; Harvey 2019; Kunkel 2017; Poliakoff 2013; Stack 2012; Winward 2012); five studies each in Spain (Ortiz-Rubio 2018; Pérez de la Cruz 2017; Santos 2017a; Santos 2017c; Vivas 2011), Sweden (Claesson 2018; Conradsson 2015; Johansson 2018; Pohl 2013; Pohl 2020), Iran (Arfa-Fatollahkhani 2019; Daneshvar 2019; Sedaghati 2016; Shahmohammadi 2017; Taheri 2011), and Taiwan (Cheng 2017; Liao 2015; Yang 2010; Yen 2011; Yuan 2020); four studies each in Canada (Almeida 2012; Nadeau 2014; Rios Romenets 2015; Silveira 2018), Poland (Cholewa 2013; Stozek 2016; Szefler-Derela 2020; Szymura 2020) and Turkey (Cakit 2007; Fil-Balkan 2018; Kurt 2018; Kurtais 2008); three studies each in Hong Kong (Kwok 2019; Mak 2008; Mak 2021) and Korea (Choi 2013; Lee HJ 2018; Youm 2020); and two studies each in Hungary (Tollar 2018; Tollar 2019), India (Ganesan 2014; Sujatha 2019), Ireland (Carroll 2018; Shanahan 2017), Japan (Miyai 2000; Miyai 2002) and New Zealand (Martin 2015; Mulligan 2018). One study each was conducted in Belgium (Nieuwboer 2007), Estonia (Medijainen 2019), the Netherlands (Capato 2020a), and Thailand (Chaiwanichsiri 2011), and one study was conducted in the Netherlands and the USA (Ellis 2005).

Of the included studies, 139 were conducted in single centers and 15 studies were conducted at multiple centers (Ashburn 2007; Ashburn 2018; Ellis 2005; Goodwin 2011; Kwok 2019; Morris 2015; Nieuwboer 2007; Paul 2014; Poliakoff 2013; Santos 2017a; Schenkman 1998; Schenkman 2012; Shanahan 2017; Volpe 2017a; Zhu 2011). For two studies (Reuter 2011; Sedaghati 2016), it was not clear whether they were conducted in a single center or in multiple centers.

The exercise intervention did not include a home-based component in the majority of studies (122 studies: Agosti 2016; Almeida 2012; Amano 2013; Arfa-Fatollahkhani 2019; Bridgewater 1996; Burini 2006; Cakit 2007; Capato 2020a; Carroll 2018; Carvalho 2015; Cheng 2017; Cheung 2018; Conradsson 2015; Corcos 2013; Cugusi 2015; Dashtipour 2015; da Silva Rocha Paz 2019; De Assis 2018; Dipasquale 2017; Duncan 2012; Ebersbach 2010; Ellis 2005; Feng 2019; Ferraz 2018; Ferrazzoli 2018; Ferreira 2018; Fietzek 2014; Fil-Balkan 2018; Fisher 2008; Frazzitta 2012; Frazzitta 2014; Frazzitta 2015; Ganesan 2014; Gao 2014; Guan 2016; Hackney 2007; Hackney 2009; Harvey 2019; Hass 2012; Hirsch 2003; Hubble 2018; Kanegusuku 2017; King 2013; Kunkel 2017; Kurt 2018; Landers 2016; Lehman 2005; Li 2012; Liao 2015; Liu 2016; Mak 2008; Medijainen 2019; Michels 2018; Miyai 2000; Miyai 2002; Morris 2009; Muller 1997; Mulligan 2018; Myers 2020; Nadeau 2014; Ni 2016; Nieuwboer 2007; Ortiz-Rubio 2018; Palmer 1986; Park 2014; Paul 2014; Pazzaglia 2020; Pedreira 2013; Peloggia Cursino 2018; Pérez de la Cruz 2017; Picelli 2016; Pohl 2013; Pohl 2020; Poier 2019; Poliakoff 2013; Protas 2005; Qutubuddin 2013; Reuter 2011; Ribas 2017; Ridgel 2019; Santos 2017a; Santos 2017b; Santos 2017c; Santos 2019; Schenkman 1998; Schenkman 2012; Schenkman 2018; Schilling 2010; Schlenstedt 2015; Schmitz-Hubsch 2006; Sedaghati 2016; Shahmohammadi 2017; Shen 2021; Shulman 2013; Silva 2019; Silva-Batista 2018; Silveira 2018; Smania 2010; Solla 2019; Sparrow 2016; Stack 2012; Stozek 2016; Sujatha 2019; Szefler-Derela 2020; Szymura 2020; Taheri 2011; Terrens 2020; Tollar 2018; Toole 2000; Van Puymbroeck 2018; Vivas 2011; Volpe 2014; Volpe 2017a; Volpe 2017b; Wan 2021; Wang 2017; Winward 2012; Yang 2010; Yen 2011; Youm 2020; Yuan 2020; Zhang 2015). The exercise intervention was conducted at home or had a home-based component in 29 studies (Allen 2010; Ashburn 2007; Ashburn 2018; Canning 2012; Canning 2015; Chaiwanichsiri 2011; Choi 2013; Cholewa 2013; Claesson 2018; Colgrove 2012; Goodwin 2011; Gu 2013; Johansson

2018; Kurtais 2008; Kwok 2019; Lee HJ 2018; Mak 2021; Martin 2015; Morris 2015; Morris 2017; Nieuwboer 2007; Schaible 2021; Shanahan 2017; Stack 2012; Tollar 2019; Vergara-Diaz 2018; Volpe 2013; Wong-Yu 2015; Zhu 2011). Whether a home-based component was included was unclear for five studies (Avenali 2021; Cherup 2021; Daneshvar 2019; De Moraes Filho 2020; Gobbi 2021).

Participants

The 156 studies included in our review represented adults (≥ 18 years of age) with a confirmed diagnosis of idiopathic PD.

The age of the participants, reported as mean or median, ranged between 59.9 years in Park 2014 to 74 years in Stack 2012.

Three studies included only men (Chaiwanichsiri 2011; Protas 2005; Shahmohammadi 2017). The remaining 153 studies included women and men. For these studies, the proportion of men ranged between 31% in Mak 2021 to 90% in Agosti 2016. More men than women were included in the majority of studies (77%) which may reflect the increased risk of men developing PD.

Based on a judgment we derived from the inclusion criteria and cognitive screening results that were reported by the study authors, for most of the studies, the samples were limited to people without severe cognitive impairment or dementia:

- 99 studies included people without cognitive impairment (Agosti 2016; Allen 2010; Amano 2013; Arfa-Fatollahkhani 2019; Ashburn 2018; Burini 2006; Canning 2012; Canning 2015; Capato 2020a; Chaiwanichsiri 2011; Cheng 2017; Cheung 2018; Cholewa 2013; Colgrove 2012; Conradsson 2015; Corcos 2013; Cugusi 2015; Dashtipour 2015; Dipasquale 2017; Ebersbach 2010; Ellis 2005; Feng 2019; Ferraz 2018; Ferreira 2018; Fil-Balkan 2018; Fisher 2008; Frazzitta 2012; Frazzitta 2014; Frazzitta 2015; Ganesan 2014; Gao 2014; Gobbi 2021; Gu 2013; Guan 2016; Hackney 2007; Hackney 2009; Hubble 2018; Kurt 2018; Landers 2016; Lehman 2005; Li 2012; Liao 2015; Liu 2016; Mak 2008; Mak 2021; Martin 2015; Medijainen 2019; Miyai 2000; Miyai 2002; Morris 2009; Morris 2015; Morris 2017; Mulligan 2018; Myers 2020; Nadeau 2014; Ni 2016; Nieuwboer 2007; Ortiz-Rubio 2018; Paul 2014; Pazzaglia 2020; Peloggia Cursino 2018; Pérez de la Cruz 2017; Reuter 2011; Santos 2017a; Santos 2017b; Santos 2017c; Santos 2019; Schaible 2021; Schenkman 1998; Schenkman 2012; Schenkman 2018; Schilling 2010; Schmitz-Hubsch 2006; Sedaghati 2016; Shahmohammadi 2017; Shen 2021; Shulman 2013; Silva-Batista 2018; Smania 2010; Solla 2019; Sparrow 2016; Szefler-Derela 2020; Szymura 2020; Taheri 2011; Terrens 2020; Tollar 2018; Tollar 2019; Van Puymbroeck 2018; Vivas 2011; Volpe 2013; Volpe 2014; Volpe 2017a; Wan 2021; Wang 2017; Wong-Yu 2015; Yen 2011; Youm 2020; Yuan 2020; Zhang 2015);
- 27 studies included people without cognitive impairment, or with mild cognitive impairment, or both (Ashburn 2007; Cakit 2007; Carvalho 2015; Choi 2013; Claesson 2018; De Assis 2018; De Moraes Filho 2020; Fietzek 2014; Johansson 2018; King 2013; King 2020; Kurtais 2008; Kwok 2019; Lee HJ 2018; Michels 2018; Muller 1997; Pedreira 2013; Poier 2019; Poliakoff 2013; Protas 2005; Qutubuddin 2013; Ribas 2017; Rios Romenets 2015; Shanahan 2017; Silva 2019; Silveira 2018; Stack 2012);
- one study included people with mild cognitive impairment (Avenali 2021);
- six studies included people for whom the cognitive stage ranged from no cognitive impairment to suspected dementia (Harvey 2019; Kunkel 2017; Picelli 2016; Pohl 2020; Schlenstedt 2015; Volpe 2017b);
- for 23 studies, we were not able to make a judgment on the participants' cognitive stage (Almeida 2012; Bridgewater 1996; Carroll 2018; Cherup 2021; Daneshvar 2019; da Silva Rocha Paz 2019; Duncan 2012; Ferrazzoli 2018; Goodwin 2011; Hass 2012; Hirsch 2003; Kanegusuku 2017; Palmer 1986; Park 2014; Pohl 2013; Ridgel 2019; Stozek 2016; Sujatha 2019; Toole 2000; Vergara-Diaz 2018; Winward 2012; Yang 2010; Zhu 2011).

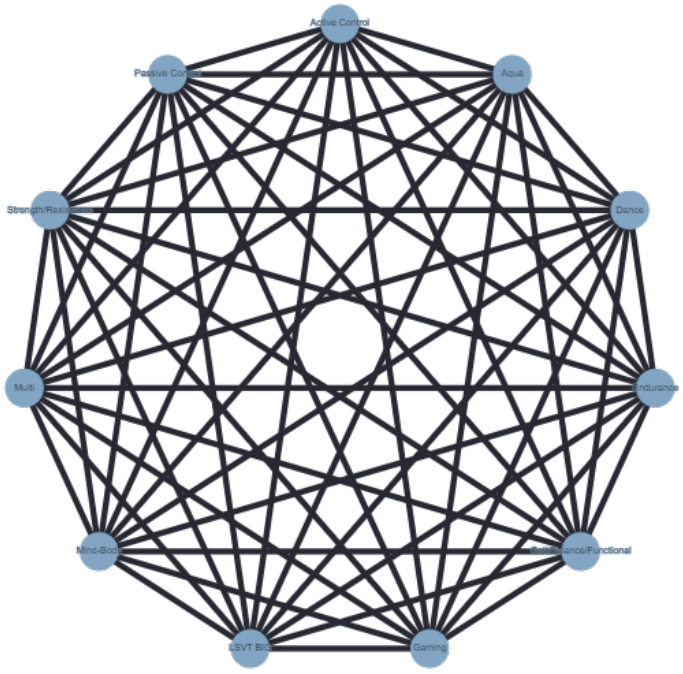
The disease severity, assessed with the original or modified Hoehn and Yahr scale (HY, Hoehn 1967), ranged between one and four. Participants with HY stages that ranged beyond stage three were included in 17 studies (Ashburn 2007; Ashburn 2018; Canning 2015; Gao 2014; King 2013; Landers 2016; Li 2012; Mak 2008; Morris 2015; Morris 2017; Nieuwboer 2007; Pohl 2013; Schmitz-Hubsch 2006; Smania 2010; Stack 2012; Wan 2021; Winward 2012). In 11 studies (Allen 2010; Almeida 2012; Liu 2016; Mulligan 2018; Palmer 1986; Pazzaglia 2020; Poier 2019; Poliakoff 2013; Qutubuddin 2013; Silveira 2018; Sujatha 2019), HY stages were not reported.

The mean or median duration of disease of the participants, which was usually reported at study arm-level as years since diagnosis of PD, ranged between 0.3 years in Schenkman 2018 ("time since diagnosis") to 13.3 years in Fietzek 2014 ("disease duration", not further specified).

Interventions

For details on the categories of interventions and control groups, please see Appendix 1. The network graph of the ideal network comparing all interventions is displayed in Figure 2.

Figure 2. Overview of the ideal network



The studies included in our review comprised the following types of physical exercise:

- aqua-based training (11 studies: Carroll 2018; De Assis 2018; Kurt 2018; Pérez de la Cruz 2017; Shahmohammadi 2017; Silva 2019; Vivas 2011; Volpe 2014; Volpe 2017a; Volpe 2017b; Wang 2017);
- dance (13 studies: Duncan 2012; Hackney 2007; Hackney 2009; Kunkel 2017; Michels 2018; Pohl 2013; Pohl 2020; Poier 2019; Rios Romenets 2015; Shanahan 2017; Solla 2019; Terrens 2020; Volpe 2013);
- endurance training (20 studies: Arfa-Fatollahkhani 2019; Burini 2006; Cakit 2007; Canning 2012; Carvalho 2015; Cugusi 2015; da Silva Rocha Paz 2019; Daneshvar 2019; Ebersbach 2010; Ferraz 2018; Fisher 2008; Mak 2021; Nadeau 2014; Reuter 2011; Ridgel 2019; Schenkman 2018; Silveira 2018; Sujatha 2019; Szefler-Derela 2020; Tollar 2018);
- flexibility (10 studies: Agosti 2016; Li 2012; Palmer 1986; Peloggia Cursino 2018; Qutubuddin 2013; Reuter 2011; Ridgel 2019; Schenkman 2012; Shen 2021; Taheri 2011);
- gait/balance/functional training (58 studies: Allen 2010; Almeida 2012; Ashburn 2018; Canning 2015; Capato 2020a; Chaiwanichsiri 2011; Cheng 2017; Cherup 2021; Claesson 2018; Conradsson 2015; Daneshvar 2019; Dipasquale 2017; Feng 2019; Ferraz 2018; Fietzek 2014; Fil-Balkan 2018; Ganesan 2014; Gobbi 2021; Gu 2013; Hirsch 2003; Hubble 2018; Johansson 2018; King 2013; Kurtais 2008; Landers 2016; Lehman 2005; Mak 2008; Martin 2015; Miyai 2000; Miyai 2002; Morris 2009; Morris 2015; Muller 1997; Nieuwboer 2007; Pazzaglia 2020; Peloggia Cursino 2018; Picelli 2016; Protas 2005; Ribas 2017; Santos 2017b; Santos 2017c; Schlenstedt 2015; Sedaghati 2016; Shahmohammadi 2017; Shulman 2013; Smania 2010; Sparrow 2016; Stack 2012; Stozek 2016; Szymura 2020; Tollar 2018; Volpe 2014; Volpe 2017b; Wang 2017; Wong-Yu 2015; Yang 2010; Yen 2011; Yuan 2020);
- gaming (5 studies: Ferraz 2018; Pazzaglia 2020; Pedreira 2013; Santos 2019; Zhu 2011);
- LSVT BIG (3 studies: Dashtipour 2015; Ebersbach 2010; Schaible 2021);
- mind-body training (23 studies: Amano 2013; Burini 2006; Cherup 2021; Cheung 2018; Choi 2013; Colgrove 2012; Guan 2016; Hackney 2009; Kwok 2019; Lee HJ 2018; Li 2012; Liu 2016; Myers 2020; Ni 2016; Palmer 1986; Poier 2019; Schmitz-Hubsch 2006; Shen 2021; Van Puymbroeck 2018; Vergara-Diaz 2018; Wan 2021; Zhang 2015; Zhu 2011);
- multi-domain training (60 studies: Ashburn 2007; Avenali 2021; Bridgewater 1996; Carvalho 2015; Cheng 2017; Cholewa 2013; Corcos 2013; da Silva Rocha Paz 2019; Dashtipour 2015; Dipasquale 2017; Ellis 2005; Feng 2019; Ferrazzoli 2018; Fil-Balkan 2018; Fisher 2008; Frazzitta 2012; Frazzitta 2014; Frazzitta 2015; Gao 2014; Gobbi 2021; Goodwin 2011; Hackney 2007; Hirsch 2003; King 2013; King 2020; Kurt 2018; Kwok 2019; Liao 2015; Mak 2008; Medijainen 2019; Miyai 2000; Miyai 2002; Morris 2009; Morris 2017; Mulligan 2018; Nadeau 2014; Park 2014; Pedreira 2013; Pérez de la Cruz 2017; Poliakoff 2013; Ribas 2017; Santos 2019; Schaible 2021; Schenkman 1998; Schenkman 2012; Shulman 2013; Silveira 2018; Smania 2010; Sujatha 2019; Szefler-Derela 2020; Terrens 2020; Tollar 2019; Toole 2000; Vivas 2011; Volpe 2013; Volpe 2017a; Winward 2012; Yang 2010; Youm 2020; Zhang 2015);
- strength/resistance training (17 studies: Carvalho 2015; Corcos 2013; De Moraes Filho 2020; Ferreira 2018; Harvey 2019; Hass 2012; Kanegusuku 2017; Li 2012; Morris 2015; Ni 2016; Ortiz-Rubio 2018; Paul 2014; Santos 2017a; Santos 2017b; Schilling 2010; Schlenstedt 2015; Silva-Batista 2018).

These interventions were compared to another type of physical exercise or, as specified below, to an active control group or a passive control group:

- active control group (13 studies: Capato 2020a; Chaiwanichsiri 2011; Fisher 2008; Gobbi 2021; Johansson 2018; King 2020; Mak 2021; Michels 2018; Morris 2015; Morris 2017; Muller 1997; Ortiz-Rubio 2018; Wong-Yu 2015);
- passive control group (91 studies: Agosti 2016; Allen 2010; Almeida 2012; Amano 2013; Arfa-Fatollahkhani 2019; Ashburn 2007; Ashburn 2018; Avenali 2021; Bridgewater 1996; Cakit 2007; Canning 2012; Canning 2015; Carroll 2018; Cheung 2018; Choi 2013; Cholewa 2013; Claesson 2018; Colgrove 2012; Conradsson 2015; Cugusi 2015; De Assis 2018; De Moraes Filho 2020; Duncan 2012; Ebersbach 2010; Ellis 2005; Ferrazzoli 2018; Ferreira 2018; Fietzek 2014; Frazzitta 2012; Frazzitta 2014; Frazzitta 2015; Ganesan 2014; Gao 2014; Goodwin 2011; Gu 2013; Guan 2016; Hackney 2009; Harvey 2019; Hass 2012; Hubble 2018; Kanegusuku 2017; Kunkel 2017; Kurtais 2008; Landers 2016; Lee HJ 2018; Lehman 2005; Liao 2015; Liu 2016; Mak 2008; Martin 2015; Medijainen 2019; Mulligan 2018; Myers 2020; Ni 2016; Nieuwboer 2007; Park 2014; Paul 2014; Picelli 2016; Pohl 2013; Pohl 2020; Poliakoff 2013; Protas 2005; Qutubuddin 2013; Rios Romenets 2015; Santos 2017a; Santos 2017c; Schenkman 1998; Schenkman 2018; Schilling 2010; Schmitz-Hubsch 2006; Sedaghati 2016; Shanahan 2017; Silva 2019; Silva-Batista 2018; Silveira 2018; Solla 2019; Sparrow 2016; Stack 2012; Stozek 2016; Szymura 2020; Taheri 2011; Tollar 2018; Tollar 2019; Toole 2000; Van Puymbroeck 2018; Vergara-Diaz 2018; Wan 2021; Winward 2012; Yen 2011; Youm 2020; Yuan 2020).

For three studies (Santos 2019; Schaible 2021; Schenkman 2012), we did not include all study arms in our analyses. They included treatments that did not fulfill the criteria for being categorized as an eligible intervention or comparator as clearly as other interventions of the same (potential) category (e.g. in terms of the components of the training or the degree of supervision). We excluded these study arms from our analyses in order to preserve homogeneity within our categories (for details, see Characteristics of included studies).

The length of intervention ranged between two weeks (Fietzek 2014; Lehman 2005; Morris 2009) and two years (Corcos 2013; Tollar 2019), with a mean length of 11.9 weeks.

The duration of a single training session ranged between 15 minutes (Shulman 2013; duration increased over the course of the intervention) and two hours (Morris 2015; Stozek 2016; Wong-Yu 2015).

Outcomes

Of the 156 studies included in our review, 109 studies reported data we included in our network meta-analyses. Eighty-five studies provided information on adverse events. All outcomes included in our network meta-analysis were assessed shortly (≤ six weeks) after the intervention.

Severity of motor signs

The severity of motor signs was reported in 71 studies. Of these, 56 studies reported data on the motor score of the Unified Parkinson's Disease Rating Scale (UPDRS-M, Fahn 1987) (Almeida 2012; Amano 2013; Burini 2006; Canning 2012; Capato 2020a; Carroll 2018; Carvalho 2015; Choi 2013; Cholewa 2013; Colgrove 2012; Corcos 2013; Cugusi 2015; da Silva Rocha Paz 2019; De Assis 2018; Ebersbach 2010; Ellis 2005; Feng 2019; Fil-Balkan 2018; Fisher 2008; Frazzitta 2014; Ganesan 2014; Gao 2014; Gu 2013; Hackney 2007; Hackney 2009; Kurt 2018; Lee HJ 2018; Miyai 2002; Morris 2015; Muller 1997; Ni 2016; Park 2014; Pérez de la Cruz 2017; Pohl 2013; Poliakoff 2013; Qutubuddin 2013; Reuter 2011; Ridgel 2019; Santos 2017b; Schaible 2021; Schenkman 2012; Schlenstedt 2015; Schmitz-Hubsch 2006; Shen 2021; Shulman 2013; Solla 2019; Terrens 2020; Vergara-Diaz 2018; Volpe 2013; Volpe 2014; Volpe 2017a; Volpe 2017b; Wang 2017; Youm 2020; Zhang 2015; Zhu 2011). Twelve studies reported data on the motor score of the Movement Disorder Society-Sponsored Revision of the Unified Parkinson's Disease Rating Scale (MDS-UPDRS-M, Goetz 2008) (Avenali 2021; Duncan 2012; King 2020; Kwok 2019; Mak 2021; Michels 2018; Morris 2017; Nadeau 2014; Rios Romenets 2015; Santos 2017a; Schenkman 2018; Van Puymbroeck 2018). Two studies reported data on the 14-item version of the UPDRS-M (Cheng 2017; Li 2012). One study reported data on the Hoehn and Yahr scale (HY, Hoehn 1967) (Smania 2010). Fifty-one studies reported the severity of motor signs during the on-medication state (Almeida 2012; Amano 2013; Avenali 2021; Burini 2006; Canning 2012; Capato 2020a; Carroll 2018; Cheng 2017; Cholewa 2013; Cugusi 2015; De Assis 2018; Ebersbach 2010; Ellis 2005; Feng 2019; Fisher 2008; Frazzitta 2014; Ganesan 2014; Gu 2013; Hackney 2007; Hackney 2009; Kurt 2018; Kwok 2019; Lee HJ 2018; Li 2012; Mak 2021; Michels 2018; Miyai 2002; Morris 2015; Morris 2017; Muller 1997; Ni 2016; Pohl 2013; Poliakoff 2013; Qutubuddin 2013; Ridgel 2019; Rios Romenets 2015; Santos 2017a; Santos 2017b; Schaible 2021; Schenkman 2012; Schlenstedt 2015; Schmitz-Hubsch 2006; Shen 2021; Shulman 2013; Smania 2010; Solla 2019; Terrens 2020; Volpe 2014; Volpe 2017a; Youm 2020; Zhang 2015). Five studies reported the outcome during the off-medication state (Duncan 2012; King 2020; Pérez de la Cruz 2017; Schenkman 2018; Vergara-Diaz 2018). One study provided data for both the on- and off-medication states (Corcos 2013). The timing of assessment relative to the medication state was unclear for 14 studies (Carvalho 2015; Choi 2013; Colgrove 2012; da Silva Rocha Paz 2019; Fil-Balkan 2018; Gao 2014; Nadeau 2014; Park 2014; Reuter 2011; Van Puymbroeck 2018; Volpe 2013; Volpe 2017b; Wang 2017; Zhu 2011).

Quality of life

Quality of life (QoL) was reported in 55 studies. Fifty studies reported data on the Parkinson's Disease Questionnaire 39 (PDQ-39, Jenkinson 1997b; Peto 1995) (Allen 2010; Amano 2013; Ashburn 2018; Burini 2006; Canning 2012; Canning 2015; Carroll 2018; Cheng 2017; Cholewa 2013; Corcos 2013; Daneshvar 2019; Ferraz 2018; Ferrazzoli 2018; Ferreira 2018; Gobbi 2021; Johansson 2018; King 2020; Kunkel 2017; Liao 2015; Michels 2018; Morris 2009; Morris 2015; Morris 2017; Nadeau 2014; Ni 2016; Nieuwboer 2007; Pedreira 2013; Peloggia Cursino 2018; Pohl 2013; Pohl 2020; Poier 2019; Poliakoff 2013; Qutubuddin 2013; Rios Romenets 2015; Santos 2017a; Santos 2017b; Schaible 2021; Schenkman 2012; Schlenstedt 2015; Schmitz-Hubsch 2006; Shulman 2013; Terrens 2020; Tollar 2018; Tollar 2019; Vergara-Diaz 2018; Volpe 2013; Volpe 2014; Volpe 2017a; Volpe 2017b; Winward 2012). Two studies reported data on the Parkinson's Disease Questionnaire 8, i.e. the short-form of the PDQ-39 (PDQ-8, Jenkinson 1997a) (Kwok 2019; Li 2012). Two studies reported data on the Parkinson's Disease Quality of Life Questionnaire (PDQ-L, De Boer 1996) (Lee HJ 2018; Shahmohammadi 2017). One study reported data on the EuroQol (EQ-5D) questionnaire (EuroQol Group 1990) (Goodwin 2011).

Freezing of gait

Freezing of gait was reported in 20 studies. Sixteen studies reported data on the Freezing of Gait Questionnaire (FOG-Q, Giladi 2000) (Allen 2010; Canning 2015; Carroll 2018; Cheng 2017; Duncan 2012; Hackney 2007; Hackney 2009; Medijainen 2019; Nieuwboer 2007; Pohl 2020; Rios Romenets 2015; Santos 2017a; Santos 2017c; Schlenstedt 2015; Van Puymbroeck 2018; Volpe 2013). Four studies reported data on the New Freezing of Gait Questionnaire (NFOG-Q, Nieuwboer 2009) (Capato 2020a; King 2020; Martin 2015; Paul 2014).

Functional mobility and balance

Functional mobility and balance was reported in 54 studies. Fifty-three studies reported data on the Timed Up and Go test (TUG, Podsiadlo 1991), which measures time taken in seconds for a person to get up from a chair, walk a certain distance (usually three meters), turn around, and walk back to the chair and sit down (Almeida 2012; Arfa-Fatollahkhani 2019; Capato 2020a; Chaiwanichsiri 2011; Cheng 2017; Cherup 2021; Choi 2013; Corcos 2013; Cugusi 2015; da Silva Rocha Paz 2019; De Moraes Filho 2020; Ebersbach 2010; Feng 2019; Ferreira 2018; Fil-Balkan 2018; Gao 2014; Guan 2016; Hackney 2007; Hackney 2009; Kunkel 2017; Kurt 2018; Kwok 2019; Li 2012; Liao 2015; Liu 2016; Mak 2021; Michels 2018; Morris 2009; Morris 2015; Ni 2016; Nieuwboer 2007; Paul 2014; Pérez de la Cruz 2017; Pohl 2013; Ridgel 2019; Rios Romenets 2015; Santos 2019; Schilling 2010; Schlenstedt 2015; Sedaghati 2016; Shen 2021; Shulman 2013; Silva 2019; Solla 2019; Tollar 2019; Vergara-Diaz 2018; Volpe 2014; Volpe 2017a; Volpe 2017b; Wan 2021; Wang 2017; Wong-Yu 2015; Zhang 2015). One study reported data on the TUG with a distance of 2.44 meters to be covered (Youm 2020).

Adverse events (number of participants with any adverse event)

Of the 156 included studies, 85 studies provided information on adverse events (i.e. occurrence or absence) (Allen 2010; Ashburn 2007; Ashburn 2018; Canning 2012; Canning 2015; Cakit 2007; Capato 2020a; Carroll 2018; Chaiwanichsiri 2011; Cheng 2017; Cherup 2021; Cheung 2018; Claesson 2018; Colgrove 2012; Conradsson 2015; Corcos 2013; Cugusi 2015; Dashtipour 2015; Dipasquale 2017; Ferraz 2018; Fietzek 2014; Fisher 2008; Frazzitta 2015; Ganesan 2014; Gao 2014; Goodwin 2011; Hackney 2009; Harvey 2019; Hass 2012; Hubble 2018; Johansson 2018; King 2013; King 2020; Kunkel 2017; Kwok 2019; Lee HJ 2018; Li 2012; Liao 2015; Mak 2021; Martin 2015; Michels 2018; Morris 2009; Morris 2015; Morris 2017; Myers 2020; Nadeau 2014; Ni 2016; Nieuwboer 2007; Ortiz-Rubio 2018; Park 2014; Paul 2014; Pérez de la Cruz 2017; Picelli 2016; Pohl 2013; Pohl 2020; Poier 2019; Poliakoff 2013; Reuter 2011; Ribas 2017; Rios Romenets 2015; Santos 2017a; Schaible 2021; Schenkman 1998; Schenkman 2012; Schenkman 2018; Sedaghati 2016; Shanahan 2017; Shulman 2013; Silva-Batista 2018; Smania 2010; Solla 2019; Sparrow 2016; Szefler-Derela 2020; Terrens 2020;Tollar 2018; Tollar 2019; Vergara-Diaz 2018; Volpe 2013; Volpe 2014; Volpe 2017b; Wong-Yu 2015; Yang 2010; Yen 2011; Yuan 2020; Zhang 2015).

Adverse events were measured and reported heterogeneously. The reports varied, for example, in the selection and specification of adverse event, in the way the events were counted (i.e. report of the number of events or report of the number of participants with adverse events), and in the timing of their assessment (i.e. collection of data only during delivery of the intervention or during the whole course of the study). Moreover, while in some studies certain harms were described as adverse events, in other studies, the same harms were recorded as reasons for dropout (i.e. narratively or in a flow chart) instead of adverse events. Furthermore, few studies provided data that were available for, and reported separately by, all trial arms. In particular, the documentation of adverse events in control groups was often missing or reduced in comparison to the report of adverse events in experimental groups. Therefore, conducting a quantitative synthesis on the number of participants with any adverse event using a network meta-analysis was not possible. As a result, we provide a narrative report of the data on adverse events.

Conflicts of interest

Exclusively non-commercial funding sources were reported in 92 studies (Agosti 2016; Allen 2010; Almeida 2012; Amano 2013; Ashburn 2007; Ashburn 2018; Avenali 2021; Bridgewater 1996; Canning 2012; Canning 2015; Capato 2020a; Chaiwanichsiri 2011; Cheng 2017; Cheung 2018; Claesson 2018; Colgrove 2012; Conradsson 2015; Corcos 2013; Daneshvar 2019; Duncan 2012; Ebersbach 2010; Feng 2019; Fietzek 2014; Fisher 2008; Gobbi 2021; Goodwin 2011; Gu 2013; Hackney 2007; Hackney 2009; Hubble 2018; Johansson 2018; Kanegusuku 2017; King 2013; King 2020; Kunkel 2017; Kurt 2018; Kwok 2019; Landers 2016; Lee HJ 2018; Li 2012; Liao 2015; Mak 2021; Medijainen 2019; Miyai 2000; Miyai 2002; Morris 2015; Morris 2017; Muller 1997; Myers 2020; Nadeau 2014; Nieuwboer 2007; Park 2014; Paul 2014; Pedreira 2013; Pohl 2013; Pohl 2020; Poier 2019; Poliakoff 2013; Rios Romenets 2015; Santos 2017a; Santos 2017b; Santos 2019; Schenkman 1998; Schenkman 2012; Schenkman 2018; Schlenstedt 2015; Schmitz-Hubsch 2006; Shanahan 2017; Shen 2021; Shulman 2013; Silva 2019; Silva-Batista 2018; Silveira 2018; Smania 2010; Solla 2019; Sparrow 2016; Stack 2012; Szymura 2020; Tollar 2018; Tollar 2019; Toole 2000; Van Puymbroeck 2018; Vergara-Diaz 2018; Vivas 2011; Wan 2021; Winward 2012; Wong-Yu 2015; Yang 2010; Yen 2011; Youm 2020; Yuan 2020; Zhang 2015).

Four studies were funded or supported (i.e. provision of equipment or facilities) by a commercial entity (Harvey 2019, "Speedflex Europe Ltd"; Pazzaglia 2020, "BTS Spa, Garbagnate Milanese"; Schilling 2010, "Life Fitness, Inc"; Terrens 2020, "Lee Silverman Voice Treatment small student grant").

In one study, funding sources included an association of physiotherapists (Martin 2015, "Physiotherapy New Zealand's Older Adult and Neurology Special Interest Groups").

In 17 studies, it was explicitly reported that no specific funding or financial support was received (Cherup 2021; Fil-Balkan 2018; Frazzitta 2012; Frazzitta 2014; Frazzitta 2015; Gao 2014; Ni 2016; Ortiz-Rubio 2018; Pérez de la Cruz 2017; Schaible 2021; Shahmohammadi 2017; Smania 2010; Szefler-Derela 2020; Volpe 2014; Volpe 2017a), or no funding sources were declared (Arfa-Fatollahkhani 2019, "none declared"; Michels 2018, "N/A"; Peloggia Cursino 2018, "nothing to declare").

Forty-two studies provided no information on funding sources (Arfa-Fatollahkhani 2019; Burini 2006; Cakit 2007; Carroll 2018; Carvalho 2015; Choi 2013; Cholewa 2013; Cugusi 2015; Dashtipour 2015; da Silva Rocha Paz 2019; De Assis 2018; De Moraes Filho 2020; Dipasquale 2017; Ellis 2005; Ferraz 2018; Ferrazzoli 2018; Ferreira 2018; Ganesan 2014; Guan 2016; Hass 2012; Hirsch 2003; Kurtais 2008; Lehman 2005; Liu 2016; Mak 2008; Morris 2009; Mulligan 2018;

Picelli 2016; Protas 2005; Qutubuddin 2013; Reuter 2011; Ribas 2017; Ridgel 2019; Santos 2017c; Sedaghati 2016; Stozek 2016; Sujatha 2019; Taheri 2011; Volpe 2013; Volpe 2017b; Wang 2017; Zhu 2011).

In 90 studies, the authors declared that there were no conflicts of interest (Agosti 2016; Almeida 2012; Ashburn 2007; Avenali 2021; Canning 2012; Carvalho 2015; Chaiwanichsiri 2011; Cheng 2017; Cherup 2021; Cheung 2018; Cholewa 2013; Claesson 2018; Conradsson 2015; Daneshvar 2019; Dashtipour 2015; De Assis 2018; De Moraes Filho 2020; Dipasquale 2017; Duncan 2012; Ferraz 2018; Ferrazzoli 2018; Fietzek 2014; Fil-Balkan 2018; Fisher 2008; Frazzitta 2012; Frazzitta 2014; Frazzitta 2015; Ganesan 2014; Gao 2014; Gobbi 2021; Hass 2012; Hirsch 2003; Hubble 2018; Johansson 2018; Kanegusuku 2017; Kunkel 2017; Kurt 2018; Kwok 2019; Landers 2016; Li 2012; Liao 2015; Liu 2016; Mak 2021; Martin 2015; Medijainen 2019; Miyai 2000; Miyai 2002; Morris 2009; Morris 2015; Morris 2017; Mulligan 2018; Myers 2020; Nadeau 2014; Ni 2016; Ortiz-Rubio 2018; Pazzaglia 2020; Peloggia Cursino 2018; Pérez de la Cruz 2017; Pohl 2013; Poier 2019; Qutubuddin 2013; Santos 2017a; Santos 2017b; Santos 2017c; Santos 2019; Schenkman 2018; Schlenstedt 2015; Shahmohammadi 2017; Shen 2021; Silva 2019; Silva-Batista 2018; Silveira 2018; Smania 2010; Solla 2019; Sparrow 2016; Stozek 2016; Szymura 2020; Tollar 2018; Tollar 2019; Van Puymbroeck 2018; Vivas 2011; Volpe 2013; Volpe 2014; Volpe 2017a; Winward 2012; Wong-Yu 2015; Yang 2010; Youm 2020; Yuan 2020Zhang 2015).

Eleven studies declared potential conflicts of interest, including relationships with commercial entities (e.g. pharmaceutical companies), that were not directly related to the study (Allen 2010; Canning 2015; Corcos 2013; Ebersbach 2010; Harvey 2019; Michels 2018; Paul 2014; Rios Romenets 2015; Schaible 2021; Shulman 2013; Szefler-Derela 2020).

Three studies declared potential conflicts of interest that were limited to relationships with non-commercial entities (e.g. universities) (Ashburn 2018; Goodwin 2011; Wan 2021).

Five studies declared the following potential conflicts of interest related to the study.

- King 2020: "(The last author) has an equity interest in APDM, a company that may have a commercial interest in the results of this study. This potential conflict of interest has been reviewed and managed by the Research & Development Committee at the VA Portland Health Care System and Oregon Health & Science University. They have put in place a plan to help ensure that this research study is not affected by the financial interest".
- Nieuwboer 2007: "The proceeds of the sale of the CD-Rom will be used to fund completion of analysis of the full RESCUE dataset. We may be involved in this further work".
- Pohl 2020: "(The first author) is a non-practicing certified practitioner of the Ronnie Gardiner Method. She was blind to the results of the outcome evaluations of all patients and did not take part in the interviews".
- Ridgel 2019: "(The first author) is a co-inventor on two patents which are related to the device used in this study: “Bike System for Use in Rehabilitation of a Patient,” US 10,058,736 and US 9,802,081. No royalties have been distributed from this patent".
- Vergara-Diaz 2018: "(The last author) is the founder and sole owner of the Tree of Life Tai Chi Center. (His) interests were reviewed and managed by the Brigham and Women’s Hospital and Partner’s HealthCare in accordance with their conflict of interest policies".

Forty-seven studies provided no information on conflicts of interest (Amano 2013; Arfa-Fatollahkhani 2019; Bridgewater 1996; Burini 2006; Cakit 2007; Capato 2020a; Carroll 2018; Choi 2013; Colgrove 2012; Cugusi 2015; da Silva Rocha Paz 2019; Ellis 2005; Feng 2019; Ferreira 2018; Gu 2013; Guan 2016; Hackney 2007; Hackney 2009; King 2013; Kurtais 2008; Lee HJ 2018; Lehman 2005; Mak 2008; Muller 1997; Palmer 1986; Park 2014; Pedreira 2013; Picelli 2016; Poliakoff 2013; Protas 2005; Reuter 2011; Ribas 2017; Schenkman 1998; Schenkman 2012; Schilling 2010; Schmitz-Hubsch 2006; Sedaghati 2016; Shanahan 2017; Stack 2012; Sujatha 2019; Taheri 2011; Terrens 2020; Toole 2000; Volpe 2017b; Wang 2017; Yen 2011; Zhu 2011).

Ongoing studies

We classified 58 studies as ongoing because this was indicated by the study publication, the study completion date reported in the trial registry was 2020 or later, or relevant changes have been made in the trial registry indicating that the trial was ongoing (ACTRN12617001057370; ACTRN12620001135909; Bevilacqua 2020; ChiCTR1900022621; ChiCTR2000029025; ChiCTR2000029135; ChiCTR2000036306; ChiCTR2000037178; ChiCTR2000037305; ChiCTR2000037384; CTRI/2018/05/014241; CTRI/2019/06/019618; CTRI/2020/06/025794; DRKS00018841; Gooßes 2020; Hackney 2020; Li 2021; Lima 2020; Mayoral-Moreno 2021; NCT02457832; NCT03244813; NCT03343574; NCT03560089; NCT03563807; NCT03582371; NCT03711955; NCT03751371; NCT03833349; NCT03860649; NCT03882879; NCT03960931; NCT03972969; NCT03974529; NCT03983785; NCT04000360; NCT04046276; NCT04063605; NCT04122690; NCT04135924; NCT04194762; NCT04215900; NCT04379778; NCT04558879; NCT04613141; NCT04644367; NCT04665869; NCT04699617; NCT04863118; NCT04872153; NCT04878679; RBR-26kn3b; RBR-277fqv; RBR-5r5dhf; RBR-5yjyr7; RBR-74683n; RBR-8s5v5f; RBR-9v7gj4; TCTR20201009001). One of these studies was suspended due to COVID-19 but may be continued (NCT04215900).

Studies awaiting classification

We listed 68 studies (including published full-text articles, abstracts, and trial registry records) as "awaiting classification" due to insufficient information to judge eligibility. According to the available information, these studies were completed or potentially could have been completed.

We contacted the authors of 14 studies in order to receive additional information to allow a judgment on their eligibility, but received either no response or insufficient information for clarification (Amara 2020; de Oliveira 2017; Huang 2020; Kargarfard 2012; Khongprasert 2019; Koli 2018; Lee G 2018; Lee 2019; Mohammadpour 2018; Ogundele 2018; Rosenfeldt 2021; Shen 2014; Stozek 2017; Swarnakar 2019). One study providing insufficient information to judge eligibility was identified during the peer review process for this review (Wróblewska 2019). We will contact the study authors in order to clarify eligibility in a future update of this review. For 53 studies identified through registry searches, we were not able to make a judgment on their eligibility or to identify published or unpublished data linked to the study, or the study completion date reported in the trial registry was 2019 or before and there have been

no updates in the trial registry indicating that the trial was ongoing (ACTRN12605000566639; ACTRN12609000900213; ACTRN12612001016820; ACTRN12618000923268p; ChiCTR1800019534; ChiCTR-INR-17011340; ChiCTR-IOR-16009065; ChiCTR-IPR-17011875; ChiCTR-TRC-14004549; CTRI/2017/08/009471; DRKS00008732; IRCT2015040616830N4; IRCT20160712288885N1; IRCT20171030037099N1; NCT00004760; NCT00029809; NCT00167453; NCT00387218; NCT01014663; NCT01076712; NCT01246700; NCT01427062; NCT01439022; NCT01562496; NCT01757509; NCT01835652; NCT01960985; NCT02017938; NCT02267785; NCT02419768; NCT02476240; NCT02476266; NCT02615548; NCT02656355; NCT02674724; NCT02745171; NCT02816619; NCT02999997; NCT03212014; NCT03406728; NCT03443752; NCT03568903; NCT03618901; NCT03689764; NCT04012086; RBR-34d7jm; RBR-3vm7bf; RBR-3z39v3; RBR-4m3k2c; RBR-6rngmb; RBR-7xfkpx; TCTR20180111003; TCTR20180530004).

Excluded studies

After screening of titles/abstracts, we excluded 18,967 records that did not match our inclusion criteria. We evaluated reports of 32 studies in more detail, which were finally excluded for one or more of the following reasons (see Characteristics of excluded studies table):

- 16 studies compared interventions that were too similar; that is, they would have been categorized as the same type of intervention according to our adapted version of the ProFaNE taxonomy (Lamb 2011) (Antunes Marques 2019; Cancela 2020; Capato 2020b; Combs 2013; Granziera 2021; Melo 2018; Moon 2020; Passos-Monteiro 2020; Picelli 2012; Sahu 2018; Serrao 2019; Silva-Batista 2020; Soke 2021; Van Wegen 2015; Wang 2018; Zhu 2020);
- 10 studies were not RCTs (Hashimoto 2015; Israel 2018; Kalyani 2019; Maciel 2020; Rawson 2019; Sage 2009; Segura 2020; Yousefi 2009; Yu 1998; Zhang 2018);
- three studies did not include any or fewer than five supervised training sessions (Laupheimer 2011; Thaut 1996; Xiao 2016);
- two studies were terminated (NCT03637023; NCT04291027); and
- one study was a cluster-RCT (Munneke 2010).

Risk of bias in included studies

Using the RoB 2 tool, we assessed the risk of bias for 93 RCTs that contributed results to our primary outcomes which are included in Summary of findings 1 and Summary of findings 2 (Allen 2010; Almeida 2012; Amano 2013; Ashburn 2018; Avenali 2021; Burini 2006; Canning 2012; Canning 2015; Capato 2020a; Carroll 2018; Carvalho 2015; Cheng 2017; Choi 2013; Cholewa 2013; Colgrove 2012; Corcos 2013; Cugusi 2015; da Silva Rocha Paz 2019; Daneshvar 2019; De Assis 2018; Duncan 2012; Ebersbach 2010; Ellis 2005; Feng 2019; Ferraz 2018; Ferrazzoli 2018; Ferreira 2018; Fil-Balkan 2018; Fisher 2008; Frazzitta 2014; Ganesan 2014; Gao 2014; Gobbi 2021; Goodwin 2011; Gu 2013; Hackney 2007; Hackney 2009; Johansson 2018; King 2020; Kunkel 2017; Kurt 2018; Kwok 2019; Lee HJ 2018; Li 2012; Liao 2015; Mak 2021; Michels 2018; Miyai 2002; Morris 2009; Morris 2015; Morris 2017; Muller 1997; Nadeau 2014; Ni 2016; Nieuwboer 2007; Park 2014; Pedreira 2013; Peloggia Cursino 2018; Pérez de la Cruz 2017; Pohl 2013; Pohl 2020; Poier 2019; Poliakoff 2013; Qutubuddin 2013; Reuter 2011; Ridgel 2019; Rios Romenets 2015; Santos 2017a; Santos 2017b; Schaible 2021; Schenkman 2012; Schenkman 2018; Schlenstedt 2015; Schmitz-Hubsch 2006; Shahmohammadi 2017; Shen 2021; Shulman 2013; Smania 2010; Solla 2019; Terrens 2020; Tollar 2018; Tollar 2019; Van Puymbroeck 2018; Vergara-Diaz 2018; Volpe 2013; Volpe 2014; Volpe 2017a; Volpe 2017b; Wang 2017; Winward 2012; Youm 2020; Zhang 2015; Zhu 2011). These studies contributed 71 study results to the severity of motor signs, and 55 study results to quality of life. The RoB 2 judgments for all study results per outcomes and for all domains are available in a supplementary file (Ernst 2022). Traffic light plots (domain-level judgments for each individual result) and summary plots (distribution of judgments within each domain) are displayed for study results on the severity of motor signs in Figure 3 and Figure 4, and for study results on quality of life in Figure 5 and Figure 6, respectively. We summarize the judgments below.

Figure 3. Risk of bias traffic light plot for severity of motor signs.

Figure 3. (Continued)

Figure 3. (Continued)

D2: Bias due to deviations from intended intervention.
D3: Bias due to missing outcome data.
D4: Bias in measurement of the outcome.
D5: Bias in selection of the reported result.

X High
\- Some concerns
\+ Low

Figure 4. Risk of bias summary plot for severity of motor signs.

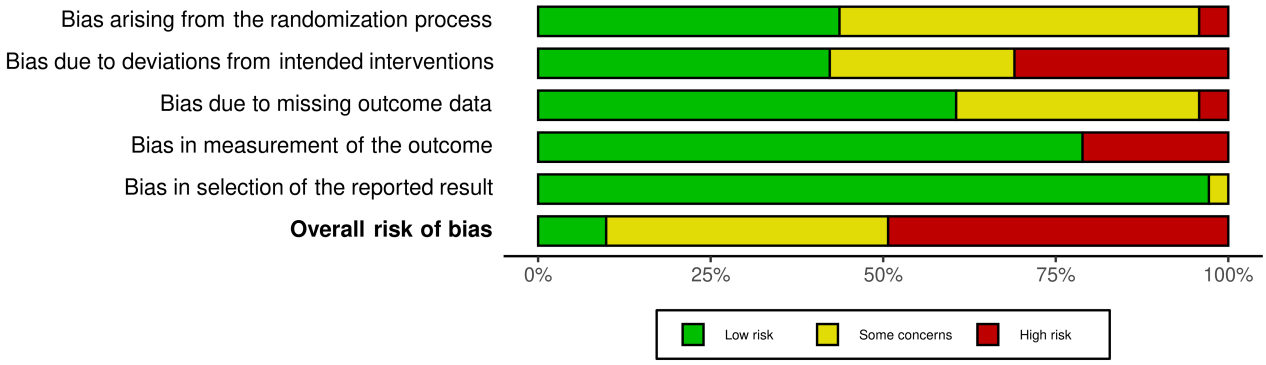


Figure 5. Risk of bias summary plot for quality of life.

Figure 5. (Continued)

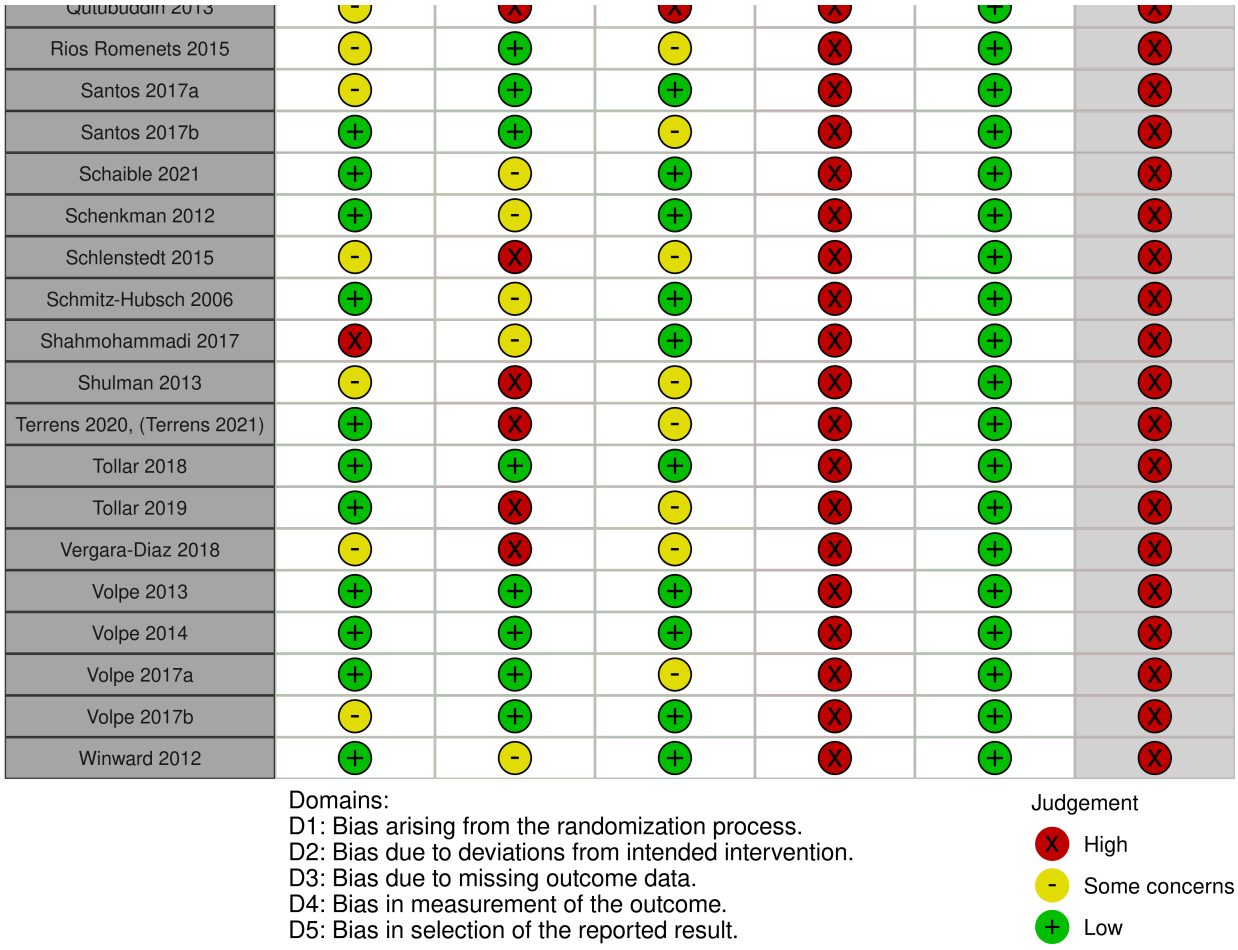
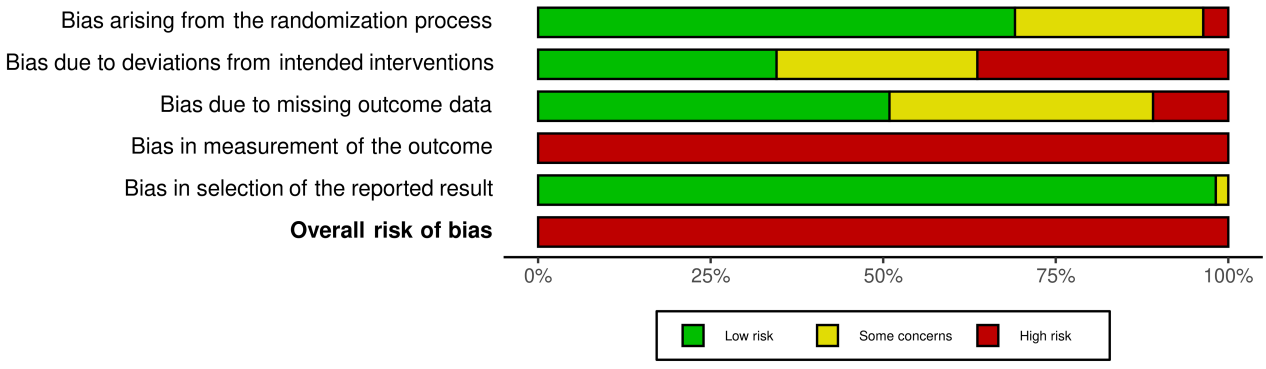


Figure 6. Risk of bias traffic light plot for quality of life.



Since the reporting of adverse events was highly heterogeneous and frequently incomplete, retrieving effect estimates for a network meta-analysis and conducting a formal assessment of risk of bias was not feasible. Therefore, we made an informal judgment of the risk of bias for this outcome.

Severity of motor signs

For the severity of motor signs, we judged the overall risk of bias as low for seven study results (9.9%, Capato 2020a; Cheng 2017; Colgrove 2012; Corcos 2013; Li 2012; Volpe 2013; Volpe 2014). We had some concerns regarding overall risk of bias for 29 study results

(40.9%). We judged 35 study results (49.3%) to be at high overall risk of bias. Most frequently, we had concerns regarding bias due to deviations from the intended interventions, as the results reported by trialists frequently lacked data from a substantial proportion of participants who had been randomized.

Risk of bias by comparison

We had no concerns regarding risk of bias for the effects of two interventions versus a passive control group. For the comparison of dance with a passive control group, the effect estimate was dominated by 'high risk of bias' studies with a weight of around 70% in the primary analysis. However, both the primary analysis and the sensitivity analysis, which was limited to 'low risk of bias' studies, suggested an effect in favor of dance. For the comparison of flexibility training with a passive control group, 'high risk of bias' studies accounted for around 30% of the effect estimate. Effects within equivalence of flexibility training and a passive control group were suggested by both the primary and the sensitivity analysis.

For the effects of the remaining interventions versus a passive control group, we had some concerns regarding risk of bias. For the comparisons of aqua-based, gait/balance/functional, mind-body, multi-domain, and strength/resistance training with a passive control group, the contribution of 'high risk of bias' studies to the effect estimates ranged between around 40% and 60%. While the primary analysis suggested effects in favor of the interventions, the confidence intervals included effects within equivalence with a passive control group in the sensitivity analysis limited to 'low risk of bias' studies. For the comparisons of endurance training and LSVT BIG with a passive control group, the effect estimates were highly affected by study results that were at least of some concern regarding risk of bias, while 'low risk of bias' studies contributed only little weight to the estimates (i.e. below 5%). The sensitivity analysis did not include data on the effects of endurance training and LSVT BIG versus a passive control group.

Quality of life

Due to the nature of self-reported questionnaires and the corresponding subjectivity of the assessment of quality of life, we judged all study results to be at high overall risk of bias.

Considering the domains that are not affected by self-reporting of the outcome only (i.e. excluding domain 4: "bias in measurement of the outcome"), we judged eight study results (14.5%) to be at low risk of bias (Cheng 2017; Corcos 2013; Liao 2015; Morris 2009; Nieuwboer 2007; Tollar 2018; Volpe 2013; Volpe 2014). For 20 study results (36.4%), we had some concerns regarding risk of bias (Allen 2010; Canning 2012; Canning 2015; Daneshvar 2019; Ferrazzoli 2018; Goodwin 2011; Johansson 2018; Michels 2018; Morris 2015; Morris 2017; Poier 2019; Rios Romenets 2015; Santos 2017a; Santos 2017b; Schaible 2021; Schenkman 2012; Schmitz-Hubsch 2006; Volpe 2017a; Volpe 2017b; Winward 2012), and we judged 27 study results (49.1%) to be at high risk of bias (Amano 2013; Ashburn 2018; Burini 2006; Carroll 2018; Cholewa 2013; Ferraz 2018; Ferreira 2018; Gobbi 2021; King 2020; Kunkel 2017; Kwok 2019; Lee HJ 2018; Li 2012; Nadeau 2014; Ni 2016; Pedreira 2013; Peloggia Cursino 2018; Pohl 2013; Pohl 2020; Poliakoff 2013; Qutubuddin 2013; Schlenstedt 2015; Shahmohammadi 2017; Shulman 2013; Terrens 2020; Tollar 2019; Vergara-Diaz 2018).

Risk of bias by comparison

For the effects of six interventions (i.e. aqua-based, endurance, gait/balance/functional training, LSVT BIG, multi-domain, and strength/resistance training versus a passive control group), we had some concerns regarding risk of bias that were due to self-reporting of the outcome (i.e. high risk in domain 4: "bias in measurement of the outcome"). Considering only the domains that are not affected by self-reporting of the outcome, the effect estimates were highly affected by studies at low risk of bias or studies with some concerns regarding risk of bias.

We had serious concerns regarding risk of bias for the effects of dance, flexibility training, gaming, and mind-body training versus a passive control group, because the effect estimates were highly affected by 'high risk of bias' studies even when bias in measurement of the outcome was not taken into account.

Adverse events

Reporting of adverse events was highly heterogeneous and frequently incomplete: most studies did not report events for all groups. Therefore, we judged the risk of bias for this outcome to be high.

Effects of interventions

See: **Summary of findings 1** Network estimates of effects and confidence in the evidence for physical exercise in people with Parkinson's disease on the severity of motor signs; **Summary of findings 2** Network estimates of effects and confidence in the evidence for physical exercise in people with Parkinson's disease on quality of life; **Summary of findings 3** Estimates of effects and confidence in the evidence for physical exercise in people with Parkinson's disease on adverse events

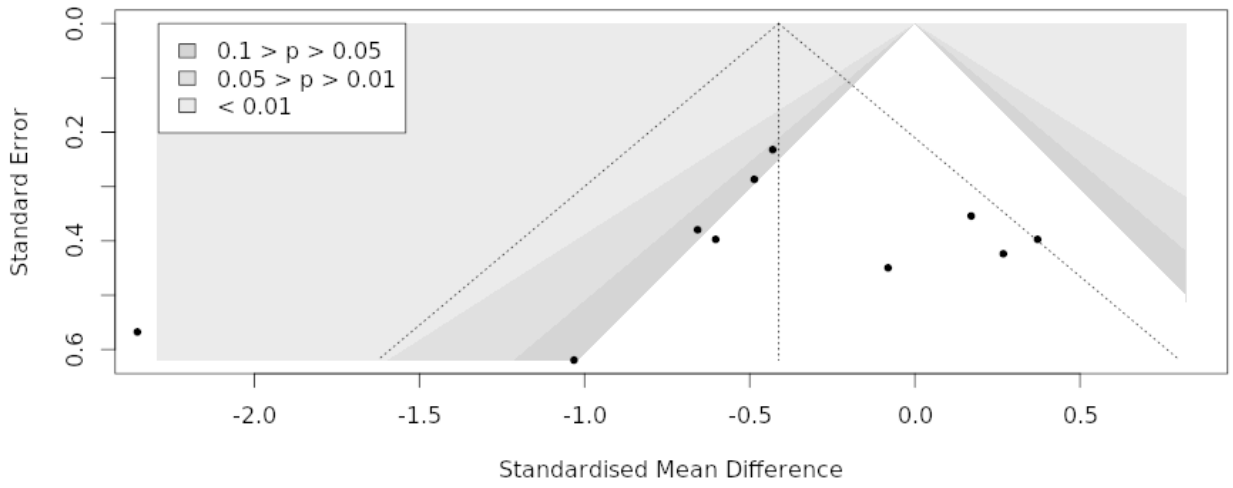
We present our main findings from the NMAs for each comparison of interventions included in our decision set with a passive control group, which was the most common comparator, in Summary of findings 1 and Summary of findings 2. Results for other comparisons are reported below and in the additional tables and figures. Additionally, we present key results from the NMAs in an interactive summary of findings table. We present our main findings on the occurrence of adverse events in Summary of findings 3.

Pairwise comparisons

Pairwise comparisons are part of the NMAs, and we did not perform additional pairwise meta-analyses. The direct effect estimates for all pairwise comparisons are presented in the upper triangle of each league table (Table 1; Table 2; Table 3; Table 4).

For the comparison of the effects on the severity of motor signs between mind-body training and a passive control group, funnel plot analysis did not suggest asymmetry (P = 0.47; Figure 7). Since this was the only pairwise comparison across outcomes, with a minimum of 10 studies, we did not conduct further funnel plot analyses.

Figure 7. Funnel plot for the comparison of the effects on severity of motor signs between mind-body training and a passive control group.



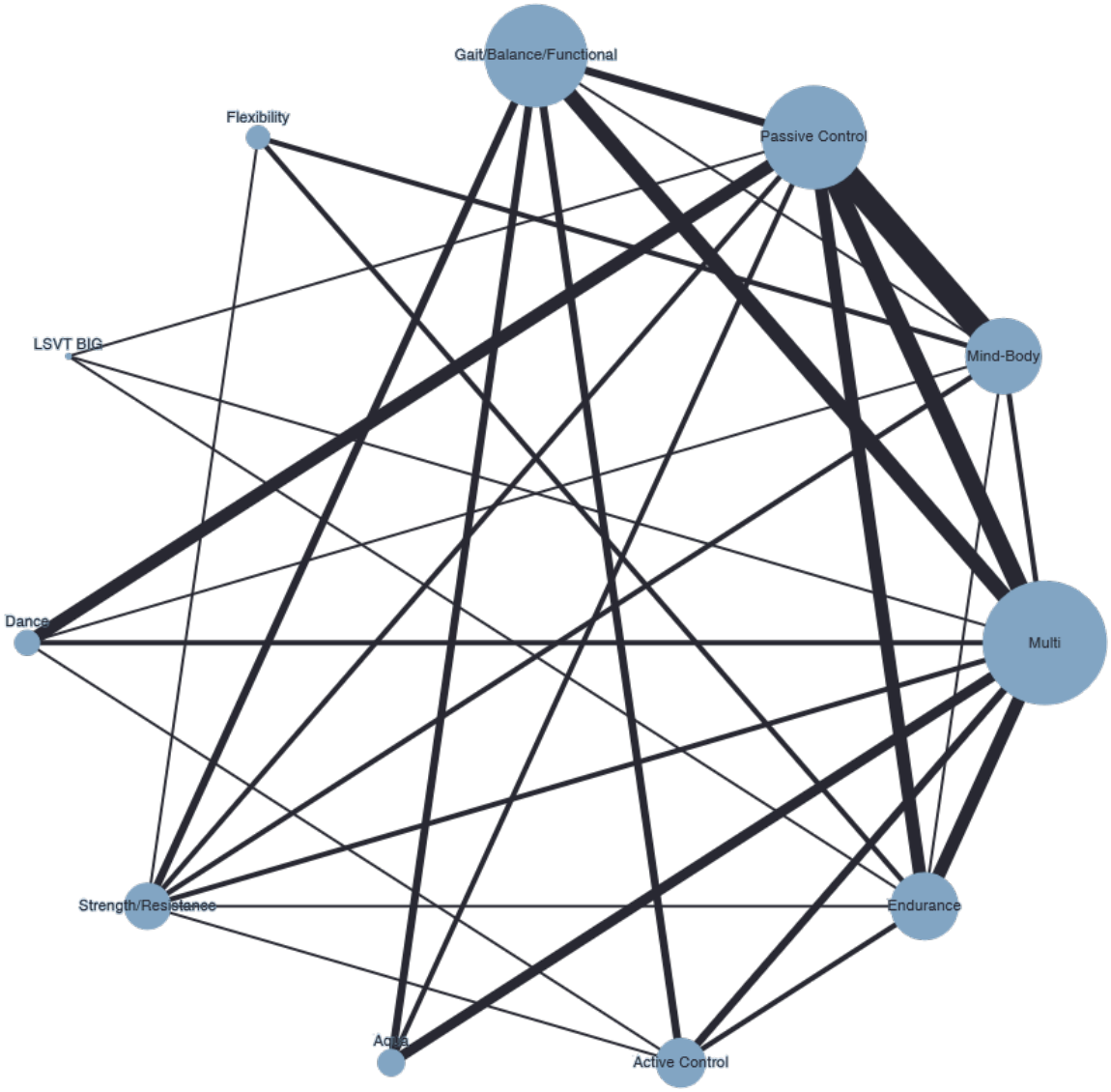
Transitivity

As the clinical and methodological characteristics that could potentially affect the relative treatment effects were similar across the included trials, we assumed that the transitivity assumption holds. Distributions of potential effect modifiers across the different pairwise comparisons are displayed in a supplementary file (Ernst 2022).

Severity of motor signs

Data on the severity of motor signs were reported in 71 studies, of which seven had three arms (3196 participants; Almeida 2012; Amano 2013; Avenali 2021; Burini 2006; Canning 2012; Capato 2020a; Carroll 2018; Carvalho 2015; Cheng 2017; Choi 2013; Cholewa 2013; Colgrove 2012; Corcos 2013; Cugusi 2015; da Silva Rocha Paz 2019; De Assis 2018; Duncan 2012; Ebersbach 2010; Ellis 2005; Feng 2019; Fil-Balkan 2018; Fisher 2008; Frazzitta 2014; Ganesan 2014; Gao 2014; Gu 2013; Hackney 2007; Hackney 2009; King 2020; Kurt 2018; Kwok 2019; Lee HJ 2018; Li 2012; Mak 2021; Michels 2018; Miyai 2002; Morris 2015; Morris 2017; Muller 1997; Nadeau 2014; Ni 2016; Park 2014; Pérez de la Cruz 2017; Pohl 2013; Poliakoff 2013; Qutubuddin 2013; Reuter 2011; Ridgel 2019; Rios Romenets 2015; Santos 2017a; Santos 2017b; Schaible 2021; Schenkman 2012; Schenkman 2018; Schlenstedt 2015; Schmitz-Hubsch 2006; Shen 2021; Shulman 2013; Smania 2010; Solla 2019; Terrens 2020; Van Puymbroeck 2018; Vergara-Diaz 2018; Volpe 2013; Volpe 2014; Volpe 2017a; Volpe 2017b; Wang 2017; Youm 2020; Zhang 2015; Zhu 2011). The fully-connected network was based on 85 pairwise comparisons and included data on all interventions except for gaming (Figure 8).

Figure 8. Network graph for severity of motor signs. Treatments are connected by a line when there is at least one study comparing the two treatments.
Line width: number of studies. Node width: number of participants.



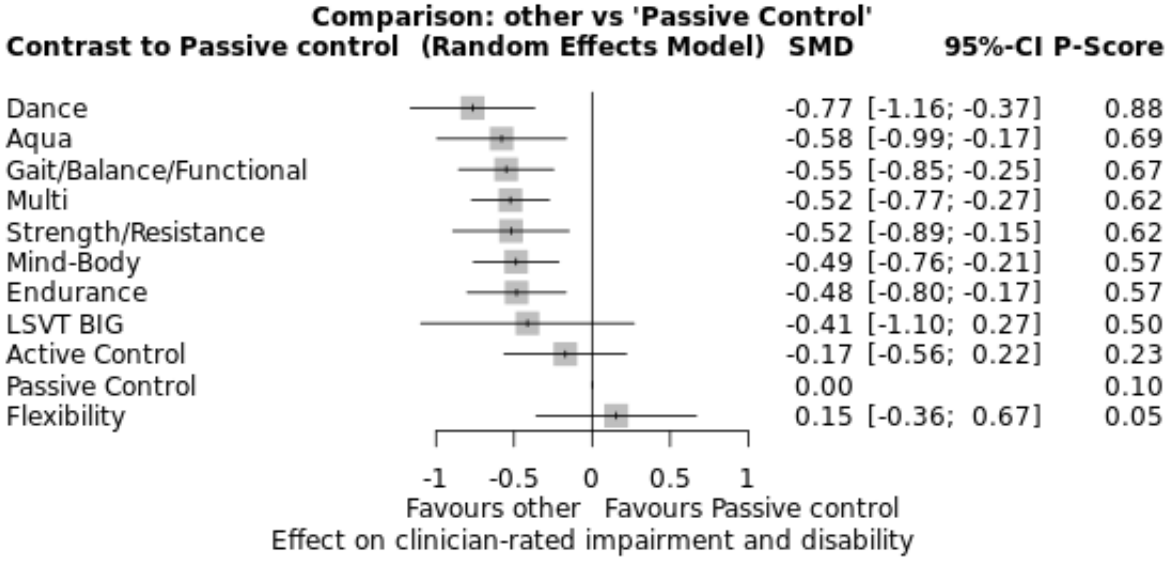
A league table with results for all pairwise comparisons, including network estimates and direct estimates, is displayed in Table 1. Please note that higher scores denote higher severity of motor signs. Therefore, negative estimates reflect improvement. Also, please note that the minimum clinically important difference for improvement of -2.5 points on the UPDRS-M corresponds to an SMD of -0.19 (Shulman 2010).

The evidence suggests that the severity of motor signs was decreased for seven interventions compared to a passive control group (dance: SMD -0.77, 95% CI -1.16 to -0.37; aqua-based training: SMD -0.58, 95% CI -0.99 to -0.17; gait/balance/functional training: SMD -0.55, 95% CI -0.85 to -0.25; multi-domain training: SMD -0.52, 95% CI -0.77 to -0.27; strength/resistance training: SMD -0.52, 95% CI -0.89 to -0.15; mind-body training: SMD -0.49, 95% CI -0.76 to -0.21; endurance training: SMD -0.48, 95% CI -0.80 to -0.17). For the same interventions, the evidence also suggests decreases in the severity of motor signs compared to flexibility training (dance: SMD -0.92, 95% CI -1.55 to -0.29; aqua-based training: SMD -0.73, 95% CI -1.36 to -0.11; gait/balance/functional training: SMD -0.70, 95% CI -1.25 to -0.16; multi-domain training: SMD -0.68, 95% CI -1.20 to -0.16; strength/resistance training: SMD -0.67, 95% CI -1.22 to -0.13; mind-body training: SMD -0.64, 95% CI -1.14 to -0.14; endurance training: SMD -0.64, 95% CI -1.14 to -0.13). Moreover, for dance and gait/balance/functional training, the evidence suggests that the severity of motor signs was decreased compared to an

active control group (dance: SMD -0.59, 95% CI -1.11 to -0.08; gait/balance/functional training: SMD -0.38, 95% CI -0.75 to -0.01). We did not identify evidence for further statistically significant effects. However, we observed that several interventions may also have beneficial effects on the severity of motor signs compared to an active control group, but the CIs extended across the line of no effect (e.g. aqua-based training: SMD -0.41, 95% CI -0.90 to 0.09; multi-domain training: SMD -0.35, 95% CI -0.71 to 0.01; strength/resistance training: SMD -0.35, 95% CI -0.79 to 0.10; endurance training: SMD -0.31, 95% CI -0.73 to 0.10).

The highest-ranked interventions were dance (P-score: 0.88), aqua-based training (P-score: 0.69), and gait/balance/functional training (P-score: 0.67). The lowest-ranked interventions were flexibility training (P-score: 0.05), a passive control group (P-score: 0.10), and an active control group (P-score: 0.23) (Figure 9).

Figure 9. Forest plot for severity of motor signs.
Reference treatment: passive control. Treatment effects are expressed as standardized mean differences (SMD) with 95% confidence intervals (CI). Treatments are ordered by P-score (descending). Please note that severity of motor signs is labelled 'clinician-rated impairment and disability' (CRID), a term we had originally used for this outcome, but ultimately discarded for the sake of higher accuracy and better readability.



Cochran's Q test and I^2 statistics indicated moderate to substantial heterogeneity between the studies (Q_{total} = 163.38, degrees of freedom (df) = 68, P < 0.001; Q_{within} = 87.87, df = 40, P < 0.001; $Q_{between}$ = 75.51, df = 28, P < 0.001; I^2 = 58.4%, Tau^2 = 0.1501).

For the severity of motor signs, we judged 35 study results (49.3%) to be at high overall risk of bias. Most frequently, we had concerns regarding bias due to deviations from the intended interventions, as the results reported by trialists frequently lacked data from a substantial proportion of participants who had been randomized, which may lead to an overestimation of effects.

We rated the confidence in the evidence for the severity of motor signs using the CINeMA approach (Nikolakopoulou 2020), for the comparison of each intervention included in our decision set, except gaming, with a passive control group. The evidence suggests that dance has a moderate beneficial effect on the severity of motor signs (high confidence), and aqua-based, gait/balance/functional, and multi-domain training might have a moderate beneficial effect on the severity of motor signs (low confidence). Furthermore, we found that mind-body and endurance training might have a small beneficial effect on the severity of motor signs (low confidence). Flexibility training might have a trivial or no effect on the severity of motor signs (low confidence). The evidence is very uncertain about the effects of strength/resistance training and LSVT BIG on the severity of motor signs (very low confidence).

The most common limitations to our confidence in the effects on the severity of motor signs were either: (a) a large proportion of 'high risk of bias' studies and inconsistency between results of the primary analysis and sensitivity analysis limited to 'low risk of bias' studies (downgraded by one level for risk of bias for the effects of aqua-based, gait/balance/functional, multi-domain, strength/resistance, and mind-body training); or (b) a large proportion of studies with at least some concerns regarding risk of bias while no sensitivity analysis could be conducted (downgraded by one level for risk of bias for the effect of LSVT BIG), and inconsistencies between the effects observed when considering only confidence intervals and when additionally considering prediction intervals (downgraded by one level for heterogeneity for the effects of aqua-based, endurance, gait/balance/functional, mind-body, multi-domain, and strength/resistance training). Prediction intervals are provided in Appendix 11. Details on reasons for downgrading are provided in Summary of findings 1.

Tests for inconsistencies in closed loops indicated disagreements between direct and indirect estimates for the comparisons of gait/balance/functional training with mind-body training (P = 0.002), and strength/resistance training with a passive control group (P = 0.046) (Table 5, Figure 10).

Figure 10. Comparison of direct and indirect evidence (in closed loops) for severity of motor signs. Treatment effects are expressed as standardized mean differences (SMD) with 95% confidence intervals (CI). Please note that

severity of motor signs is labelled 'clinician-rated impairment and disability' (CRID), a term we had originally used for this outcome, but ultimately discarded for the sake of higher accuracy and better readability.

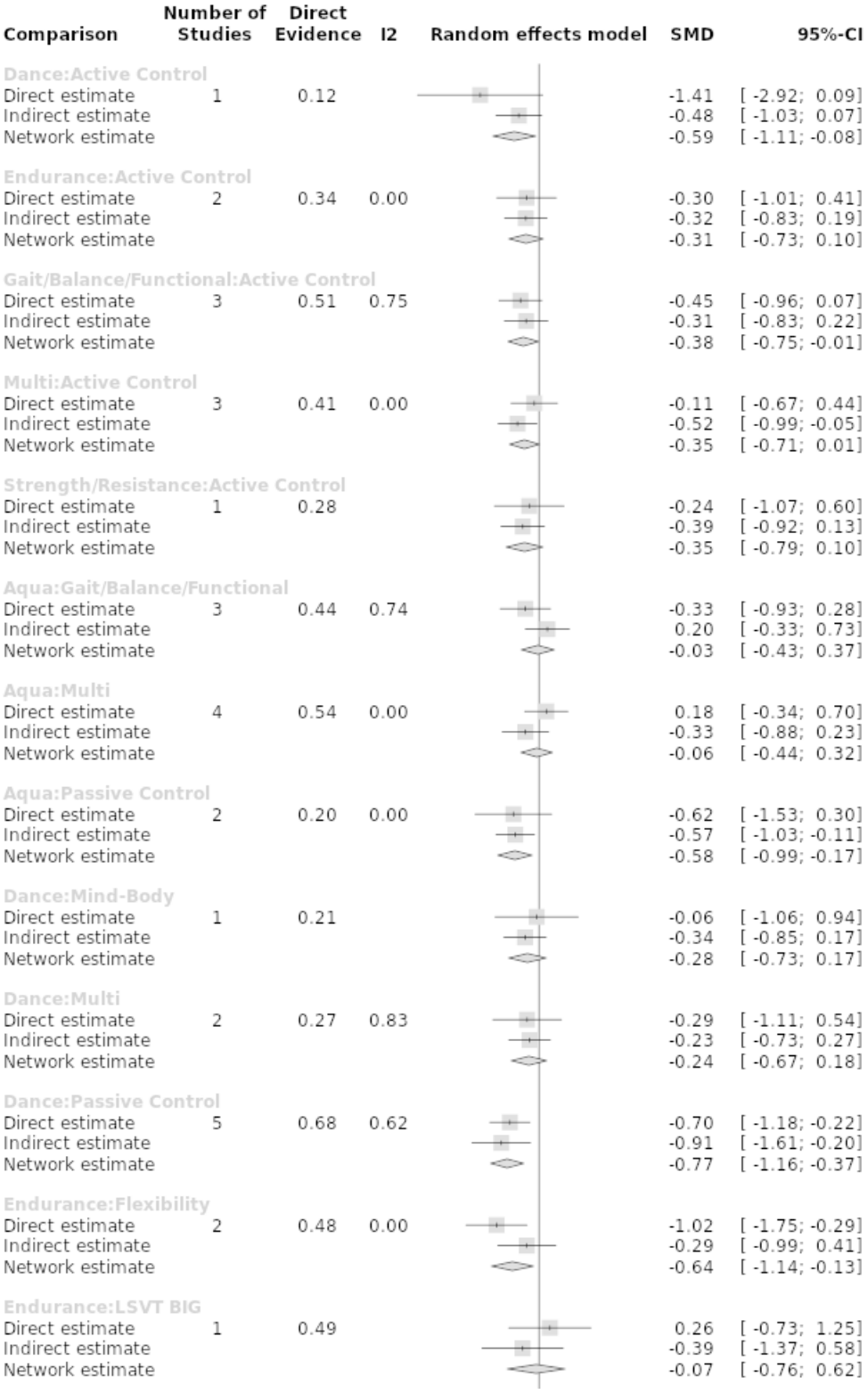


Figure 10. (Continued)

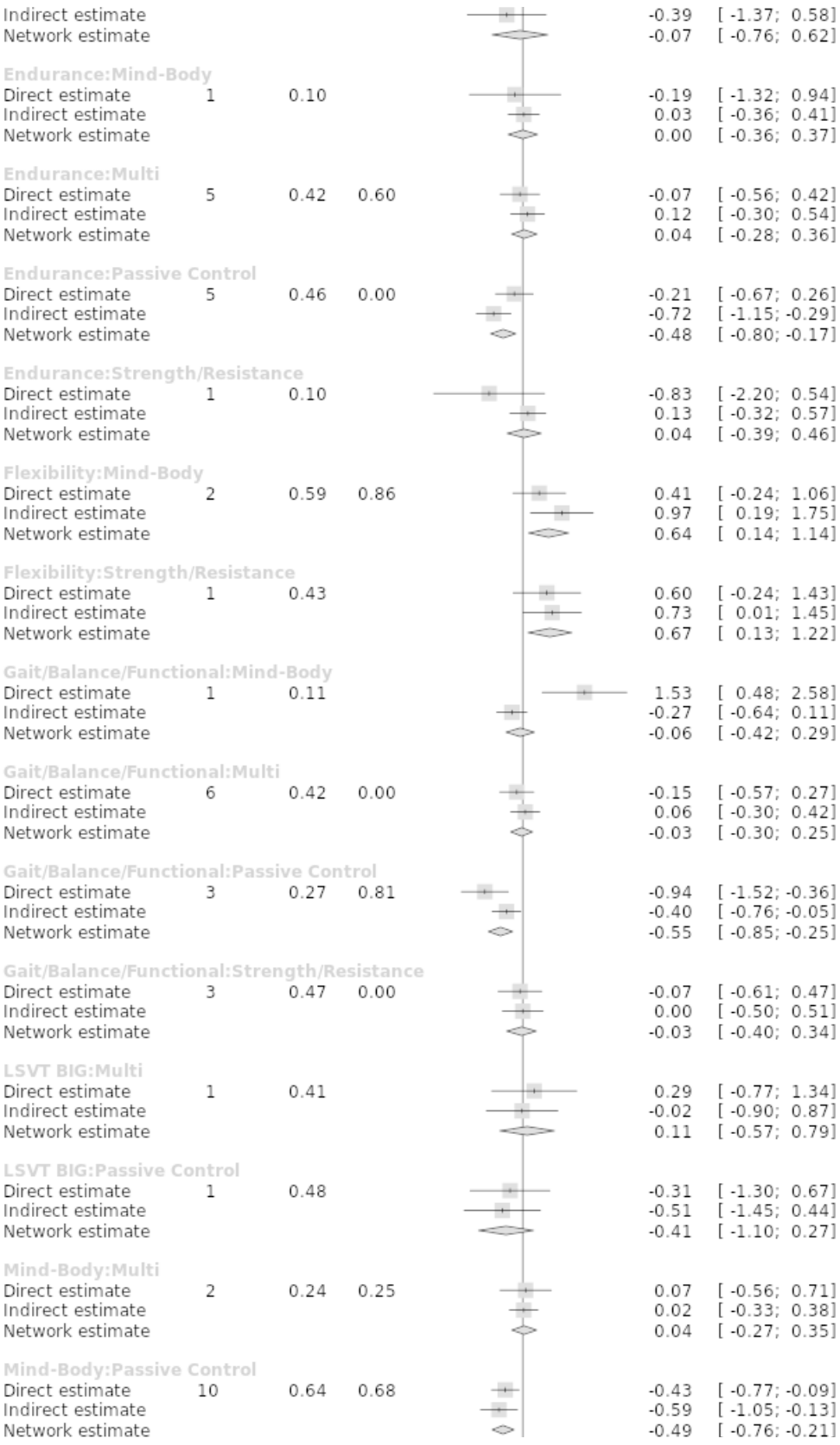
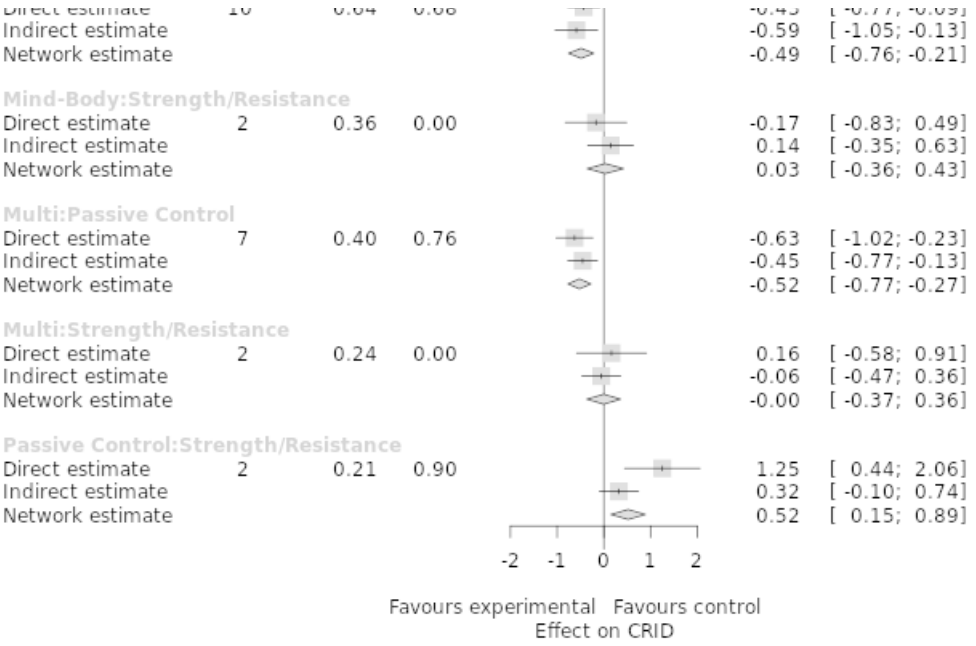


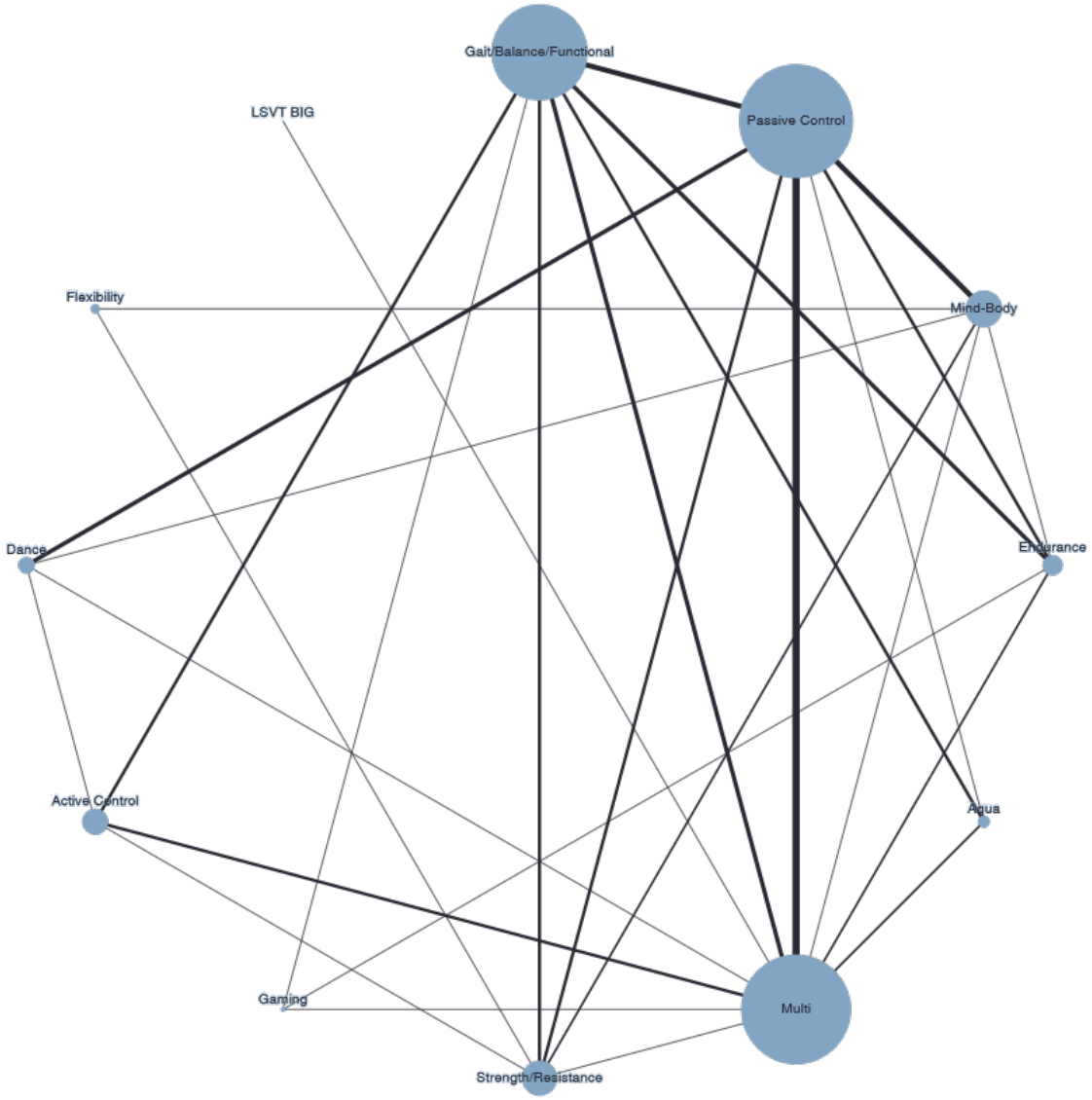
Figure 10. (Continued)



Quality of life

Data on quality of life (QoL) were reported in 55 studies, of which six had three arms (3283 participants; Allen 2010; Amano 2013; Ashburn 2018; Burini 2006; Canning 2012; Canning 2015; Carroll 2018; Cheng 2017; Cholewa 2013; Corcos 2013; Daneshvar 2019; Ferraz 2018; Ferrazzoli 2018; Ferreira 2018; Gobbi 2021; Goodwin 2011; Johansson 2018; King 2020; Kunkel 2017; Kwok 2019; Lee HJ 2018; Li 2012; Liao 2015; Michels 2018; Morris 2009; Morris 2015; Morris 2017; Nadeau 2014; Ni 2016; Nieuwboer 2007; Pedreira 2013; Peloggia Cursino 2018; Pohl 2013; Pohl 2020; Poier 2019; Poliakoff 2013; Qutubuddin 2013; Rios Romenets 2015; Santos 2017a; Santos 2017b; Schaible 2021; Schenkman 2012; Schlenstedt 2015; Schmitz-Hubsch 2006; Shahmohammadi 2017; Shulman 2013; Terrens 2020; Tollar 2018; Tollar 2019; Vergara-Diaz 2018; Volpe 2013; Volpe 2014; Volpe 2017a; Volpe 2017b; Winward 2012). The fully-connected network was based on 67 pairwise comparisons and included data on all interventions (Figure 11).

Figure 11. Network graph for quality of life. Treatments are connected by a line when there is at least one study comparing the two treatments.
Line width: number of studies. Node width: number of participants.



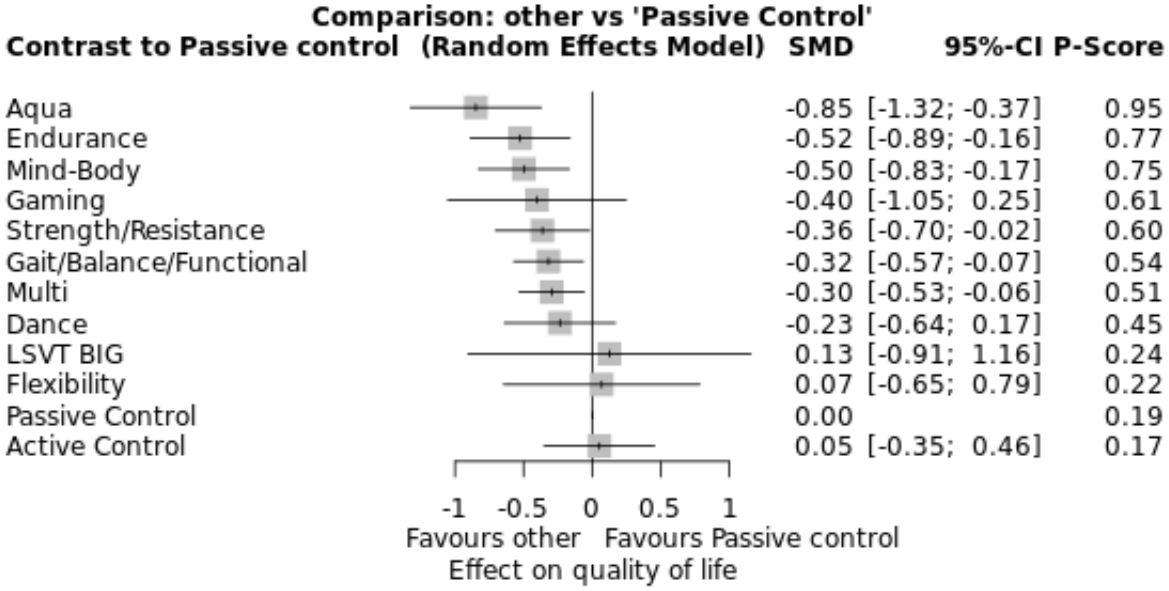
A league table with results for all pairwise comparisons, including network estimates and direct estimates, is displayed in Table 2. Please note that higher scores denote lower QoL. Therefore, negative estimates reflect improvement. Also, please note that the minimum clinically important difference for improvement of -4.72 points on the PDQ-39 corresponds to an SMD of -0.27 (Horvath 2017).

The evidence suggests that QoL was increased for six interventions compared to a passive control group (aqua-based training: SMD -0.85, 95% CI -1.32 to -0.37; endurance training: SMD -0.52, 95% CI -0.89 to -0.16; mind-body training: SMD -0.50, 95% CI -0.83 to -0.17; strength/resistance training: SMD -0.36, 95% CI -0.70 to -0.02; gait/balance/functional training: SMD -0.32, 95% CI -0.57 to -0.07; multi-domain training: SMD -0.30, 95% CI -0.53 to -0.06). For three interventions, the evidence also suggests increases in QoL compared to an active control group (aqua-based training: SMD -0.90, 95% CI -1.47 to -0.33; endurance training: SMD -0.58, 95% CI -1.07 to -0.08; mind-body training: SMD -0.55, 95% CI -1.03 to -0.07). Moreover, for aqua-based training, the evidence suggests that QoL was increased compared to gait/balance/functional training (SMD -0.53, 95% CI -0.99 to -0.07), multi-domain training (SMD -0.55, 95% CI -1.02 to -0.09), and flexibility training (SMD -0.92, 95% CI -1.76 to -0.08). There was no further evidence of statistically significant effects. However, we observed that several interventions may also have beneficial effects on QoL compared to an active control group,

but the CIs extended across the line of no effect (e.g. multi-domain training: SMD -0.55, 95% CI -1.03 to -0.07; strength/resistance training: SMD -0.41, 95% CI -0.87 to 0.04; gait/balance/functional training: SMD -0.37, 95% CI -0.76 to 0.02). Furthermore, the effect of aqua-based training on QoL may be increased compared to dance (SMD -0.61, 95% CI -1.22 to 0.00) and strength/resistance training (SMD -0.49, 95% CI -1.03 to 0.06), but the CIs touched or extended across the line of no effect. Also, the CIs related to some comparisons that involved LSVT BIG were very wide. That is, the CIs of the effects of LSVT BIG on QoL compared to flexibility training and an active control group included both inferiority and superiority of LSVT BIG (LSVT BIG compared to flexibility: SMD 0.06, 95% CI -1.18 to 1.30; LSVT BIG compared to an active control group: SMD 0.07, 95% CI -1.00 to 1.15).

The highest-ranked interventions were aqua-based training (P-score: 0.95), endurance training (P-score: 0.77), and mind-body training (P-score: 0.75). The lowest-ranked interventions were an active control group (P-score: 0.17), a passive control group (P-score: 0.19), and flexibility training (P-score: 0.22) (Figure 12).

Figure 12. Forest plot for quality of life. Reference treatment: passive control. Treatment effects are expressed as standardized mean differences (SMD) with 95% confidence intervals (CI). Treatments are ordered by P-score (descending).



Cochran's Q test and I^2 statistics indicated moderate to substantial heterogeneity between the studies (Q_{total} = 125.02, df = 50, P < 0.001; Q_{within} = 71.91, df = 26, P < 0.001; $Q_{between}$ = 53.11, df = 24, P < 0.001; I^2 = 60.0%, Tau^2 = 0.1210).

For QoL, we judged all study results to be at high overall risk of bias due to the subjectivity of the assessment. Moreover, we frequently had concerns regarding bias due to deviations from the intended interventions, as the results reported by trialists frequently lacked data from a substantial proportion of participants who had been randomized. Both self-report of the outcome and failure to report data for the intention-to-treat sample may lead to an overestimation of effects.

Again, we rated the confidence in the evidence for QoL using the CINeMA approach for the comparison of each intervention included in our decision set with a passive control group (Nikolakopoulou 2020). The evidence suggests that aqua-based training probably has a large beneficial effect on QoL (moderate confidence). Furthermore, we found that endurance training might have a moderate beneficial effect, while gait/balance/functional and multi-domain training might have a small beneficial effect on quality of life (low confidence). The evidence is very uncertain about the effects of mind-body training, gaming, strength/resistance training, dance, LSVT BIG, and flexibility training on QoL (very low confidence).

A primary limitation to our confidence in the effects was due to the self-report of QoL and the corresponding risk of bias in the measurement of the outcome as assessed by domain 4 of the RoB 2 tool (Sterne 2019). Therefore, for all comparisons, we downgraded by one level for risk of bias. For the effects of mind-body training, gaming, dance, and flexibility training on QoL compared to a passive control group, we downgraded by a total number of two levels for risk of bias, because the effect estimates were highly affected by studies that were judged to be at high risk of bias considering only the domains that are not affected by self-reporting of the outcome (i.e. excluding domain 4 of the RoB 2 tool). The second most common limitation to our confidence in the evidence were inconsistencies between the

effects observed when considering only confidence intervals and when additionally considering prediction intervals (downgraded by one level for heterogeneity for the effects of endurance, gait/balance/functional, mind-body, multi-domain, and strength/resistance training). Prediction intervals are provided in Appendix 12. Details on reasons for downgrading are provided in Summary of findings 2.

Tests for inconsistencies in closed loops indicated disagreement between direct and indirect estimates for the comparison of strength/resistance training with a passive control group (P = 0.031) (Table 6, Figure 13).

Figure 13. Comparison of direct and indirect evidence (in closed loops) for quality of life. Treatment effects are expressed as standardized mean differences (SMD) with 95% confidence intervals (CI). QoL = quality of life

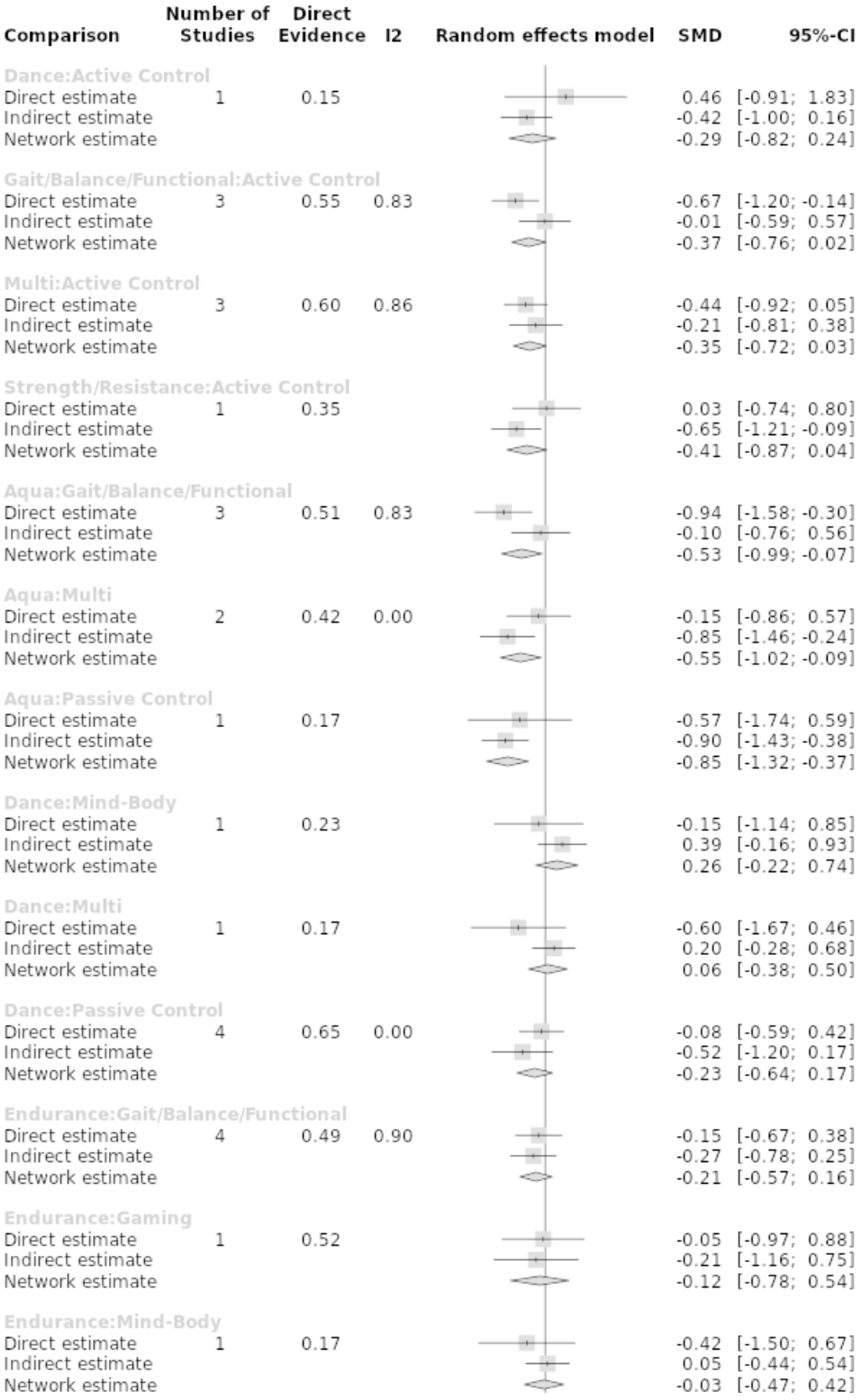


Figure 13. (Continued)

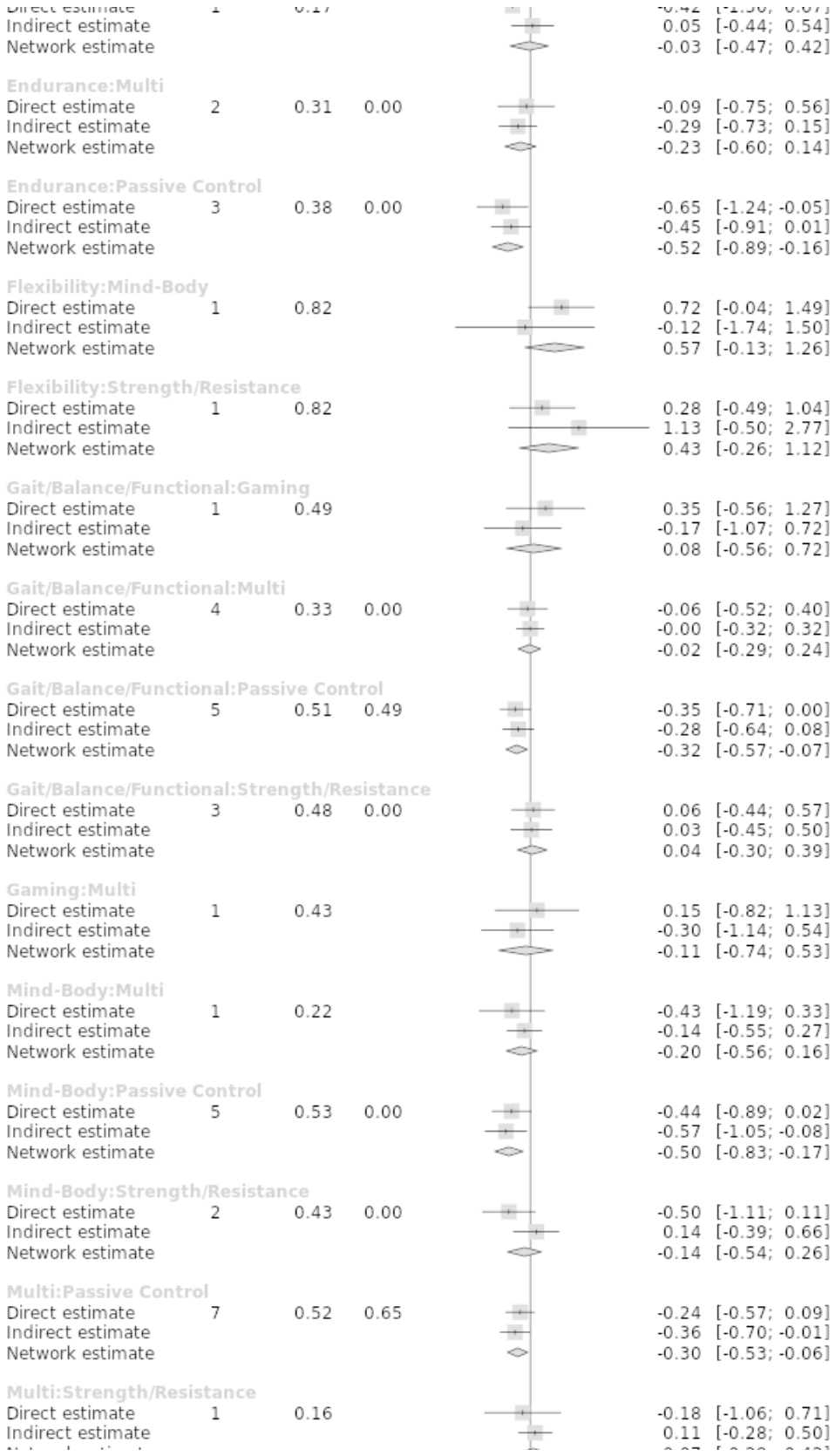
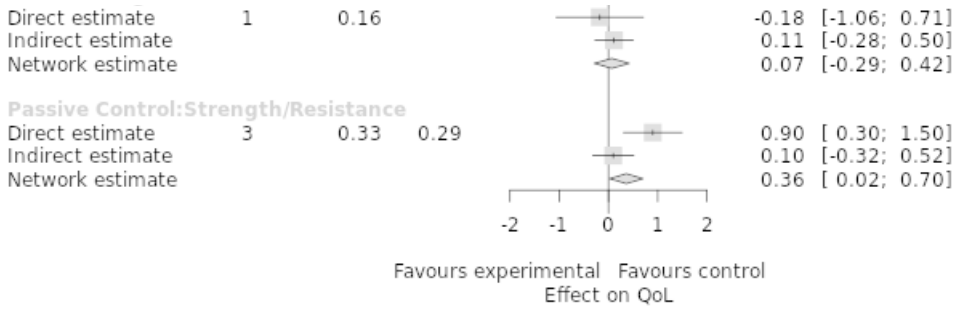


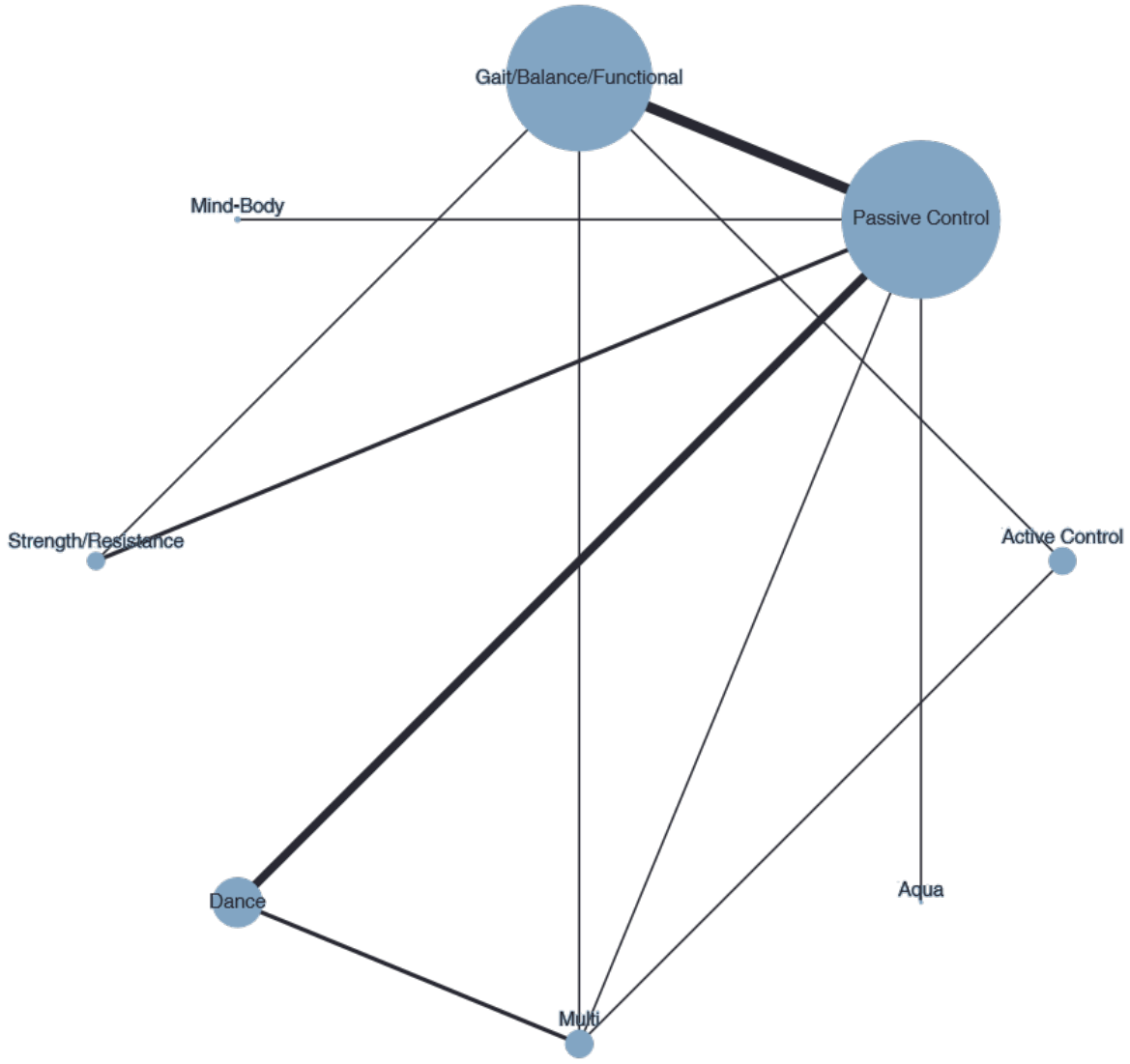
Figure 13. (Continued)



Freezing of gait

Data on freezing of gait were reported in 20 studies (1048 participants; Allen 2010; Canning 2015; Capato 2020a; Carroll 2018; Cheng 2017; Duncan 2012; Hackney 2007; Hackney 2009; King 2020; Martin 2015; Medijainen 2019; Nieuwboer 2007; Paul 2014; Pohl 2020; Rios Romenets 2015; Santos 2017a; Santos 2017c; Schlenstedt 2015; Van Puymbroeck 2018; Volpe 2013). All studies had two arms. The fully-connected network was based on 20 pairwise comparisons and included data on all interventions except for endurance training, flexibility training, gaming, and LSVT BIG (Figure 14).

Figure 14. Network graph for freezing of gait. Treatments are connected by a line when there is at least one study comparing the two treatments.
Line width: number of studies. Node width: number of participants.

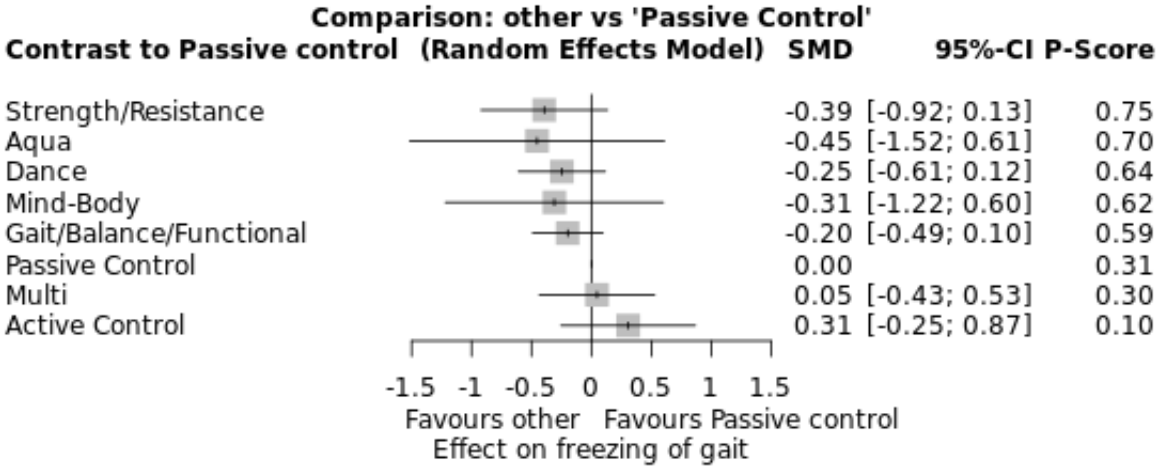


A league table with results for all pairwise comparisons including network estimates and direct estimates is displayed in Table 3. Please note that higher scores denote increased freezing of gait. Therefore, negative estimates reflect improvement. Also, please note that the minimum clinically important difference for improvement of -3 points on the FOG-Q corresponds to an SMD of -0.64 (Fietzek 2020).

We did not identify evidence for statistically significant effects on freezing of gait. However, according to the estimates, some interventions may have beneficial effects on freezing of gait compared to an active control group, but the CIs extended across the line of no effect (e.g. strength/resistance training: SMD -0.70, 95% CI -1.45 to 0.05; dance: SMD -0.55, 95% CI -1.18 to 0.08; gait/balance/functional training: SMD -0.50, 95% CI -1.02 to 0.01). Gait/balance/functional training may also have a beneficial effect on freezing of gait compared to a passive control group, but again, the CI extended across the line of no effect (SMD -0.20, 95% CI -0.49 to 0.10). Also, the CIs related to some comparisons that involved aqua-based training were very wide. That is, the CIs of the effects of aqua-based training on freezing of gait compared to strength/resistance training and mind-body training included both inferiority and superiority of aqua-based training (strength/resistance training compared to aqua-based training: SMD 0.06, 95% CI -1.13 to 1.25; aqua-based training compared to mind-body training: SMD -0.14, 95% CI -1.54 to 1.25).

The highest-ranked interventions were strength/resistance training (P-score: 0.75), aqua-based training (P-score: 0.70), and dance (P-score: 0.64). The lowest-ranked interventions were an active control group (P-score: 0.10), multi-domain training (P-score: 0.30), and a passive control group (P-score: 0.31) (Figure 15). However, the ranking of the interventions should be interpreted very carefully given the large size of the confidence intervals of the effect estimates.

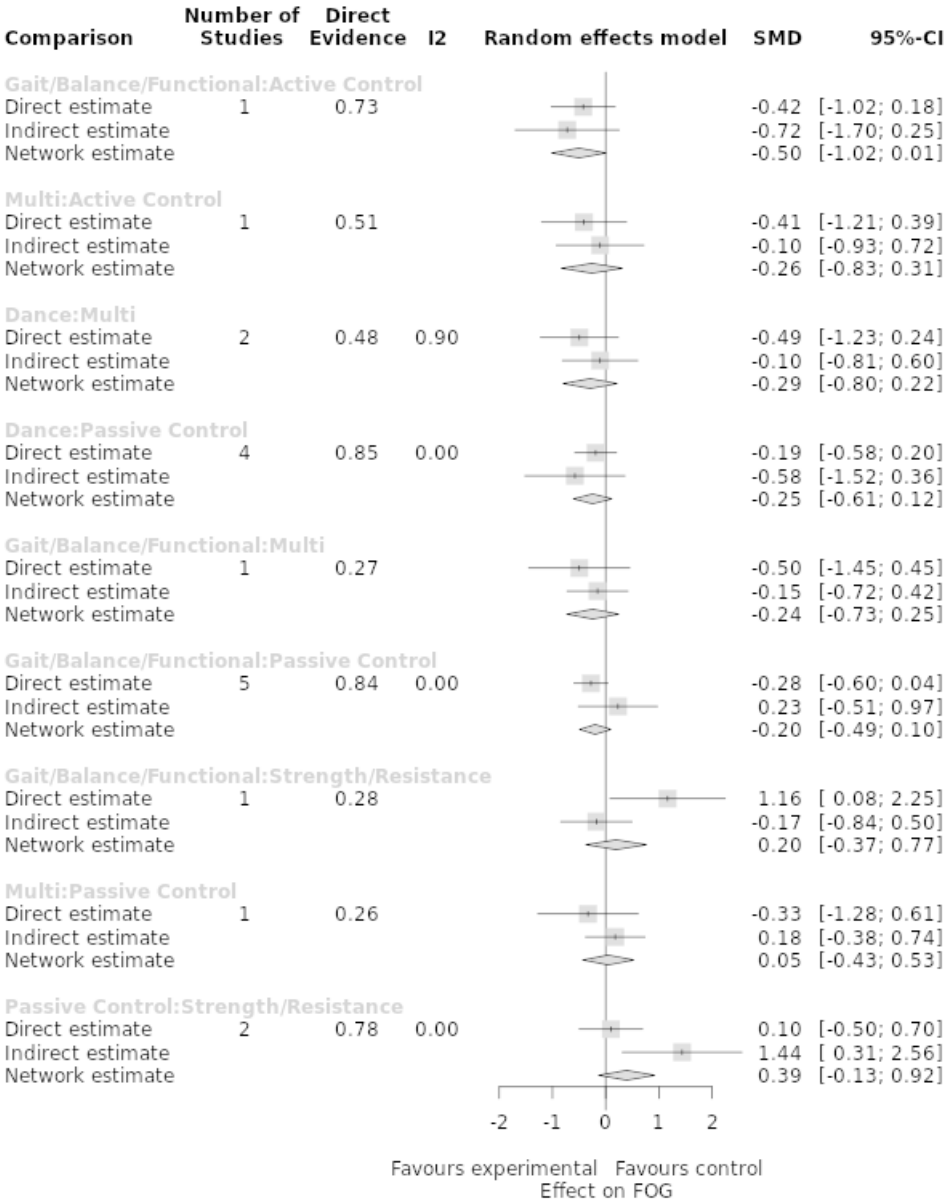
Figure 15. Forest plot for freezing of gait. Reference treatment: passive control. Treatment effects are expressed as standardized mean differences (SMD) with 95% confidence intervals (CI). Treatments are ordered by P-score (descending).



The presence of moderate heterogeneity between the studies as indicated by I^2 statistics was not found to be statistically significant according to Cochran's Q test (Q_{total} = 22.36, df = 13, P = 0.050; Q_{within} = 14.83, df = 9, P = 0.10; $Q_{between}$ = 7.53, df = 4, P = 0.11; I^2 = 41.9%, Tau^2 = 0.0632).

Tests for inconsistencies in closed loops indicated disagreements between direct and indirect estimates for the comparisons of both gait/balance/functional training and a passive control group with strength/resistance training (P = 0.0395) (Table 7, Figure 16).

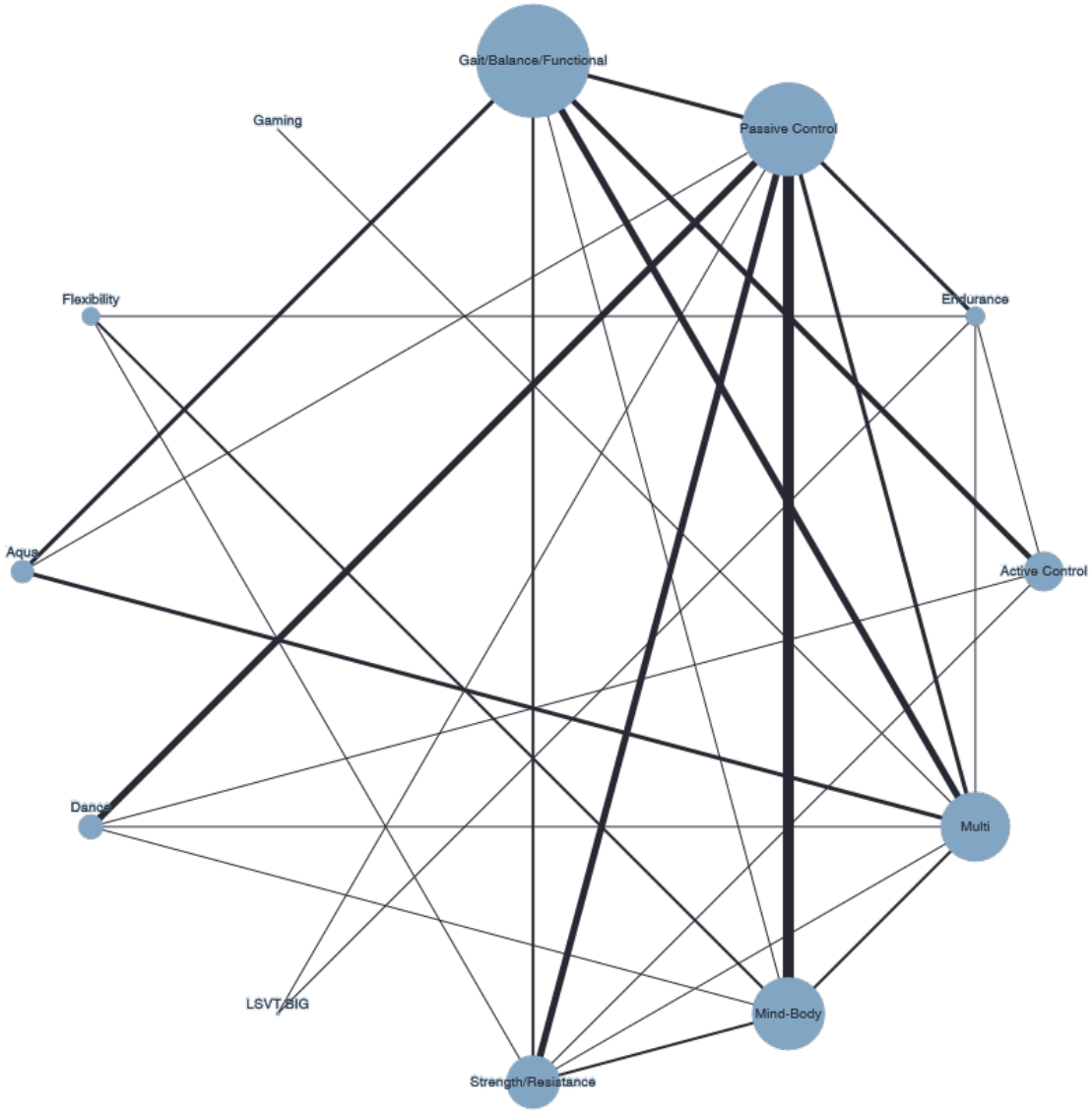
Figure 16. Comparison of direct and indirect evidence (in closed loops) for freezing of gait. Treatment effects are expressed as standardized mean differences (SMD) with 95% confidence intervals (CI). FOG = freezing of gait



Functional mobility and balance

Data on functional mobility and balance were reported in 54 studies, of which six had three arms (2546 participants; Almeida 2012; Arfa-Fatollahkhani 2019; Capato 2020a; Chaiwanichsiri 2011; Cheng 2017; Cherup 2021; Choi 2013; Corcos 2013; Cugusi 2015; da Silva Rocha Paz 2019; De Moraes Filho 2020; Ebersbach 2010; Feng 2019; Ferreira 2018; Fil-Balkan 2018; Gao 2014; Guan 2016; Hackney 2007; Hackney 2009; Kunkel 2017; Kurt 2018; Kwok 2019; Li 2012; Liao 2015; Liu 2016; Mak 2021; Michels 2018; Morris 2009; Morris 2015; Ni 2016; Nieuwboer 2007; Paul 2014; Pérez de la Cruz 2017; Pohl 2013; Ridgel 2019; Rios Romenets 2015; Santos 2019; Schilling 2010; Schlenstedt 2015; Sedaghati 2016; Shen 2021; Shulman 2013; Silva 2019; Solla 2019; Tollar 2019; Vergara-Diaz 2018; Volpe 2014; Volpe 2017a; Volpe 2017b; Wan 2021; Wang 2017; Wong-Yu 2015; Youm 2020; Zhang 2015). The fully-connected network was based on 64 pairwise comparisons and included data on all interventions (Figure 17).

Figure 17. Network graph for functional mobility and balance. Treatments are connected by a line when there is at least one study comparing the two treatments.
Line width: number of studies. Node width: number of participants.



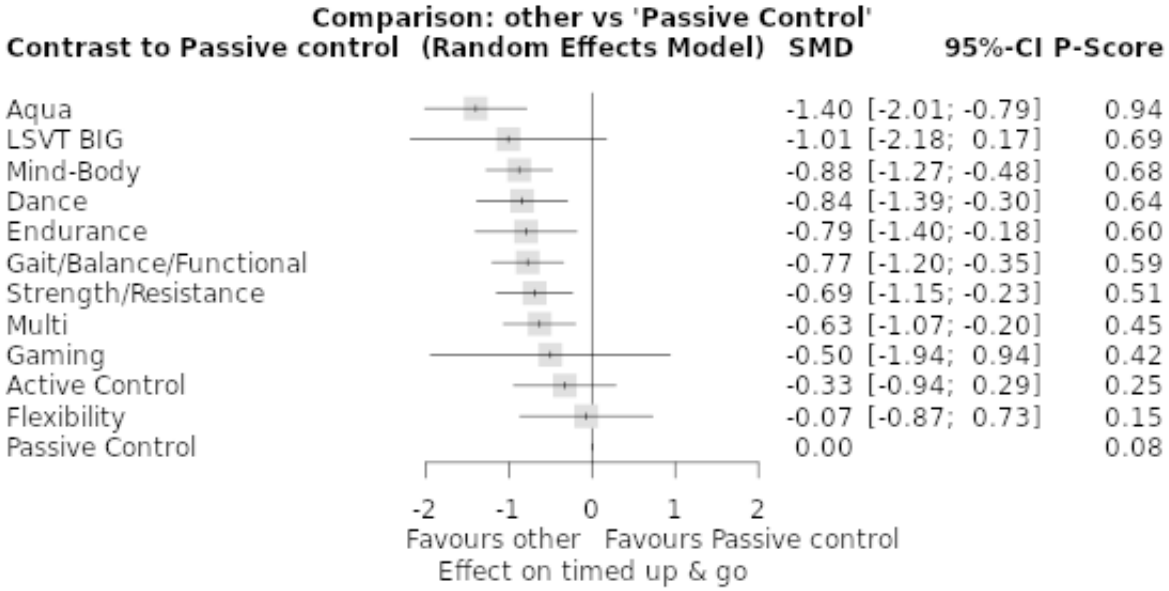
A league table with results for all pairwise comparisons, including network estimates and direct estimates, is displayed in Table 4. Please note that higher scores denote more time to complete the Timed Up and Go test (TUG) and thus, worse functionality and balance. Therefore, negative estimates reflect improvement. Also, please note that the minimum detectable change of -3.5 seconds on the TUG corresponds to an SMD of -0.86 (Huang 2011).

The evidence suggests that functional mobility and balance were increased for seven interventions compared to a passive control group (aqua-based training: SMD -1.40, 95% CI -2.01 to -0.79; mind-body training: SMD -0.88, 95% CI -1.27 to -0.48; dance: SMD -0.84, 95% CI -1.39 to -0.30; endurance training: SMD -0.79, 95% CI -1.40 to -0.18; gait/balance/functional training: SMD -0.77, 95% CI -1.20 to -0.35; strength/resistance training: SMD -0.69, 95% CI -1.15 to -0.23; multi-domain training: SMD -0.63, 95% CI -1.07 to -0.20). Moreover, for aqua-based training, the evidence suggests that functional mobility and balance were increased compared to gait/balance/functional training (SMD -0.63, 95% CI -1.19 to -0.06), strength/resistance training (SMD -0.71, 95% CI -1.40 to -0.01), multi-domain training (SMD -0.77, 95 % CI -1.33 to -0.20), an active control group (SMD -1.07, 95% CI -1.83 to -0.32), and flexibility training (SMD -1.33, 95% CI -2.29 to -0.37). We also identified evidence suggesting that functional mobility and balance were increased for mind-body training compared to flexibility training (SMD -0.81, 95% CI -1.58 to -0.04). There was no further

evidence of statistically significant effects. However, we observed that gait/balance/functional training may have a beneficial effect on functional mobility and balance compared to an active control group, but the CIs extended across the line of no effect (SMD -0.45, 95% CI -0.99 to 0.10). Similarly, LSVT BIG may have a large beneficial effect on functional mobility and balance compared to a passive control group, but the CI extended across the line of no effect (SMD -1.01, 95% CI -2.18 to 0.17). The CIs related to comparisons that involved gaming were very wide. For example, the estimate of the effect of gaming on functional mobility and balance compared to an active control group included both benefit and harm (SMD -0.18, 95% CI -1.69 to 1.34). This also applies to effects of gaming on functional mobility and balance in relation to other types of physical exercise. For example, the CIs included both inferiority and superiority of the effects of gaming on functional mobility and balance compared to LSVT BIG (LSVT BIG compared to gaming: SMD -0.50, 95% CI -2.35 to 1.35), or multi-domain training (multi-domain training compared to gaming: SMD -0.13, 95% CI -1.50 to 1.25).

The highest-ranked interventions were aqua-based training (P-score: 0.94), LSVT BIG (P-score: 0.69), and mind-body training (P-score: 0.68), while the lowest-ranked interventions were a passive control group (P-score: 0.08), flexibility training (P-score: 0.15), and an active control group (P-score: 0.25) (Figure 18).

Figure 18. Forest plot for functional mobility and balance. Reference treatment: passive control. Treatment effects are expressed as standardized mean differences (SMD) with 95% confidence intervals (CI). Treatments are ordered by P-score (descending).



Cochran's Q test and I^2 statistics indicated substantial to considerable heterogeneity between the studies (Q_{total} = 204.30, df = 48, P < 0.001; Q_{within} = 108.31, df = 27, P < 0.001; $Q_{between}$ = 95.99, df = 21, P < 0.001; I^2 = 76.5%, Tau^2 = 0.3436).

Tests for inconsistencies in closed loops indicated disagreements between direct and indirect estimates for the comparisons of dance with a passive control group (P = 0.015), dance with multi-domain training (P = 0.0495), and multi-domain training with a passive control group (P = 0.007) (Table 8, Figure 19).

Figure 19. Comparison of direct and indirect evidence (in closed loops) for functional balance and mobility. Treatment effects are expressed as standardized mean differences (SMD) with 95% confidence intervals (CI). TUG = Timed Up & Go test

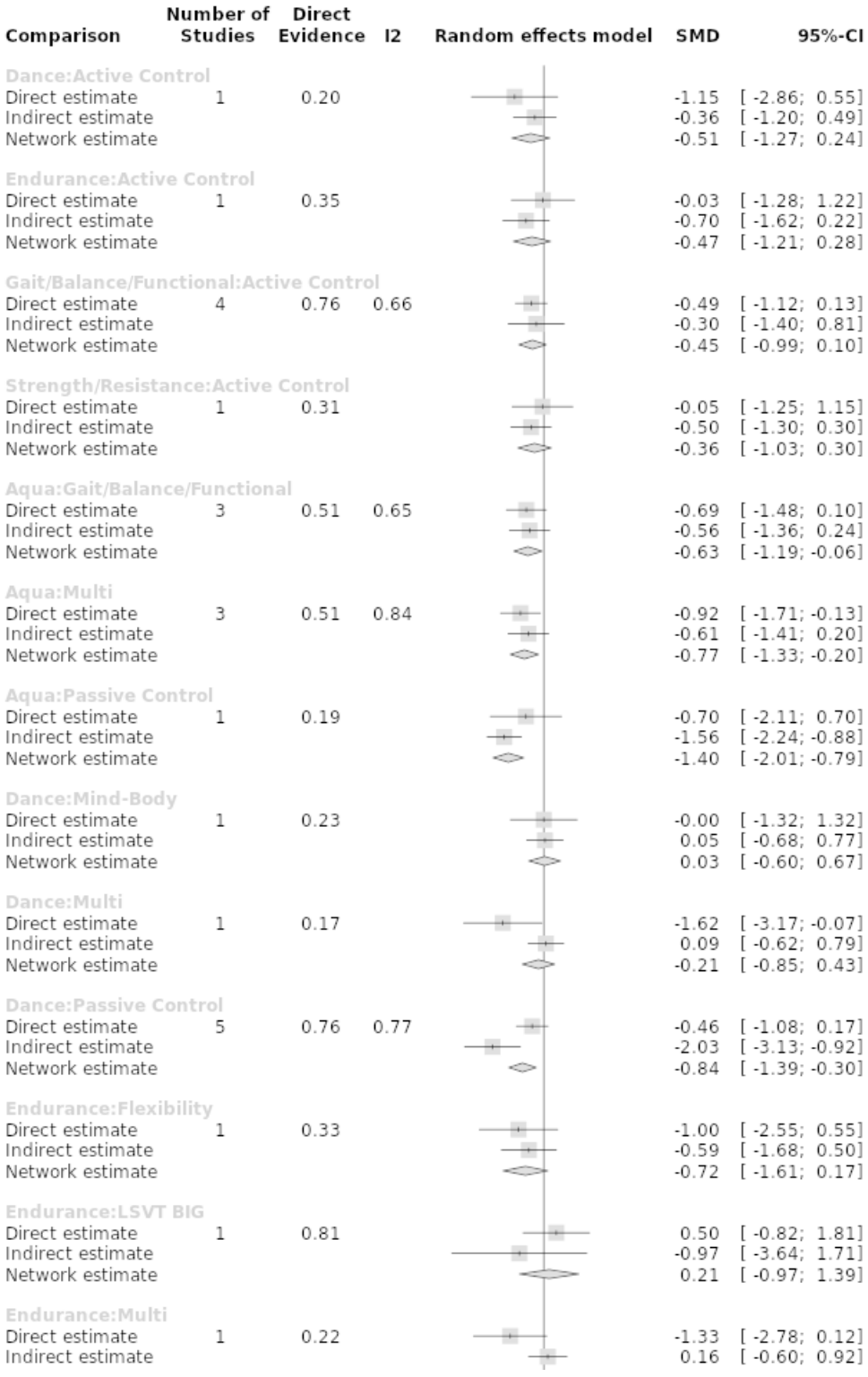


Figure 19. (Continued)

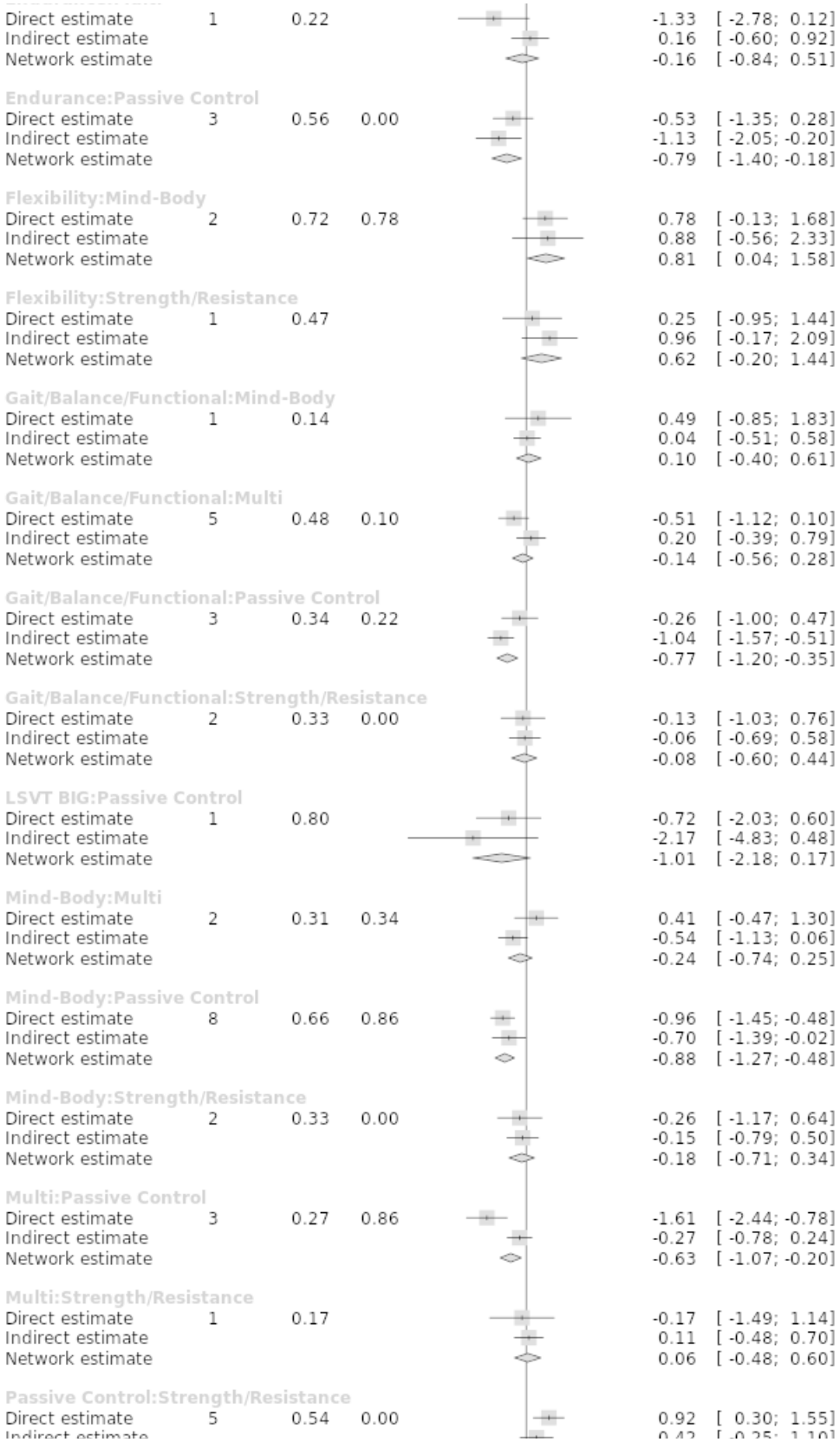
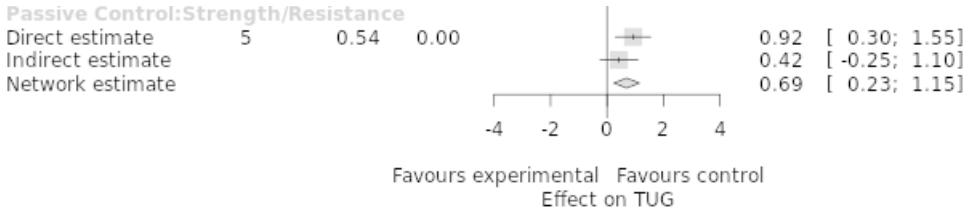


Figure 19. (Continued)



Adverse events (number of participants with any adverse event)

Due to heterogeneity in the measurement and report of adverse events, we did not conduct a quantitative synthesis on the number of participants with any adverse event using an NMA. Instead, we provide a narrative report of the data. For the sake of consistency, we summarize the harms that were described as adverse events by the trialists, while we do not report harms recorded as reasons for dropout unless trialists described them elsewhere as adverse events.

Among the 156 included studies, 85 studies (5192 participants) provided some kind of safety information (i.e. occurrence or absence of events mostly described as adverse events; Allen 2010; Ashburn 2007; Ashburn 2018; Canning 2012; Canning 2015; Cakit 2007; Capato 2020a; Carroll 2018; Chaiwanichsiri 2011; Cheng 2017; Cherup 2021; Cheung 2018; Claesson 2018; Colgrove 2012; Conradsson 2015; Corcos 2013; Cugusi 2015; Dashtipour 2015; Dipasquale 2017; Ferraz 2018; Fietzek 2014; Fisher 2008; Frazzitta 2015; Ganesan 2014; Gao 2014; Goodwin 2011; Hackney 2009; Harvey 2019; Hass 2012; Hubble 2018; Johansson 2018; King 2013; King 2020; Kunkel 2017; Kwok 2019; Lee HJ 2018; Li 2012; Liao 2015; Mak 2021; Martin 2015; Michels 2018; Morris 2009; Morris 2015; Morris 2017; Myers 2020; Nadeau 2014; Ni 2016; Nieuwboer 2007; Ortiz-Rubio 2018; Park 2014; Paul 2014; Pérez de la Cruz 2017; Picelli 2016; Pohl 2013; Pohl 2020; Poier 2019; Poliakoff 2013; Reuter 2011; Ribas 2017; Rios Romenets 2015; Santos 2017a; Schaible 2021; Schenkman 1998; Schenkman 2012; Schenkman 2018; Sedaghati 2016; Shanahan 2017; Shulman 2013; Silva-Batista 2018; Smania 2010; Solla 2019; Sparrow 2016; Szefler-Derela 2020; Terrens 2020;Tollar 2018; Tollar 2019; Vergara-Diaz 2018; Volpe 2013; Volpe 2014; Volpe 2017b; Wong-Yu 2015; Yang 2010; Yen 2011; Yuan 2020; Zhang 2015). Seventy-one studies (46%) did not provide any information on adverse events. Thirteen studies reported falls, but did not label them as adverse events (Cakit 2007; Ferraz 2018; Gao 2014; Goodwin 2011; Hackney 2009; Martin 2015; Morris 2017; Paul 2014; Schenkman 2018; Sedaghati 2016; Smania 2010; Volpe 2014; Wong-Yu 2015). Forty studies reported that there were no adverse events (Canning 2012; Capato 2020a; Carroll 2018; Chaiwanichsiri 2011; Cherup 2021; Cheung 2018; Colgrove 2012; Cugusi 2015; Dipasquale 2017; Fisher 2008; Frazzitta 2015; Ganesan 2014; Hass 2012; Hubble 2018; Lee HJ 2018; Liao 2015; Mak 2021; Morris 2009; Myers 2020; Nadeau 2014; Ni 2016; Ortiz-Rubio 2018; Park 2014; Pérez de la Cruz 2017; Picelli 2016; Pohl 2013; Pohl 2020; Ribas 2017; Santos 2017a; Schaible 2021; Schenkman 1998; Shanahan 2017; Silva-Batista 2018; Solla 2019; Szefler-Derela 2020; Tollar 2018; Tollar 2019; Yang 2010; Yuan 2020; Zhang 2015), and four studies reported that there were no serious or major adverse events (Dashtipour 2015; Li 2012; Shulman 2013; Volpe 2017b). Twenty-eight studies reported that adverse events occurred (Allen 2010; Ashburn 2007; Ashburn 2018; Canning 2015; Cheng 2017; Claesson 2018; Conradsson 2015; Corcos 2013; Fietzek 2014; Harvey 2019; Johansson 2018; King 2013; King 2020; Kunkel 2017; Kwok 2019; Michels 2018; Morris 2015; Nieuwboer 2007; Poier 2019; Poliakoff 2013; Reuter 2011; Rios Romenets 2015; Schenkman 2012; Sparrow 2016; Terrens 2020; Vergara-Diaz 2018; Volpe 2013; Yen 2011). Twenty studies reported the events, separated by all groups (Ashburn 2007; Ashburn 2018; Claesson 2018; Conradsson 2015; Corcos 2013; Harvey 2019; King 2013; Kunkel 2017; Kwok 2019; Michels 2018; Nieuwboer 2007; Poier 2019; Poliakoff 2013; Reuter 2011; Rios Romenets 2015; Schenkman 2012; Sparrow 2016; Terrens 2020; Vergara-Diaz 2018; Volpe 2013), and eight studies reported the events either only for selected groups or combined for the groups (Allen 2010; Canning 2015; Cheng 2017; Fietzek 2014; Johansson 2018; King 2020; Morris 2015; Yen 2011). The events reported by studies were: pain, falls, tendency to fall, fractures, soreness, adverse events without specification, fatigue, hospitalization, injuries, surgeries, death, dizziness, drop in blood pressure, heart problems, hypotension after intense walking uphill in hot weather, illness, lightheadedness, muscle cramps, panic attack, respiratory infection, serious adverse events without specification, slipped disc, sprain/strain, sprained ankle, stiffness, and twisted ankle. Most studies reported events for the intervention groups only.

In summary, only 85 studies provided some kind of safety data, mostly only for the intervention groups. No adverse events occurred in 40 studies. No serious or major adverse events occurred in four studies. Adverse events occurred in 28 studies. The most frequently reported events were falls (18 studies) and pain (10 studies).

Retrieving effect estimates for a network meta-analysis was not feasible because reporting of adverse events was highly heterogeneous and frequently incomplete. Therefore, we judged the risk of bias for this outcome to be high.

We rated the confidence in the evidence for adverse events using the GRADE approach (Schünemann 2022). We downgraded our confidence in the evidence by two levels for risk of bias due to highly heterogeneous and frequently incomplete reporting of safety data. We downgraded by one level for imprecision, as we could not estimate the effects using quantitative analyses. As a result, the evidence is very uncertain about the effect of physical exercise on the risk of adverse events.

Subgroup analyses

We conducted subgroup analyses by the length of intervention (< 12 weeks, ≥ 12 weeks) for all outcomes included in the NMAs. Due to the distribution of characteristics of the included studies and participants, we were not able to perform subgroup analyses by the age (< 50 years, ≥ 50 years), sex (male, female), or cognitive stage (without cognitive impairment, with cognitive impairment) of the participants. We describe the results of the NMAs for each outcome, separated by the length of intervention, below (data not shown). Please note that there is no formal statistical test for the presence of subgroup differences in NMAs. Therefore, we have reported the results of the subgroup analyses narratively; these results should be interpreted with caution (see also 'Impact of the length of the intervention' section in the Summary of main results).

Severity of motor signs

From 71 studies reporting the severity of motor signs, the length of intervention was less than 12 weeks for 41 studies, and 12 weeks or longer for 30 studies. The network of studies (1514 participants) with interventions lasting less than 12 weeks included data on all interventions included in the full analysis (i.e. all interventions except for gaming), while no data on aqua-based training, LSVT BIG, and gaming were included in the network of studies (1032 participants) with interventions lasting for 12 weeks or longer. Both networks were fully connected.

Analyzing studies with an intervention length of less than 12 weeks, we found evidence suggesting that the severity of motor signs was decreased for four interventions compared to a passive control group (mind-body training: SMD -0.65, 95% CI -1.17 to -0.12; aqua-based training: SMD -0.63, 95% CI -1.12 to -0.14; gait/balance/functional training: SMD -0.56, 95% CI -0.94 to -0.18; multi-domain training: SMD -0.52, 95% CI -0.88 to -0.18). We did not identify evidence for further statistically significant effects. However, we observed that several interventions may also have beneficial effects on the severity of motor signs compared to an active control group, but the CIs extended across the line of no effect (aqua-based training: SMD -0.48, 95% CI -1.05 to 0.09; gait/balance/functional training: SMD -0.40, 95% CI -0.83 to 0.02; multi-domain training: SMD -0.36, 95% CI -0.80 to 0.07). Similarly, some interventions may have beneficial effects on the severity of motor signs compared to flexibility training, but, again, the CIs extended across the line of no effect (mind-body training: SMD -1.48, 95% CI -2.99 to 0.02; aqua-based training: SMD -1.47, 95% CI -2.98 to 0.05; gait/balance/functional training: SMD -1.39, 95% CI -2.87 to 0.09).

Analyzing studies with an intervention length of 12 weeks or longer, we found evidence suggesting that the severity of motor signs was decreased for five interventions compared to a passive control group (dance: SMD -0.93, 95% CI -1.42 to -0.43; endurance training: SMD -0.66, 95% CI -1.12 to -0.20; strength/resistance training: SMD -0.64, 95% CI -1.18 to -0.11; multi-domain training: SMD -0.60, 95% CI -0.99 to -0.21; mind-body training: SMD -0.46, 95% CI -0.80 to -0.11). Also, the evidence suggests that the severity of motor signs was decreased for three interventions compared to flexibility training (dance: SMD -0.95, 95% CI -1.67 to 0.22; endurance training: SMD -0.68, 95% CI -1.28 to -0.07; strength/resistance training: SMD -0.66, 95% CI -1.29 to -0.03). Similar to the interventions lasting less than 12 weeks, some interventions lasting longer than 12 weeks may also have beneficial effects on the severity of motor signs compared to flexibility training (multi-domain training: SMD -0.62, 95% CI -1.24 to 0.00; mind-body training: SMD -0.48, 95% CI -1.03 to 0.08), but the CIs touched or extended across the line of no effect. Also, the effect of dance on the severity of motor signs may be superior to the effect of mind-body training, but the CI extended across the line of no effect (SMD -0.47, 95% CI -1.02, 0.08).

In the analysis of studies with an intervention lasting less than 12 weeks using a passive control group as reference treatment, the highest-ranked interventions were mind-body training (P-score: 0.78), aqua-based training (P-score: 0.77), and gait/balance/functional training (P-score: 0.71). The lowest-ranked interventions were flexibility training (P-score: 0.06), a passive control group (P-score: 0.17), and an active control group (P-score: 0.30).

In the analysis of studies with an intervention lasting for 12 weeks or longer using a passive control group as reference treatment, the highest-ranked interventions were dance (P-score: 0.89), endurance training (P-score: 0.70), and strength/resistance training (P-score: 0.68). The lowest-ranked interventions were a passive control group (P-score: 0.15), flexibility training (P-score: 0.16), and an active control group (P-score: 0.33).

Cochran's Q test and I^2 statistics indicated that there was moderate to substantial heterogeneity between the studies in the subgroup analyses (< 12 weeks: Q_{total} = 93.57, df = 34, P < 0.001; Q_{within} = 53.09, df = 19, P < 0.001; $Q_{between}$ = 40.48, df = 15; P < 0.001; I^2 = 63.7%, Tau^2 = 0.1925; and ≥ 12 weeks: Q_{total} = 60.11, df = 25, P < 0.001; Q_{within} = 23.18, df = 13, P = 0.040; $Q_{between}$ = 36.94, df = 12, P < 0.001; I^2 = 58.4%, Tau^2 = 0.1593).

Quality of life

From 55 studies reporting QoL, the length of intervention was less than 12 weeks for 35 studies, and 12 weeks or longer for 20 studies. The network of studies (1826 participants) with interventions lasting for less than 12 weeks included data on all interventions included in the full analysis except for flexibility training, while no data on gaming, dance, and LSVT BIG were included in the network of studies (1457 participants) with interventions lasting for 12 weeks or longer. Both networks were fully connected.

Analyzing studies with an intervention length of less than 12 weeks, we found evidence suggesting that QoL was increased for three interventions compared to a passive control group (aqua-based training: SMD -1.01, 95% CI -1.61 to -0.42; endurance training: SMD -0.57, 95% CI -1.04 to -0.10; strength/resistance training: SMD -0.58, 95% CI -1.15 to -0.01). No further statistically significant effects were observed. Gait/balance/functional training lasting for up to 12 weeks may have a beneficial effect on QoL compared to a passive control group, but the CI extended across the line of no effect (SMD -0.37, 95% CI -0.77 to 0.02). Furthermore, the effect of aqua-based training may be superior to the effects of other types of physical exercise - for example, gait/balance/functional training (SMD -0.64, 95% CI -1.19 to -0.09) or LSVT BIG (SMD -1.24, 95% CI -2.48 to 0.00) - but the CIs extended across or touched the line of no effect.

Analyzing studies with an intervention length of 12 weeks or longer, we found evidence suggesting that QoL was increased for four interventions compared to a passive control group (dance: SMD -0.68, 95% CI -1.29 to -0.08; mind-body training: SMD -0.51, 95% CI -0.88 to -0.14; multi-domain training: SMD -0.37, 95% CI -0.66 to -0.08; gait/balance/functional training: SMD -0.29, 95% CI -0.55 to -0.02). The evidence also suggests that QoL was increased

compared to an active control group for seven interventions (dance: SMD -1.45, 95% CI -2.26 to -0.63; mind-body training: SMD -1.27, 95% CI -1.95 to -0.59; endurance training: SMD -1.24, 95% CI -2.01 to -0.48; multi-domain training: SMD -1.13, 95% CI -1.70 to -0.57; aqua-based training: SMD -1.05, 95% CI -2.09 to -0.01; gait/balance/functional training: SMD -1.05, 95% CI -1.61 to -0.48; strength/resistance training: SMD -1.00, 95% CI -1.68 to -0.32) as well as for a passive control group (SMD -76, 95% CI -1.35 to -0.17). Moreover, we observed evidence suggesting that QoL was increased for mind-body training compared to flexibility training (SMD -0.63, 95% CI -1.12 to -0.14). None of the remaining effects were statistically significant. However, the effects of both dance and multi-domain training on QoL may be increased compared to the effect of flexibility training, but the CIs touched or extended across the line of no effect (dance: SMD -0.81, 95% CI -1.62 to 0.00; multi-domain training: SMD -0.50, 95% CI -1.09 to 0.10).

For the analysis of studies with an intervention length of less than 12 weeks, the presence of moderate to substantial heterogeneity between the studies, as indicated by I^2 statistics, was not found to be statistically significant according to Cochran's Q test (Q_{total} = 75.33, df = 28, P < 0.001; Q_{within} = 51.44, df = 12, P < 0.001; $Q_{between}$ = 23.88, df = 16, P = 0.09; I^2 = 52.8%, Tau^2 = 0.1670). There was no evidence of important heterogeneity in the analysis of studies with an intervention lasting for 12 weeks or longer (Q_{total} = 21.92, df = 14, P = 0.08; Q_{within} = 11.69, df = 7, P = 0.111; $Q_{between}$ = 10.24, df = 7, P = 0.18; I^2 = 36.1%, Tau^2 = 0.0839).

In the analysis of studies with an intervention lasting less than 12 weeks using a passive control group as reference treatment, the highest-ranked interventions were aqua-based training (P-score: 0.96), endurance training (P-score: 0.75), and strength/resistance training (P-score: 0.74). The lowest-ranked interventions were a passive control group (P-score: 0.19), LSVT BIG (P-score: 0.19), and dance (P-score: 0.26).

In the analysis of studies with an intervention lasting for 12 weeks or longer using a passive control group as reference treatment, the highest-ranked interventions were dance (P-score: 0.86), mind-body training (P-score: 0.78), and endurance training (P-score: 0.72). The lowest-ranked interventions were an active control group (P-score: 0.01), flexibility training (P-score: 0.20), and a passive control group (P-score: 0.24).

Freezing of gait

From 20 studies reporting freezing of gait, the length of intervention was less than 12 weeks for 11 studies, and 12 weeks or longer for nine studies. The network of studies (1457 participants) with interventions lasting for less than 12 weeks included data on all interventions included in the full analysis (i.e. all interventions except for endurance, flexibility training, gaming, and LSVT BIG), while the network of studies (505 participants) with interventions lasting for 12 weeks or longer only included data on gait/balance/functional training, dance, strength/resistance, and multi-domain training, and a passive control group. Both networks were fully connected.

No statistically significant effects were observed in the subgroup analyses. However, analyzing studies with an intervention length of less than 12 weeks, as for the full analysis, both strength/resistance training and gait/balance/functional training may have beneficial effects on freezing of gait compared to an active control group, but the CIs crossed the line of no effect (strength/resistance training: SMD -0.86, 95% CI -1.73 to 0.02; gait/balance/functional training: SMD -0.45, 95% CI -0.96 to 0.06).

Similarly to the full analysis, in the analysis of studies with an intervention length of less than 12 weeks, the highest-ranked interventions using a passive control group as reference treatment were strength/resistance training (P-score: 0.77), aqua-based training (P-score: 0.68), and dance (P-score: 0.64), and the lowest-ranked interventions were an active control group (P-score: 0.09), a passive control group (P-score: 0.34), and multi-domain training (P-score: 0.38).

In the analysis of studies with an intervention lasting for 12 weeks or longer using a passive control group as reference treatment, the highest-ranked intervention was gait/balance/functional training (P-score: 0.78) followed by dance (P-score: 0.58), strength/resistance training (P-score: 0.58), a passive control group (P-score: 0.38), and multi-domain training (P-score: 0.18). However, as for the full analysis, the ranking of the interventions should be interpreted very carefully given the large size of the confidence intervals of the effect estimates and the absence of evidence for effects in the subgroup analyses.

Cochran's Q test and I^2 statistics did not indicate that there was important heterogeneity in the analysis of studies with an intervention length of less than 12 weeks (Q_{total} = 6.12, df = 4, P = 0.19; Q_{within} = 0.31, df = 1, P = 0.58; $Q_{between}$ = 5.81, df = 3, P = 0.12; I^2 = 34.6%, Tau^2 = 0.0594). However, there was evidence of moderate to substantial heterogeneity in the analysis of studies with an intervention lasting for 12 weeks or longer (Q = 13.37, df = 5, P = 0.02; I^2 = 62.6%, Tau^2 = 0.1601).

Functional mobility and balance

From 54 studies reporting functional mobility and balance, the length of intervention was less than 12 weeks for 31 studies, and 12 weeks or longer for 23 studies. The network of studies (1514 participants) with interventions lasting for less than 12 weeks included data on all interventions, while no data on aqua-based training, gaming, and LSVT BIG were included in the network of studies with interventions lasting 12 weeks or longer (1032 participants). Both networks were fully connected.

Analyzing studies with an intervention length of less than 12 weeks, we found evidence for differences in functional mobility and balance in favor of mind-body training compared with gait/balance/functional training (SMD -1.40, 95% CI -2.61 to -0.20), strength/resistance training (SMD -1.41, 95% CI -2.78 to -0.05), multi-domain training (SMD -1.42, 95% CI -2.54 to -0.30), dance (SMD -1.67, 95% CI -3.09 to -0.24), endurance training (SMD -1.78, 95% CI -3.38 to -0.17), an active control group (SMD -1.97, 95% CI -3.32 to -0.63), a passive control group (SMD -2.14, 95% CI -3.32 to -0.95), and flexibility training (SMD -2.77, 95% CI -5.10 to -0.45). Also, the evidence suggests that functional mobility and balance were increased for aqua-based training compared with gait/balance/functional training (SMD -0.68, 95% CI -1.34 to -0.03), multi-domain training (SMD -0.70, 95% CI -1.37 -0.03), an active control group (SMD -1.26, 95% CI -2.16 to -0.35), and a passive control group (SMD -1.42, 95% CI -2.18 to -0.65), and for gait/balance/functional training compared with a passive control group (SMD -0.73, 95% CI -1.32 to -0.14). We did not observe evidence for further statistically significant effects. Aqua-based training may have a large effect on

functional mobility and balance compared to flexibility training, but the CI crossed the line of no effect (SMD -2.06, 95% CI -4.19 to 0.08). Similarly, both strength/resistance training and multi-domain training may have beneficial effects on functional mobility and balance compared to a passive control group, but the CIs crossed the line of no effect (strength/resistance training: SMD -0.72, 95% CI 1.52 to 0.07; multi-domain training: SMD -0.72, 95% CI -1.46 to 0.02).

In the analysis of studies with an intervention length of 12 weeks or longer, we observed evidence suggesting differences in functional mobility and balance in favor of endurance training compared with flexibility training (SMD -1.54, 95% CI -2.90 to -0.17), and a passive control group (SMD -1.62, 95% CI -2.68 to -0.55), as well as for dance compared with flexibility training (SMD -1.22, 95% -2.38 to -0.06) and a passive control group (SMD -1.30, 95% CI -2.11 to -0.50). Moreover, the evidence suggests that functional mobility and balance were increased in comparison with a passive control group for gait/balance/functional training (SMD -1.06, 95% -1.95 to -0.17), multi-domain training (SMD -0.94, 95% CI -1.55 to -0.33), mind-body training (SMD -0.79, 95% CI -1.23 to -0.34), and strength/resistance training (SMD -0.67, 95% CI -1.27 to -0.08). The effect of an active control group on functional mobility and balance may be increased compared to the effect of a passive control group, but the very wide CI, including a large effect in favor of the active control group, crossed the line of no effect (SMD -1.59, 95% CI -3.21 to 0.04).

Using a passive control group as reference treatment, mind-body training (P-score: 0.97), aqua-based training (P-score: 0.86), and gait/balance/functional training (P-score: 0.58) were the highest-ranked interventions, and flexibility training (P-score: 0.13), a passive control group (P-score: 0.18), and an active control group (P-score: 0.26) were the lowest-ranked interventions in the NMA of studies with an intervention lasting for less than 12 weeks.

In the NMA of studies with an intervention lasting 12 weeks or longer, the highest-ranked interventions were endurance training (P-score: 0.84), an active control group (P-score: 0.78) and dance (P-score: 0.74). The lowest-ranked interventions were a passive control group (P-score: 0.06), flexibility training (P-score: 0.11), and strength/resistance training (P-score: 0.37).

Cochran's Q test and I^2 statistics indicated that there was substantial to considerable heterogeneity between the studies in the subgroup analyses (< 12 weeks: $Q_{total} = 116.39$, df = 22, P < 0.001; $Q_{within} = 34.07$, df = 13, P = 0.001; $Q_{between} = 82.32$, df = 9, P < 0.001; $I^2 = 81.1\%$, $Tau^2 = 0.4526$; and ≥ 12 weeks: $Q_{total} = 67.18$, df = 18, P < 0.001; $Q_{within} = 11.72$, df = 7, P = 0.11; $Q_{between} = 55.46$, df = 11, P < 0.001; $I^2 = 73.2\%$, $Tau^2 = 0.3271$).

Sensitivity analysis

We used the Risk of Bias 2 tool (RoB 2) to assess risk of bias for the study results on the severity of motor signs and QoL (Sterne 2019). We performed sensitivity analyses to test the robustness of our results by analyzing trial results at low overall risk of bias. Since we judged all study results on QoL to be at high risk of bias, we only performed a sensitivity analysis for study results on the severity of motor signs.

The sensitivity analysis on the severity of motor signs included seven study results judged to be at low risk of bias (492 participants). The fully-connected network was based on only nine pairwise comparisons, and included data on all interventions included in the full analysis except for endurance training and LSVT BIG.

The evidence suggests that the severity of motor signs was decreased for dance compared to a passive control group (SMD -1.69, 95% CI -3.31 to -0.06). In comparison to an active control group, the evidence suggests that the severity of motor signs was decreased for dance (SMD -1.65, 95% CI -2.87 to -0.42), and for gait/balance/functional training (SMD -0.88, 95% CI -1.24 to -0.53). Moreover, the evidence suggests decreases in the severity of motor signs compared to flexibility training for dance (SMD -1.49, 95% CI -2.58 to -0.41), mind-body training (-0.84, 95% CI -1.20 to -0.48), and strength/resistance training (SMD -0.60, 95% CI -0.95 to -0.24). Furthermore, the evidence suggests that the severity of motor signs was decreased for dance compared to multi-domain training (SMD -0.99, 95% CI -1.85 to -0.14). No more statistically significant effects were observed. However, the CIs of many comparisons were wide and included up to large effects while crossing the line of no effect (e.g. dance compared to strength/resistance training: SMD -0.90, 95% CI -1.92 to 0.13; mind-body training compared to a passive control group: SMD -1.03, 95% CI -2.25 to 0.18; mind-body training compared to strength/resistance training: SMD -0.24, 95% CI -0.59 to 0.10), or large effects in both directions (e.g. multi-domain training compared to aqua-based training: SMD -0.01, 95% CI -1.06 to 1.04).

The highest-ranked interventions were dance (P-score: 0.95), mind-body training (P-score: 0.76), and gait/balance/functional training (P-score: 0.67). The lowest-ranked interventions were an active control group (P-score: 0.14), a passive control group (P-score: 0.19), and flexibility training (P-score: 0.20). Aqua-based training, which was ranked second among 11 interventions in the full analysis, was ranked sixth among nine interventions in the sensitivity analysis.

Please note that the results of the sensitivity analysis should be interpreted with caution, given the limited amount of data and the large confidence intervals in the effect estimates.

DISCUSSION

Summary of main results

Our objectives were to compare the effects of different types of physical exercise in adults with Parkinson's disease (PD) on the severity of motor signs, quality of life (QoL), and the occurrence of adverse events, and to generate a clinically meaningful treatment ranking using network meta-analyses (NMAs).

We identified 156 randomized controlled trials (RCTs) which evaluated physical exercise for people with PD. We included 109 studies, providing data on 4394 participants, in our NMAs. The studies comprised various types of physical exercise which we categorized into 10 groups of exercise based on an adapted version of the ProFaNE taxonomy (Lamb 2011):

- aqua-based training;
- dance;
- endurance training;
- flexibility training;
- gait/balance/functional training;
- gaming;

- LSVT BIG;
- mind-body training;
- multi-domain training; and
- strength/resistance training.

These interventions were compared to another type of physical exercise, an active control group, or, most frequently, to a passive control group.

Effects on severity of motor signs, quality of life, freezing of gait, and functional mobility and balance

We conducted NMAs for the severity of motor signs, QoL, freezing of gait, and functional mobility and balance. For each of these outcomes, we generated a treatment ranking based on a fully-connected network. Due to heterogeneity in measuring and reporting of safety outcomes, we were not able to conduct an NMA on adverse events.

We report the results and our confidence in the evidence for the effects of each type of physical exercise compared to a passive control group, on the severity of motor signs and QoL, in Summary of findings 1 and Summary of findings 2, respectively. We summarize below the results for the effects of each type of physical exercise compared to a passive control group, and for differences in the effects between exercise types, on all outcomes.

We observed evidence of beneficial effects for several types of physical exercise compared to a passive control group:

- The fully-connected network for the effects on the severity of motor signs included data from 71 studies (3196 participants) on all interventions except for gaming. The evidence suggests that dance has a moderate beneficial effect on the severity of motor signs (high confidence), and aqua-based, gait/balance/functional, and multi-domain training might have a moderate beneficial effect on the severity of motor signs (low confidence). We also found that mind-body and endurance training might have a small beneficial effect on the severity of motor signs (low confidence). Flexibility training might have a trivial or no effect on the severity of motor signs (low confidence). The evidence is very uncertain about the effects of strength/resistance training and LSVT BIG on the severity of motor signs (very low confidence). The intervention with the highest rank was dance, followed by aqua-based and gait/balance/functional training. The lowest-ranked interventions were flexibility training, followed by a passive and an active control group.
- The fully-connected network for the effects on QoL included data from 55 studies (3283 participants) on all interventions. The evidence suggests that aqua-based training probably has a large beneficial effect on QoL (moderate confidence). The evidence also suggests that endurance training might have a moderate beneficial effect, and that gait/balance/functional and multi-domain training might have a small beneficial effect on QoL (low confidence). The evidence is very uncertain about the effects of mind-body training, gaming, strength/resistance training, dance, LSVT BIG, and flexibility training on QoL (very low confidence). The intervention with the highest rank was aqua-based training, followed by endurance and mind-body training. The lowest-ranked interventions were an active control group, followed by a passive control group and flexibility training.
- The fully-connected network for the effects on freezing of gait included data from 20 studies (1048 participants) on all interventions except for endurance training, flexibility training, gaming, and LSVT BIG. Gait/balance/functional training may have a beneficial effect on freezing of gait, but the CI extended across the line of no effect. The intervention with the highest rank was strength/resistance training, followed by aqua-based training and dance. The lowest-ranked interventions were an active control group, followed by multi-domain training and a passive control group.
- The fully-connected network for the effects on functional mobility and balance included data from 54 studies (2546 participants) on all interventions. The evidence suggests that functional mobility and balance were increased for seven interventions compared to a passive control group (i.e. aqua-based training, mind-body training, dance, endurance training, gait/balance/functional training, strength/resistance training, and multi-domain training). LSVT BIG may have a beneficial effect on functional mobility and balance, but the confidence interval (CI) extended across the line of no effect. The intervention with the highest rank was aqua-based training, followed by LSVT BIG and mind-body training. The lowest-ranked interventions were a passive control group, followed by flexibility training and an active control group.

Across outcomes, we observed only little evidence of differences in the effects between different types of physical exercise, as follows.

- The evidence suggests that the effect of aqua-based training on QoL was superior to the effects of gait/balance/functional training and multi-domain training. The effect of aqua-based training on QoL may also be increased compared to dance and strength/resistance training, but the CIs touched or extended across the line of no effect. The evidence also suggests that the effect of aqua-based training on functional mobility and balance was superior to the effects of gait/balance/functional training, strength/resistance training, and multi-domain training.
- We observed evidence suggesting that the effects of flexibility training were inferior to the effects of one or more types of physical exercise in each analysis that included data on this intervention (i.e. severity of motor signs, QoL, and functional mobility and balance).

In summary, we observed evidence of beneficial effects on various outcomes for several types of physical exercise, but little evidence of differences between these interventions.

Effects on adverse events

The measurement and reporting of adverse events was highly heterogeneous and frequently incomplete. Among 156 studies included in this review, 85 studies (5192 participants) provided some kind of safety data; that is, data on events described as adverse events. Forty trials reported that there were no adverse events and four trials reported that there were no serious or major adverse events. Twenty-eight studies reported that adverse events occurred. The most frequently reported events were falls (reported in 18 studies) and pain (reported in 10 studies). Most studies reported events for the intervention groups only. The evidence is very uncertain about the effect of physical exercise on the risk of adverse events (very low confidence).

Impact of the length of the intervention

The pattern of evidence we observed in subgroup analyses separated by the length of the intervention was similar to the pattern observed in the full analysis including all studies. First, as in the full analysis, we found evidence of statistically significant effects on the severity of motor signs, QoL, and functional mobility and balance in favor of several types of physical exercise, but no evidence of statistically significant effects on freezing of gait in the subgroup analyses. Second, we observed only little evidence of differences between the interventions. In particular, we observed evidence of statistically significant effects on the severity of motor signs, QoL, and functional mobility and balance, in favor of an intervention compared with a passive control group, more frequently in the analyses of studies with an intervention lasting for 12 weeks or longer compared to the analyses of studies with an intervention lasting for a shorter period. Therefore, the observation of beneficial effects for people with PD might be facilitated by longer training periods. We seldom observed evidence suggesting that there were statistically significant differences between the interventions with regard to their effect on QoL and functional mobility and balance, but we observed such evidence more frequently in the analyses of studies with an intervention length of less than 12 weeks compared to the analyses of studies with an intervention lasting for 12 weeks or longer. The results of the subgroup analyses should be interpreted with caution. First, since there is no formal statistical test for the presence of subgroup differences, our observation of a potentially positive impact of the intervention length should be regarded as exploratory. Second, differences between the interventions should be interpreted carefully due to the lack of full data on all interventions in some subgroup analyses, and large confidence intervals in the effect estimates. Third, it should be noted that, in addition to the effects described above, we observed further estimates with CIs that included beneficial effects of interventions but crossed the line of no effect in both the full analyses and the subgroup analyses.

Overall completeness and applicability of evidence

Types of physical exercise in this systematic review

We adapted the ProFaNE taxonomy developed in Lamb 2011 to categorize physical exercise, based on all the information available describing the interventions' characteristics, according to the dominant exercise category, and irrespective of how the study authors labeled the interventions (e.g. whether they described interventions as an experimental or a control arm). This procedure allowed us to group similar interventions and compare their effects on people with PD in NMAs. However, we acknowledge that it also entailed making a series of decisions about study inclusion and intervention classification that inevitably involved judgment and trade-offs. We outline the main considerations below.

First, applying the ProFaNE taxonomy in the way we did required us to exclude studies comparing interventions that were too similar to be grouped into different categories of our taxonomy. Similarly, we pooled arms of interventions that fell into the same category according to our taxonomy, but may have varied in features irrelevant to the taxonomy (e.g. intensity), allowing a certain degree of heterogeneity within the categories. Moreover, in order to preserve homogeneity within our categories, for three studies, we did not include all study arms in our analyses because the studies included treatments that did not fulfill the criteria for being categorized as an eligible intervention or comparator as clearly as other interventions of the same category.

Second, we did not include some types of physical exercise, such as boxing, in this review. As a result, we did not include the entire landscape of studies on physical exercise for people with PD.

Third, for those exercise types we did include, we may have masked the impact of potential effect modifiers. For example, our taxonomy led us to categorize both tango and waltz/foxtrot as 'dance' types of physical exercise. However, if certain features that vary between these dance styles are important for the effects of exercise - as suggested by Hackney and colleagues who compared tango, waltz/foxtrot, and no intervention, and identified evidence of differences in the effects of the dance styles (Hackney 2009) - we would have masked the impact of those features.

Fourth, it should be noted that our ability confidently to categorize interventions according to the dominant exercise category varied for different exercise types. For example, we were more certain in categorizing interventions as dance or mind-body training than we were categorizing interventions that comprised treadmill training, for example, which could have been categorized either as gait/balance/functional training, endurance training, or even multi-domain training based on the information describing this intervention.

Finally, our definition of some categories was quite narrow. We considered interventions that deliver the 'Lee Silverman Voice Training BIG' (LSVT BIG) as a separate exercise category, as we were particularly interested in this intervention. However, we included data from only three trials with this intervention in this review, which limited our confidence in the effects of this program. Also, our 'gaming' category included interventions that involve structured, physical exercises delivered via video-games, virtual reality applications, or both. We limited this category to interventions not already categorized as any of the other exercise types. As a result, this category included data from only five trials, and does not cover the various interventions for people with PD that employ video-games, virtual reality applications, or related technology. Combining these interventions would have required us to use a broader definition (e.g. virtual-reality-supported interventions, 'exergaming').

In conclusion, the approach we employed to define and compare the interventions should be regarded as an approximation of the full landscape of exercise programs available for people with PD, and as a tool used to discriminate between groups of these interventions.

Flexibility training

We did not observe any evidence of beneficial effects of flexibility training. However, the flexibility training interventions included in our review were usually used by trialists as a control group without the intention to show any positive effects. Therefore, we cannot rule out that well-designed flexibility training might have beneficial effects for people with PD.

Timing of assessment of motor signs

For the sake of consistency, we prioritised data on the severity of motor signs (e.g. scores of the UPDRS-M) measured during the on-medication state, which was reported by most studies.

However, one included study reported data for both the on- and off-medication states (Corcos 2013). The Corcos 2013 study provided evidence of between-group differences when UPDRS-M scores were measured during the off-medication state but no evidence of statistically significant effects when measured during the on-medication state. Similar results were observed in a study of 130 participants with PD by Van der Kolk and colleagues, who compared an endurance training with a control group instructed to do stretching, flexibility, and relaxation exercises, and found evidence of a beneficial effect of endurance training on MDS-UPDRS-M scores only when measured during the off-medication state (Van der Kolk 2019). While this study was not eligible for inclusion in this review, as the number of supervised sessions was below five (i.e. the minimum level of supervision required), it is in line with the study by Corcos and colleagues suggesting that the timing of assessment with respect to the medication state could be a confounder (Corcos 2013). Therefore, combining data measured during the on-medication state with data measured during the off-medication state across trials may have masked the potential impact of this confounder and increased heterogeneity in our results.

Study population in this systematic review

Most studies included only people with mild to moderate PD and without major cognitive impairment. Therefore, the applicability of our results to people with advanced disease severity, major cognitive impairment, or both, might be limited.

Inconsistency, heterogeneity

Investigating the presence of heterogeneity and inconsistency, both locally and globally, we identified some disagreements between direct and indirect estimates, as well as heterogeneity in both pairwise comparisons and the entire networks. When reviewing the evidence base, we usually found discrepancies to be explained by the distribution of potential effect modifiers, such as the intensity of the intervention (as indicated by the frequency and duration of exercise sessions, the length of the intervention, or both), or by outlying effects of single studies that may have occurred due to the generally small number of participants in the included studies. Moreover, we had generally expected to see some degree of heterogeneity given the number and variety of interventions for people with PD included in our review. We accounted for inconsistency and heterogeneity in our ratings of confidence in the evidence.

Sensitivity analysis

We assessed the risk of bias only for study results on our primary outcomes; namely, the severity of motor signs and QoL. Since we judged all study results on QoL to be at high risk of bias, we only performed a sensitivity analysis for the study results on the severity of motor signs. Thus, we tested the robustness of our results by analyzing trial results at low overall risk of bias only to a limited extent. The results of the sensitivity analysis on the severity of motor signs were fairly comparable to the results of the full analysis. First, we identified evidence of effects on the severity of motor signs in favor of several types of physical exercise compared to a control group. As compared to the full analysis, we observed evidence of effects on the severity of motor signs compared to a passive control group for fewer interventions. However, when also considering the comparisons with an active control group and with flexibility training, the evidence suggests decreases in the severity of motor signs for the majority of exercise types included in the sensitivity analysis (i.e. dance, mind-body training, gait/balance/functional training, and strength/resistance training). The results of the sensitivity analysis should be interpreted with caution, given the limited amount of data and the large confidence intervals in the effect estimates. In order to test the robustness of the main results based on more data in future evidence syntheses, we will consider extending the sensitivity analyses to the inclusion of trial results with 'some concerns' regarding risk of bias.

Adverse events

Almost half of the studies (46%) did not provide any safety data. Reporting was highly heterogeneous and frequently incomplete in those studies that reported data on adverse events. Moreover, we only summarized harms described as adverse events by the trialists, but not harms recorded as reasons for dropout unless they were described elsewhere as adverse events by the trialists. Thus, given that trialists have different definitions of relevant adverse events, we cannot rule out that potentially relevant events occurred, but were not reported, either at the study-level or at the level of our synthesis. Therefore, the evidence is likely to be incomplete, and judgments about the safety of physical exercise for people with PD based on our review remain very uncertain.

Ongoing studies and studies awaiting classification

In addition to the studies included in our review, we identified numerous records of trials that are potentially eligible for inclusion in our review. We identified 68 trials as awaiting classification and 58 ongoing trials. However, most of these references are records from trial registries with limited information, and we derived our judgment of 'potentially eligible' using a high level of sensitivity and a low level of specificity in order to capture any relevant trials for a future update of this review. Given the specificity of our inclusion criteria (e.g. interventions need to be designed and compared appropriately to match our categorization of exercise types or control groups), we assume that the number of trials that are actually eligible for inclusion in our review is only a fraction of these numbers. Therefore, we do not think that our analyses miss a relevant amount of data at this time. Nevertheless, including data from these studies in a future update of this review may change our results.

Despite all these limitations, we were able to identify a large number of trials comparing a variety of physical exercise types with each other and with control groups considering several efficacy outcomes. In our NMAs, which were exclusively based on fully-connected networks, we were able to include data from up to 3283 participants with PD, emphasizing the overall completeness and applicability of our findings.

Quality of the evidence

Risk of bias

We assessed risk of bias for each study result on the severity of motor signs and QoL. Overall, a large number of study results had a high risk of bias. For the severity of motor signs, we judged 35 study results (49%) to be at high risk of bias. Due to the nature of self-reported questionnaires and the corresponding subjectivity of the assessment of QoL, we judged all study results to be at high overall risk of bias (i.e. due to high risk of "bias in measurement of the outcome", as assessed with domain 4 of the Risk of Bias 2

tool (RoB 2; Sterne 2019). When only considering domains that are not affected by self-reporting of the outcome, we judged 27 study results (49%) on QoL to be at high risk of bias. Most frequently, we judged the overall risk of bias to be high, because we had concerns regarding domain 2 of the RoB tool (i.e. "bias due to deviations from intended interventions"). In particular, the results reported by trialists frequently lacked data from a substantial proportion of participants (≥ 10%) who had been randomized. Therefore, we often saw the potential for a substantial impact on the result due to the failure to include these participants in the analyses.

Using an informal assessment of risk of bias, we judged the risk of bias for results on adverse events to be high, because reporting of safety data was highly heterogeneous and frequently incomplete.

Confidence in the evidence

We rated our confidence in the evidence for the effects on the severity of motor signs and QoL of each type of physical exercise compared with a passive control group. The most common limitations to our confidence in the effects were a large proportion of studies at high risk of bias and large prediction intervals.

For the effects of aqua-based training, gait/balance/functional training, multi-domain training, strength/resistance training, and mind-body training on the severity of motor signs, we downgraded by one level for risk of bias due to the large contribution of studies at high risk of bias, and inconsistency between results of the primary analysis and the sensitivity analysis limited to studies at low risk of bias. For the effects of endurance training and LSVT BIG on the severity of motor signs, we downgraded by one level for risk of bias due to the large contribution of studies with at least some concerns regarding risk of bias. No sensitivity analysis limited to studies at low risk of bias was available for these effects. We downgraded by two levels for imprecision for the effects of LSVT BIG and flexibility training on the severity of motor signs because the confidence intervals (CIs) include effects in both directions. For the effects of aqua-based training, gait/balance/functional training, multi-domain training, strength/resistance training, mind-body training, and endurance training on the severity of motor signs, we downgraded by one level for heterogeneity, because the prediction intervals (PIs) include effects in both directions (i.e. PI extends beyond the range of equivalence on the opposite side of the line of no effect favoring the passive control group), while the CIs include effects in favor of the interventions. We downgraded by one level for incoherence for the effect of strength/resistance training on the severity of motor signs, because the CI of the indirect estimate extends into the range of equivalence across the line of no effect, while the CI of the direct estimate includes an effect in favor of the intervention. Finally, since the estimates for the effect of flexibility training on the severity of motor signs are based on indirect evidence only and the global approach to assess incoherence is significant ($P < 0.05$, $I^2 = 58.4\%$), we would have downgraded by two levels for incoherence. However, in order to avoid downgrading more than once for related concerns (i.e. imprecision, heterogeneity, and incoherence), we downgraded the overall level of confidence by no more than two levels.

Due to the nature of self-reported questionnaires and the corresponding subjectivity of the assessment, we downgraded by one level for risk of bias for the effects of all interventions (i.e. aqua-based training, endurance training, mind-body training, gaming, strength/resistance training, gait/balance/functional training, multi-domain training, dance, LSVT BIG, and flexibility training) on QoL by default. Additionally, we downgraded by a second level for risk of bias for the effects of mind-body training, gaming, dance, and flexibility training on QoL, because the effects have a large contribution from studies at high risk of bias even when considering only domains that are not affected by the subjectivity of the assessment. The CIs corresponding to the effects of gaming, LSVT BIG, and flexibility training on QoL include effects in both directions. Therefore, we downgraded by two levels for imprecision. We downgraded by one level for imprecision for the effect of dance on QoL, because the estimate favors the intervention and the CI extends into the range of equivalence across the line of no effect. For the effects of endurance training, gait/balance/functional training, mind-body training, multi-domain training, and strength/resistance training on QoL, we downgraded by one level for heterogeneity, because the PIs include effects in both directions (i.e. the PIs extend beyond the range of equivalence on the opposite side of the line of no effect favoring the passive control group), while the CIs include effects in favor of the interventions. We downgraded by two levels for incoherence for the effect of strength/resistance training on QoL, because the CI of the indirect estimate includes effects in favor of both interventions (i.e. the CI extends beyond the range of equivalence on the opposite side of the line of no effect favoring the passive control group), while the CI of the direct estimate includes an effect in favor of strength/resistance training. We also downgraded by two levels for incoherence for the effects of gaming, LSVT BIG, and flexibility training, because the estimates are based on indirect evidence only and the global approach to assess incoherence is significant ($P < 0.05$, $I^2 = 60.0\%$). For the effects of gaming, strength/resistance training, LSVT BIG, and flexibility training, the overall level of confidence was very low even when avoiding downgrading more than once for related concerns (i.e. imprecision, heterogeneity, and incoherence).

We also rated the confidence in the evidence in the results on adverse events, which we reported narratively. We downgraded the confidence in the evidence by two levels for risk of bias due to highly heterogeneous and frequently incomplete reporting of safety data, and we downgraded by one level for imprecision, as we could not estimate the effects using quantitative analyses.

Potential biases in the review process

We performed an in-depth literature search based on a sensitive search strategy developed by an experienced information specialist (IM). The electronic database searches were complemented by searches of the proceedings of relevant international conferences and study registries, which allowed us to identify performed but not published studies in order to detect potential publication bias. Moreover, we were in close collaboration with clinical experts and are therefore confident that we have identified all studies relevant to the review question.

In light of the large number of search results, one review authors (ME) performed the initial screening of titles and abstracts for clearly irrelevant results (e.g. animal studies, pharmacological studies, single-arm studies). Two review authors (ME, AF) then screened the remaining results in duplicate and independently. Although we tried to maintain a high level of sensitivity during the initial screening, we recognize that this approach bears a higher risk of missing relevant records compared to two authors independently screening in duplicate at the initial screening stage. Other relevant tasks were performed fully in duplicate and

independently in order to minimize bias arising in the conduct of this review (i.e. data collection, assessment of risk of bias and the confidence of the evidence).

Both the risk of bias tool and the CINeMA approach are sensitive to subjective assessments; thus, our judgments may diverge from those of other review authors. Given the large number of study results, we made a special effort to apply the criteria for our judgments consistently. This approach may have produced judgments that were differently sensitive to specific studies and the way trialists reported them.

Agreements and disagreements with other studies or reviews

To our knowledge, this is the largest and most comprehensive systematic review with NMAs comparing different types of physical exercise for people with PD. In general, the results of our review are largely consistent with the results of previous efforts to synthesize the evidence on the efficacy and safety of physical exercise for people with PD.

Evidence from systematic reviews with network meta-analyses

This section reflects on results on the severity of motor signs, quality of life, freezing of gait, and functional mobility and balance. The results of our review are, to a large extent, consistent with the results of other systematic reviews with NMAs on physical exercise for people with PD, although comparability is limited due to several methodological differences (Álvarez-Bueno 2021; Kwok 2022; Tang 2019).

Alvarez-Bueno and colleagues conducted a systematic review with NMA analyzing the effect of exercise programs on motor symptoms in people with PD (Álvarez-Bueno 2021). The review included 56 studies providing data from 2470 participants. The review authors categorized the interventions using nine types of exercise (i.e. endurance, resistance, combined, balance, dance, alternative exercises such as yoga or tai chi, body-weight supported, and sensorimotor interventions including or not including endurance exercise). As in our review, the authors identified evidence of positive effects on the severity of motor signs for several interventions compared with a control group (i.e. dance, endurance, resistance, sensorimotor training with or without endurance exercise). Based on the ranking and the effect sizes of the interventions, the authors concluded that interventions "including more complex and demanding activities (sensorimotor training including endurance, resistance, and dance) seem to be the most effective..." (Álvarez-Bueno 2021). In line with our results, however, the effect sizes had large confidence intervals (CIs), and there was no evidence of differences between the interventions. In contrast to our results, the authors did not identify evidence of positive effects on the severity of motor signs for balance, body-weight support, and combined exercises, although it should be noted that these CIs were also large and point estimates favored the interventions. Consistent with our results, there was no evidence of differences between the interventions.

Tang and colleagues authored a review and NMA of exercise interventions, including tai chi, qigong, resistance training, aerobic exercise, multimodal exercise training, dance, tango, and yoga, for people with PD (Tang 2019). They included 19 studies with 920 participants (Tang 2019). The review authors found evidence of beneficial effects on the severity of motor signs only for dance and tango, and evidence of beneficial effects on functional mobility and balance for dance, tango, multimodal exercises, and tai chi. No evidence of effects on QoL were observed. The only evidence of differences between the interventions was observed in comparisons including a single study each (e.g. superiority in the effect of tango on severity of motor signs compared to tai chi). The review authors concluded by highlighting tango as an effective option to improve the functional mobility for people with PD. Given several methodological limitations (e.g. the search strategy was non-comprehensive, addressing a limited number of interventions; the study selection was limited to English articles; it was unclear whether all relevant steps were performed in duplicate by independent review authors; the reporting of statistical analyses and risk of bias judgments was unclear), we think that comparability to our review is limited. Nevertheless, our results are in agreement with the ones observed by Tang and colleagues as they found evidence of beneficial effects of different interventions, particularly for tango and dance, but also for other interventions such as multimodal exercise, on the severity of motor signs and functional mobility and balance. Moreover, consistent with our results, Tang and colleagues observed only little evidence of differences between the interventions. In contrast to this review, we also identified evidence of beneficial effects for QoL for several interventions.

Kwok and colleagues' systematic review with NMA included controlled clinical trials of a broad range of behavioral interventions for the management of freezing of gait (Kwok 2022). They included training programs that were eligible for inclusion in our review (e.g. gait training on treadmill and mind-body exercises) as well as interventions we did not include (e.g. action observation training and real-time biofeedback) (Kwok 2022). The NMA on freezing of gait included data from 35 studies (1454 participants). Evidence of statistically significant effects on freezing of gait compared to usual care or no treatment were found for obstacle training, gait training with treadmill, and general exercise. Further beneficial effects were found for action observation training and conventional physiotherapy after controlling for the baseline severity of freezing of gait. Evidence of differences between the behavioral interventions was observed only for comparisons involving obstacle training; that is, the effect of obstacle training on freezing of gait was superior to the effects of any other intervention except psycho-education. It should be noted that data on obstacle training were provided by only one small study (33 participants) and CIs were large.

Several methodological differences limit the comparability of the results from Kwok 2022 and our results. For example, we only included randomized controlled trials, while Kwok and colleagues also included a non-randomized study. Moreover, the authors' approach to categorizing interventions varied significantly from ours. For example, general exercises included aqua-based training; mind-body exercises included dance; and conventional physiotherapy included strength/resistance training. In contrast, we considered aqua-based training, dance, and strength/resistance training as separate, stand-alone, exercise types. Furthermore, in contrast to our review, covariates such as baseline severity of freezing of gait were statistically controlled for in the NMAs.

Despite these methodological differences, some of the results described by Kwok and colleagues may be considered as fairly similar to our results. First, in our review, we observed that gait/balance/functional training may have a beneficial effect on freezing of gait compared to both active and passive control groups. Although the CIs extended across the line of no effect for both comparisons, descriptively, this pattern is consistent with Kwok and colleagues' observation of beneficial effects of obstacle training and gait training with treadmill compared to usual care. Second, Kwok and colleagues - who considered strength/resistance training as a subtype of general exercise - found evidence of a beneficial effect of this exercise group on freezing of gait compared to usual care. Similarly, we observed that strength/resistance training may have beneficial effects on freezing of gait compared to an active control group, although the CIs extended across the line of no effect. We also found that dance may have a beneficial effect on freezing of gait compared to an active control group, although, again, the effect was not statistically significant. In contrast, Kwok and colleagues considered dance as a subtype of mind-body exercises and found no evidence of an effect on freezing of gait for this exercise group. It should be kept in mind that the differences in how we defined exercise types limit the interpretability of these comparisons.

Evidence from systematic reviews with pairwise meta-analyses

This section reflects on results on the severity of motor signs, quality of life, and functional mobility and balance. The results of our review are also, to a large extent, in agreement with the results of systematic reviews with pairwise meta-analyses on exercises such as aqua-based training or dance for people with PD.

Our results correspond to the results of a systematic review by Gomes Neto and colleagues that compared water-based exercise (i.e. aerobic and strength exercises delivered in water) with land-based exercise or usual care (Gomes Neto 2020). They including data on 435 participants from 15 studies. As observed in our review, Gomes Neto and colleagues identified evidence of a positive effect on functional mobility and balance for water-based exercise compared with a passive control group receiving usual care. Moreover, the review authors found that the effects on both QoL and functional mobility and balance observed for water-based exercise were superior to the effects of land-based exercise. Similar effects had been observed previously by Cugusi and colleagues, who also conducted a systematic review on RCTs for people with PD comparing aquatic exercise programs with land-based exercise or with a control group (Cugusi 2019). They included data from six studies (159 participants). Cugusi and colleagues analyzed effects on the severity of motor signs, and identified evidence of a positive effect of aqua-based exercise compared with a control group, but no evidence of a difference in the effects between aqua-based exercises and land-based exercises. Although we did not combine all comparator interventions as land-based exercises, as described in these reviews (Gomes Neto 2020; Cugusi 2019), but instead used several exercise categories, the results of these reviews are consistent with ours. First, analyzing the effects on the severity of motor signs, we also observed a beneficial effect of aqua-based training, while we did not observe evidence of any differences between the effects of different types of physical exercise. Second, we identified evidence of positive effects of aqua-based training on both QoL and functional mobility and balance that were superior to a passive control group, and superior to the effects of gait/balance/functional training and multi-domain training. Thus, including more recent data, combining both direct and indirect evidence using an NMA, and applying a more nuanced concept of exercises delivered in a non-aquatic setting, our review confirms the potential of aqua-based training for people with PD to reduce the severity of motor signs compared with a control group, and adds to the evidence indicating that aqua-based training might be particularly beneficial in improving functional mobility and balance and QoL.

Carapellotti and colleagues conducted a systematic review on the effects of several styles and techniques of dance (e.g. tango, Irish set dancing, and ballet) for people with PD (Carapellotti 2020). They included sixteen trials (638 participants), and performed meta-analysis on nine trials. These results of Carapellotti 2020 are comparable to ours to some degree. In line with our results, Carapellotti and colleagues found evidence of a positive effect of dance on the severity of motor signs compared with no exercise, but no evidence of differences in the effects of dance and other exercises. As observed in our review, Carapellotti and colleagues also found a positive effect of dance compared with no exercise on functional mobility and balance, but no evidence of an effect on QoL. However, in contrast to our results, the review authors also found evidence suggesting that the effects of dance on both QoL and functional mobility and balance were superior to the effects of an active control group (i.e. another exercise or physical activity), although both results were based on data from only two small studies. In summary, their results are consistent with our results indicating the potential of dance to reduce the severity of motor signs and improve functional mobility for people with PD. On the other hand, in contrast to our findings, Carapellotti 2020 observed some evidence that dance might be superior to other active interventions.

In another review published in 2020, Chen and colleagues focused on the effects of several exercise types, including dance, on QoL for people with PD (Chen 2020). Based on data from 20 studies (1143 participants), they found evidence of a positive effect of dance on QoL, compared with usual care or no exercise (Chen 2020). Please note that these differences may be due to inclusion of a small non-randomized study (15 participants) with a large effect in favor of dance, which we excluded from our review due to the study design.

More similarities can be observed when comparing our results with the results of systematic reviews on other types of physical exercise, focusing on either a specific type or several types of exercise for people with PD. For example, in agreement with our results, Jin and colleagues - whose review included data from 21 RCTs and one non-randomized trial (1199 participants) - identified beneficial effects of mind-body training (including tai chi, yoga, and qigong) compared with a control group on the severity of motor signs, QoL, and functional mobility and balance (Jin 2019). In another review, Choi and colleagues included data from 18 studies (1144 participants) (Choi 2020). Consistent with our results, they found beneficial effects of several exercise therapies - including walking exercise, strength and flexibility exercise, balancing exercise, aerobic exercise, and complex exercise (which comprised two types of exercise - compared to no exercise or regular activity on the severity of motor signs and functional mobility and balance (Choi 2020).

Beneficial effects of resistance training on QoL and functional mobility and balance compared to a control group, as observed in

our review, were also reported in a systematic review by Gamborg and colleagues (Gamborg 2022). They including data from 33 studies (1266 participants) on intensive exercise therapy with a focus on resistance training and endurance training (Gamborg 2022). For endurance training, Gamborg and colleagues identified evidence of beneficial effects on functional mobility and balance, as found in our review. In contrast to our review, the review authors did not identify evidence of a beneficial effect of endurance training on QoL. Moreover, while we found evidence of statistically significant beneficial effects of both resistance training and endurance training on the severity of motor signs, the corresponding evidence observed by Gamborg and colleagues was mixed. For endurance training, meta-analyses were conducted and the CIs extended slightly across the line of no effect for both severity of motor signs measured during the "on"-, and the "off"-state. However, for resistance training, the authors indicated that there was no change in the outcome. Please note that comparability of these findings with our results may be limited due to methodological differences. These included differences in measurement of the outcome (in contrast to Gamborg and colleagues, we combined data on the severity of motor signs measured during the "on"- and the "off-state) and selection of studies (e.g. the authors included a study that was ineligible for inclusion in our review as it compared two interventions, which we considered as similar types of strength/resistance training). However, other evidence syntheses identified evidence of statistically significant beneficial effects on the severity of motor signs for endurance training or aerobic exercise compared to a control group, consistent with the results of our review. These included a systematic review with NMA on exercise programs (Álvarez-Bueno 2021), and a systematic review with pairwise meta-analyses on exercise therapies (Choi 2020).

Evidence of effects on freezing of gait

Previous efforts to synthesize the evidence on the efficacy of physical exercise for people with PD provided mixed results with respect to the effects on freezing of gait. For example, there was a lack of evidence of statistically significant effects on freezing of gait in the systematic review by Carapellotti and colleagues, comparing dance with no intervention (Carapellotti 2020). Similarly, Cugusi and colleagues did not find evidence of a statistically significant effect of aquatic exercise programs on freezing of gait, compared with land-based exercise or with a control group (Cugusi 2019). However, evidence of statistically significant beneficial effects on freezing of gait was observed in other systematic reviews: namely, in a systematic review focusing on the effects of physiotherapy compared to no treatment or a control group (Consentino 2020), as well as in a systematic review comparing physiotherapy with placebo or no intervention (Tomlinson 2013). The interventions included in both of these reviews comprised several types of exercise, including aquatic exercise and dance; some of the corresponding analyses were based on a limited number of studies and participants. Combining the findings of these reviews with our results, the exact impact of physical exercise on freezing of gait remains inconclusive. While none of the effects we observed were statistically significant, the CIs included beneficial effects on freezing of gait for several interventions compared to a control group. This applies to the effects of strength/resistance training, dance and gait/balance/functional training compared to an active control group, and to the effect of gait/balance/functional training compared to a passive control group. Therefore, we cannot rule out that freezing of gait could be improved by some types of physical exercise, although these effects might be rather small compared to the effects on other outcomes, such as the severity of motor signs, QoL, and functional mobility and balance. Importantly, our review and the approach we adopted to derive exercise categories was not specifically designed to compare interventions based on their impact on freezing of gait.

A more nuanced approach to address this question was provided by Gilat and colleagues, who conducted a systematic review on interventions that were divided into three subcategories according to their relevance to freezing of gait (Gilat 2021). These comprised freezing-of-gait-specific (e.g. action-observation training and fall prevention training), freezing-of-gait-relevant (e.g. cognitive training, balance training, and curved treadmill training), and generic exercises (e.g. dance, yoga, aquatic training, tai chi and physiotherapy not aimed at freezing of gait). The primary meta-analysis on the effect of exercise compared with a control group included data from 41 studies (1838 participants) and indicated that both freezing-of-gait-specific and freezing of-gait-relevant exercises reduced freezing of gait, while generic exercises did not, indicating that targeted training (i.e. training that addresses specific symptoms or impairments of people with PD, e.g. gait) is needed to address freezing of gait in people with PD. Assuming that specificity of exercise is crucial to affect freezing of gait, the fact that we categorized interventions based on the dominant exercise mode may have masked potential differences in the effects of the interventions. On the other hand, it is likely that we categorized most exercises that, in theory, could target freezing of gait as gait/balance/functional training, and we observed that this type of exercise may have a beneficial effect on freezing of gait compared to control groups. Although the effects were not statistically significant, they may be regarded as consistent with the superiority of targeted exercises suggested by Gilat and colleagues. In contrast, while the authors reported that generic exercises did not affect freezing of gait, we observed that strength/resistance training and dance - that is, exercises considered as generic - may also have beneficial effects on freezing of gait compared to an active control group. Again, it should be noted that these effects were not statistically significant. This is fairly in line with results from the Kwok 2022 systematic review with NMA on behavioral interventions for the management of freezing of gait. It provided evidence of statistically significant effects on freezing of gait compared to usual care or no treatment for obstacle training, gait training with treadmill, and general exercise, and also for action-observation training and conventional physiotherapy, when controlling for the baseline severity of freezing of gait (Kwok 2022).

In conclusion, while specificity of exercise may be particularly important to address freezing of gait, we cannot rule out that people with PD may also benefit from some interventions not targeted at this outcome.

Evidence of adverse events

In accordance with the limited and heterogeneous reporting of adverse events (AEs) observed in the studies included in our review, authors of only a few systematic reviews on physical exercise for people with PD synthesized safety information. Review authors concluded that the interventions are relatively safe, given that when studies reported AEs, they were only minor (e.g. Choi 2020; Cugusi 2019; Gamborg 2022; Tomlinson 2014). This corresponds to the synthesis of safety data in this review. Therefore, although our review pointed out the difficulties in synthesizing the evidence on

the comparative safety of different types of physical exercise, our results are consistent with previous research suggesting that, in general, physical exercise seems to be relatively safe for people with PD.

Evidence of the impact of the length of intervention

Consistent with our results, authors of other systematic reviews also identified evidence suggesting that the length of intervention might have a positive impact on the beneficial effects of exercise. Combining all exercise types in a systematic review on the effects of physical exercise on QoL, Chen and colleagues identified evidence of a positive relation of the effects on QoL and the length of intervention (Chen 2020). Specifically, positive effects were observed for interventions lasting for 12 weeks or longer, but not for interventions lasting for less than 12 weeks. Similarly, in their systematic review with NMA on the effect of exercise programs on motor symptoms, Álvarez-Bueno and colleagues provided evidence suggesting that the length of interventions (in weeks) influenced the impact of the intervention on the severity of motor signs (Álvarez-Bueno 2021). However, this evidence was only found for dance, and analyses were only performed for comparisons with at least six studies (Álvarez-Bueno 2021). These results are in line with our observation of more beneficial effects on the severity of motor signs, QoL, but also on functional mobility and balance, in the analyses limited to interventions with a minimum length of 12 weeks compared to the analyses of interventions with a shorter length. In a narrative review including different types of physical exercise (multi-modal physical therapy, progressive resistance training, aerobic training, gait and balance training, tai chi, and dance), Mak and colleagues focused on long-term effects, which they defined as effects lasting at least 12 weeks (Mak 2017). They found that physical exercise could modify long-term motor symptoms and physical functioning in people with PD, with balance training having the longest carry-over effects, followed by gait and tai chi training (Mak 2017). The authors wrote that "a minimum of 4 weeks of gait training or 8 weeks of balance training can have positive effects that persist for 3–12 months after treatment completion" and that "sustained strength training, aerobic training, tai chi or dance therapy lasting at least 12 weeks" could "produce long-term beneficial effects" (Mak 2017). Finally, they recommended that training periods should last for at least 12 weeks in order to achieve clinically meaningful improvements in UPDRS-M scores. As we only analyzed outcomes assessed shortly after the intervention, our review does not allow us to draw conclusions on the sustainability of the effects of physical exercise. Nevertheless, our observation of more beneficial effects on the severity of motor signs, QoL, and on functional mobility and balance in studies with interventions lasting 12 weeks or longer corresponds with the authors' emphasis on a sufficiently long duration of exercise programs.

Methodological differences to other systematic reviews

There was usually a large overlap in the selection of eligible studies between our review and other systematic reviews on either several or specific types of exercise for people with PD. However, we excluded some studies eligible for inclusion in other reviews because: (a) they investigated interventions that did not fulfill our criteria to be considered as structured physical exercise (e.g. because physical exercise was not the primary component of the intervention, or supervision was not provided for a minimum of five training sessions, or the training lacked a certain level of structure); or (b) they compared interventions that were not sufficiently different to represent distinct exercise types as defined for our categories (e.g. aqua-based training with and without additional land-based rehabilitation in Gomes Neto 2020, or different dance styles or dance with or without a partner in Carapellotti 2020). Moreover, despite an overlap in the categorization of interventions and control groups applied in our review and in other reviews, our approach to categorizing both exercise types and control groups diverged to some degree from the approaches of other review authors, resulting in differences in the selection of interventions and the corresponding analyses. For example, Carapellotti and colleagues divided groups that were compared to dance into groups receiving no intervention, and "active control" groups receiving exercise or physical activity (Carapellotti 2020). In contrast, we considered some of these interventions as distinct physical interventions, some as active control groups (i.e. a structured, supervised, non-physical intervention), and some as passive control groups (i.e. no intervention, or unstructured interventions without supervision, including general physical activity, or usual care). This also applies to other systematic reviews; for example, the Gilat 2021 systematic review focused on the management of freezing of gait and categorized interventions according to their relevance to this outcome. Furthermore, across the systematic reviews mentioned in the Discussion section, other methodological differences occurred: for example, in the selection and application of tools used to assess risk of bias and the confidence in the evidence; in the comprehensiveness of the search strategies (e.g. limitation to English-language articles); in the measurement of the outcomes (e.g. limitation to data on the severity of motor signs measured with the UPDRS-M); and in the study inclusion criteria (e.g. inclusion of non-randomized studies).

AUTHORS' CONCLUSIONS

Implications for practice

We provide evidence of beneficial effects on the severity of motor signs, quality of life (QoL), and functional mobility and balance for most types of physical exercise for people with Parkinson's disease (PD) included in this systematic review. We also observed evidence of superiority in some effects of aqua-based training compared to effects of other interventions (i.e. an effect on QoL superior to the effects of gait/balance/functional training and multi-domain training; and an effect on functional mobility and balance superior to the effects of gait/balance/functional training, strength/resistance training, and multi-domain training). We did not identify any further evidence of differences between the exercise types. Also, while some interventions were among the three highest-ranked exercise types multiple times (i.e. aqua-based training, dance, mind-body training, and strength/resistance training), these results should be interpreted carefully due to the lack of full data on all interventions in some analyses, and large confidence intervals in the effect estimates.

In summary, the overall pattern of results across outcomes and interventions provides only little evidence of differences between the exercise types included in this review. Thus, our systematic review highlights the importance of physical exercise for people with PD in general, while the exact exercise type might be secondary with respect to the rather global outcome measures severity of motor signs and QoL. Therefore, the personal preferences of people with PD should be given special consideration. Nevertheless, fundamental principles of

exercise should be taken into account when establishing an individual training routine. For example, the World Health Organization (WHO) guidelines for physical activity for adults living with disability recommend that a variety of exercise types are undertaken, including aerobic physical activity, muscle-strengthening activities, and multi-component physical activity that emphasizes functional balance and strength training (WHO 2020). Moreover, people improve at what they practice. Thus, people with PD might be encouraged to select among the diverse landscape of available exercise programs according to their personal preferences, and establish a training routine that includes a variety of modes and addresses their individual goals, impairments, and activity limitations. Our results are consistent with the possibility that specific motor symptoms in PD (e.g. freezing of gait) may be treated most effectively with PD-specific programs rather than with 'any kind' of physical exercise. Overall, people with PD should be advised to seek professional advice, including assessment of motor and non-motor symptoms, in order to develop a training agenda based on their individual needs.

In this review, we observed up to large beneficial effects of physical exercise on the severity of motor signs. When expressed as mean differences on the motor scale of the Unified Parkinson Disease Rating Scale (UPDRS-M), the point estimates of the beneficial effects compared to a passive control group ranged between -10.32 (dance) and -5.49 (Lee Silverman Voice training BIG [LSVT BIG]). Comparing these effects to effects of pharmacotherapy in people with PD is difficult, because all participants in our review received pharmacological treatment, and physical exercise is always an "add on". Moreover, the interpretability of the effect sizes is limited due to the imprecision of the estimates. However, descriptively, the beneficial effects of physical exercise found in our review were within the range or exceeded the point estimates of the beneficial effects of pharmacological agents compared to placebo that were reported in a network meta-analysis on the efficacy and tolerability of the most frequently used drugs in the treatment of people with PD (range between -6.05 for levodopa and -1.60 for cabergoline; Zhuo 2017). Notably, comparable to our results, the drug effects were also highly heterogeneous.

In addition to the evidence of the efficacy, no major safety concerns were raised for the interventions included in our review. Therefore, several exercise programs may be selected from when establishing a training routine, provided that there are no individual safety concerns. Importantly, as the disease progresses, safety concerns may increase and the availability of safe exercise options may decrease.

We observed evidence of beneficial effects in favor of physical exercise compared with a passive control group, more frequently when analyzing studies with an intervention lasting for 12 weeks or longer compared to studies with an intervention lasting for a shorter period. Although these results should be interpreted carefully, longer training periods might have a positive impact on the effects of exercise for people with PD. As we only analyzed outcomes assessed shortly after the intervention, our review does not allow us to draw conclusions on the sustainability of the effects of physical exercise. Nevertheless, one might assume that people with PD would benefit from exercising continuously over the course of disease in order to maintain beneficial effects. Also, while eligible studies in this review had to consist of at least five directly supervised sessions, and the impact of remote supervision could not be investigated, it might be helpful in maintaining the individual training routine.

When interpreting the results of this systematic review, it should be recognized that network meta-analyses cannot replace direct head-to-head comparisons. Furthermore, although we observed only very little evidence of differences in the effects of different types of exercise, we cannot rule out the possibility that differences exist between or within the categories we used that might be clinically relevant for individuals.

Clinicians and other health professionals informing people with PD about the beneficial effects observed in this review may increase their motivation to perform physical exercise. Also, given the fact that various types of exercise show positive effects for people with PD, it would be helpful to provide regional information on the availability of specific exercise offers; for example, by self-help groups.

Implications for research

Larger, well-conducted studies are needed to increase the confidence in the evidence. In particular, 49% of study results had a high risk of bias. Most frequently, we had concerns regarding bias due to deviations from the intended interventions, as the results reported by trialists frequently lacked data from a substantial proportion of participants who had been randomized. Therefore, in order to reduce bias and increase the confidence in the effects, trialists should report results from intention-to-treat analyses and include data from all participants randomized. Furthermore, our confidence in the effects was frequently limited due to large confidence intervals, large prediction intervals, or both; these primarily affected our assessment of imprecision and heterogeneity and, may be, in part, a result of small sample sizes. In fact, the studies were usually small: on average, only 51 participants were randomized per study (range from 10 to 474), and data for the analyses were provided for only 21 participants per trial arm (range from 4 to 115). Among the 156 studies included in our review, only 77 studies (49%) described considering test power a priori. Thirty-nine studies considered test power after conducting the trial, and 40 studies did not address this issue. Therefore, in order to increase the confidence in the evidence, more trialists should consider test power when designing a trial, and intend to recruit larger samples.

The samples of most studies included in our review were limited to people with mild to moderate PD and without severe cognitive impairment or dementia. Additional studies on physical exercise recruiting people with advanced disease severity and cognitive impairment might help extend the generalizability of our findings to a broader range of people with PD.

The efficacy outcomes analyzed in this review consisted of two primary outcomes (i.e. the severity of motor signs and QoL), for which we performed additional evaluations (i.e. sensitivity analyses and in-depth risk-of-bias assessments), and two secondary outcomes (i.e. freezing of gait and functional mobility and balance). The severity of motor signs, usually measured using the UPDRS-M, was the most frequently reported outcome in the included studies. However, as the UPDRS-M was designed to measure changes in motor tone and amplitude throughout the entire body, it may not highlight other important aspects, such as gait and balance. Furthermore, in this review, we did not analyze other well-established tools to measure aspects

related to gait and balance, such as the Berg Balance Scale (Berg 1989) or the Falls Efficacy Scale (Tinetti 1990). Depending on the intervention, effects on specific outcomes may be expected to different degrees: for example, gait training may primarily affect freezing of gait while other exercise programs may have a more global effect on disease severity. Thus, investigating the differential effects of exercise more precisely would require extending our focus beyond global effects. Therefore, our results may be complemented by future evidence syntheses that address other specific effects of exercise by analyzing other outcomes and tools included in core outcome sets.

Judgments about the general and comparative safety of different types of physical exercise for people with PD based on our review remain very uncertain, as we could not conduct any quantitative analyses due to limited, incomplete, and heterogeneous reporting of the occurrence of adverse events. In order to facilitate the conduct of evidence syntheses beyond a narrative report of the data, trialists should consider reporting the safety of interventions more consistently and completely for all study arms, including control groups. This could increase the confidence in the evidence of the safety of different physical interventions for people with PD.

As we focused on the evaluation of outcomes assessed up to six weeks after the intervention, our conclusions are limited to the short-term impact of physical exercise for people with PD. Therefore, more researchers conducting evidence syntheses in the future should consider analyzing the medium- and long-term effects of physical exercise as well.

Finally, comparing groups of interventions that represented different exercise types, we investigated the effects of physical exercise using a relatively broad unit of specification. Furthermore, we conducted subgroup analyses only by the length of intervention, while we could not study the impact of further effect modifiers specified in the protocol (i.e. age, sex, cognitive stage). As a result, our review cannot address questions on the impact of several features that might moderate the effect of physical exercise, such as characteristics of the population (e.g. age, sex, cognitive stage, duration and/or severity of disease, phenotype, skills, or personal preferences and joy), parameters of the intervention (e.g. mode, intensity, frequency, complexity, supervision and feedback, specificity, personalization, or use of technology), or aspects of the study design (e.g. timing of assessment relative to medication status). More nuanced approaches accounting for these features are needed to better understand their role in the effects of exercise for people with PD. First, more investigators could study the effects of physical exercise in specific populations (e.g. people with severe cognitive impairment or dementia). Second, more investigators could conduct studies that directly compare interventions varying in one or more potentially relevant features. Third, evidence syntheses could study the impact of one or more of these features by defining more specific research questions, selecting other effect modifiers, and/or defining other subgroups (i.e. conduct subgroup analyses in studies that include people with mild cognitive impairment, and in studies that include people with severe cognitive impairment or dementia). Investigating these features may help to better understand the effects of exercise for people with PD and to improve the design of individually-tailored exercise programs.

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* Indicates the major publication for the study

CHARACTERISTICS OF STUDIES

Characteristics of included studies *[ordered by study ID]*

Agosti 2016

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** No
Participants	**Number of participants (recruited/randomized/evaluated):** NR/20/NR **Country:** Italy **Age (mean in years):** 62.9; 63.1 **Sex (male/female):** 18/2 (90% male) **Duration of disease (mean in years):** 6.5; 6 **HY (mean):** 1.7; 1.8 **UPDRS-M (mean):** 20 **MMSE (mean):** ≥ 23.8 (inclusion criteria) **Physical capability:** NR **Inclusion criteria:** Diagnosis of PD according to the United Kingdom Parkinson's Disease Society Brain Bank criteria; MMSE ≥ 23.8; stable dosage of dopaminergic medication in the last 2 months prior to enrollment and during the study; ability to walk along a 15-meter walkway at least six times without assistance **Exclusion criteria:** Other current neurological, orthopedic, or other medical conditions affecting gait
Interventions	**Length of intervention:** 4 weeks **Intervention 1:** Global Postural Reeducation (GPR method is based on the global stretching of anti-gravity muscle chains, and enhances the contraction of antagonistic muscles) [flexibility training]; 40 minutes, 3x/week **Intervention 2:** Control group [passive control group] **Primary setting:** Group **Supervision by (if provided):** NR
Outcomes	UPDRS-M, three-dimensional motion analysis **Follow-up (maximum time after end of intervention):** 8 weeks
Notes	**Funding sources:** "The work was supported by a grant from MIUR (FIRB—MERIT RBNE08LN4P:006)." **Conflicts of interest:** All authors disclosed any financial and personal relationships with other people or organizations that could inappropriately influence (bias) their work.

Allen 2010

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** Yes
Participants	**Number of participants (recruited/randomized/evaluated):** 92/48/45 **Country:** Australia **Age (mean in years):** 66.0; 68.0 **Sex (male/female):** 26/22 (54.2% male) **Duration of disease (mean in years):** 7.0; 9.0 **HY (mean):** NR **UPDRS-M (mean):** 29.0; 30.0 **MMSE (mean):** 29.0; 29.0 **Physical capability:** Short physical performance battery: 2.10; 2.09; exercise (hr/wk): 2.6; 2.6 **Inclusion criteria:** Idiopathic PD diagnosis; independent walking; aged between 30 and 80 years; stable medication in the last 2 weeks; falls in the last year or at risk of falling (operationalized by a score of 25 cm or less on the FRT or if they failed to reach criterion one of the balance tests in the QuickScreen Clinical Falls Assessments **Exclusion criteria:** Significant cognitive impairment (MMSE < 24 points); other neurological/musculoskeletal/cardiopulmonary/metabolic condition that would interfere with the safe conduct of the training or testing protocol
Interventions	**Length of intervention:** 6 months **Intervention 1:** Lower limb strengthening and balance exercises [gait/balance/functional training]; 40 to 60 minutes, 3x/week **Intervention 2:** Control group [passive control group] **Primary setting:** Group **Supervision by (if provided):** Physiotherapists with experience in neurological rehabilitation
Outcomes	PD falls risk score; number of falls; Coordinated Stability Test; yes/no question regarding FoG; FOG-Q; Swaymeter; Alternate step test component of the BBS; sit to stand time; fast walking speed (m/s); comfortable walking speed (m/s); Short Physical Performance Battery; FES; PDQ-39 **Follow-up (maximum time after end of intervention):** post-intervention
Notes	**Funding sources:** Parkinson's New South Wales (NSW) Research Grant and a Physiotherapy Research Foundation National Neurology Group Tagged Grant **Conflicts of interest:** "NE Allen received financial assistance from the University of Sydney Faculty of Health Sciences Postgraduate Research Scholarship, the George Burniston-Cumberland Foundation Fellowship and the Parkinson's NSW Research Student Award. C Sherrington and SR Lord receive salary

Allen 2010 *(Continued)*

	funding from the National Health and Medical Research Council. SR Lord is a company director of Balance Systems Inc, which makes equipment items for the PPA (POWMRI FallScreen), which is commercially available through the Prince of Wales Medical Research Institute. All other authors have no financial disclosures to make."

Almeida 2012

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** No
Participants	**Number of participants (recruited/randomized/evaluated):** NR/42/NR **Country:** Canada **Age (mean in years):** 63.86; 73.93; 67.43 **Sex (male/female):** 31/11 (73.8% male) **Duration of disease (mean in years):** NR **HY (mean):** NR **UPDRS-M (mean):** 23.68; 22.07; 24.21 **MMSE (mean):** NR **Physical capability:** Step length (cm): 63.9; 57.6; 57.7 Velocity (cm/s): 119.2; 108.5; 109.0 **Inclusion criteria:** Diagnosed with PD, responsive to anti-Parkinsonian medication, and were in an optimally medicated or “on” medication state at the time of all training and testing sessions. **Exclusion criteria:** Past history of neurological conditions other than PD or orthopedic or visual disturbances that severely impaired walking ability. Also, participants were removed if they were unable to independently walk down an 8-meter GAITRite carpet for a total of 10 trials.
Interventions	**Length of intervention:** 6 weeks **Intervention 1:** Treadmill group [gait/balance/functional training]; 30 minutes; 3x/week **Intervention 2:** Overground group (walk down equally spaced transverse lines, presented on a 16-meter carpet) [gait/balance/functional training]; 30 minutes; 3x/week **Intervention 3:** Control group [passive control group] **Primary setting:** Group **Supervision by (if provided):** spotters
Outcomes	Step length, velocity, TUG, UPDRS-M, 30-second sit to stand test

Almeida 2012 *(Continued)*

	Severity of motor signs assessed during: on-medication state
	Follow-up (maximum time after end of intervention): 6 weeks
Notes	**Funding sources:** supported by a Natural Sciences and Engineering Research Council of Canada (NSERC) grant, the Canadian Foundation for Innovation, and Sun Life Financial
	Conflicts of interest: None

Amano 2013

Study characteristics	
Methods	Randomized controlled trial
	Single center
	A priori consideration of test power: No
Participants	**Number of participants (recruited/randomized/evaluated):** NR/24/24
	Country: USA
	Age (mean in years): 66; 66
	Sex (male/female): 14/10 (58.3% male)
	Duration of disease (mean in years): 8; 5
	HY (mean): 2.4; 2.4
	UPDRS-M (mean): 23.1; 23.1
	MMSE (mean): > 26/30 (inclusion criteria)
	Physical capability: gait velocity (m/s): 1.01; 1.09
	Inclusion criteria:
	All participants were diagnosed as having idiopathic PD by a fellowship-trained movement disorders neurologist using standard criteria.
	Exclusion criteria:
	Any history or evidence of neurological deficit other than PD; MMSE ≤ 26 points; inability to walk independently; previous training in any forms of tai chi or current participation in any structured exercise program equating to greater than 20 min per week; inability to understand the protocol
Interventions	**Length of intervention:** 16 weeks
	Intervention 1: Tai chi [mind-body training]; 60 minutes; 3x/week
	Intervention 2: Non-contact control group [passive control group]
	Primary setting: Group
	Supervision by (if provided): NR
Outcomes	Experimental gait initiation and gait analysis; UPDRS-M
	Severity of motor signs assessed during: on-medication state

Amano 2013 *(Continued)*

	Follow-up (maximum time after end of intervention): post-intervention
Notes	**Funding sources:** National Institutes of Health **Conflicts of interest:** NR

Arfa-Fatollahkhani 2019

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** No
Participants	**Number of participants (recruited/randomized/evaluated):** 50/30/20 **Country:** Iran **Age (mean in years):** 60.63; 61.55 **Sex (male/female):** 15/5 (75% male) **Duration of disease (mean in years):** 8.89; 8.50 **HY (mean):** 2.13; 2.0 **UPDRS-M (mean):** 18.45; 17.88 **MMSE (mean):** 27.54; 28.0 **Physical capability:** Short-form 8 - physical condition score: 37.27; 40.71 **Inclusion criteria:** PD according to UK Brain Bank criteria; aged between 30 and 75 years old; UPDRS-M range of 10 to 30; HY stage between 1.5 and 2.5; and MMSE > 24 **Exclusion criteria:** Participants were excluded if they were not in aforementioned stage; had any alterations in dosage and type of medications; high-risk factors for cardiovascular diseases based on the American College of Sport Medicine Guideline; visual or auditory disturbances; vertigo; orthopedics problems; dementia; any other neurologic comorbidities other than PD; were involved in any other exercise or rehabilitation program.
Interventions	**Length of intervention:** 10 weeks **Intervention 1:** Treadmill training [endurance training]; 30 minutes; 2x/week; 10 weeks **Intervention 2:** Control group [passive control group] **Primary setting:** Individual **Supervision by (if provided):** Sports Medicine specialist
Outcomes	SF-8; 6-MIN-W; TUG **Follow-up (maximum time after end of intervention):** 2 months
Notes	**Funding sources:** NR

Arfa-Fatollahkhani 2019 *(Continued)*

Conflicts of interest: NR

Ashburn 2007

Study characteristics	
Methods	Randomized controlled trial Multicenter **A priori consideration of test power:** Yes
Participants	**Number of participants (recruited/randomized/evaluated):** 1107/142/133 **Country:** UK **Age (mean in years):** 72.7; 71.6 **Sex (male/female):** 86/56 (60.6% male) **Duration of disease (mean in years):** 7.7; 9.0 **HY (range):** 2 to 4 **UPDRS-M (mean):** NR **MMSE (mean):** NR **Physical capability:** No. of falls in previous year: 60; 61 **Inclusion criteria:** Confirmed diagnosis of idiopathic PD, independently mobile, living at home in the community, experienced more than one fall in the previous 12 months, and passed a screening test for gross cognitive impairment **Exclusion criteria:** Unable to participate in assessments because of pain, and acute medical condition and in receipt of, or soon to receive, treatment
Interventions	**Length of intervention:** 6 weeks **Intervention 1:** Exercise group (six levels of exercise progression, which comprised muscle strengthening (knee and hip extensors, hip abductors), range of movement (ankle, pelvic tilt, trunk, and head), balance training (static, dynamic, and functional) and walking (inside and outside)) [multi-domain training]; 60 minutes; 1x/week **Intervention 2:** Control group [passive control group] **Primary setting:** Individual **Supervision by (if provided):** Physiotherapist
Outcomes	BBS; self-assessment Parkinson's Disease Disability Scale; QoL thermometer; falls; EQ-5D; muscle strength **Follow-up (maximum time after end of intervention):** 20 weeks
Notes	**Funding sources:** Action Medical Research, John and Lucille Van Geest Foundation

Ashburn 2007 *(Continued)*

	Conflicts of interest: None

Ashburn 2018

Study characteristics	
Methods	Randomized controlled trial Multicenter **A priori consideration of test power:** Yes
Participants	**Number of participants (recruited/randomized/evaluated):** 541/474/425 **Country:** UK **Age (mean in years):** 71.0; 73.0 **Sex (male/female):** 266/208 (56.1% male) **Duration of disease (mean in years):** 8.0; 8.0 **HY (range):** 1 to 4 **UPDRS-M (mean):** NR **MMSE (mean):** 28.0; 29.0 **Physical capability:** PASE: 107.8; 100.1 **Inclusion criteria:** Clinically confirmed diagnosis of Parkinson's disease in accordance with UK Brain Bank criteria; living in their own home; independently mobile with or without an aid; experienced at least one fall in the previous 12 months; scored 24 or more on MMSE; cognitive ability to give informed consent; able to understand and follow commands; considered able to participate in an exercise and strategy programme **Exclusion criteria:** Cognitive impairment
Interventions	**Length of intervention:** 6 months **Intervention 1:** PDSAFE (individually tailored, progressive, home-based exercise and strategies to avoid falls) [gait/balance/functional training]; 60 to 90 minutes; 2x/month **Intervention 2:** Control group [passive control group] **Primary setting:** Individual **Supervision by (if provided):** Registered physiotherapists
Outcomes	Fall diaries (number of falls); fractures and rate of near falling; Mini-BESTest; chair stand test; N-FOG-Q; medication use; Geriatric Depression Scale; FES; PDQ-39; PASE; EQ-5D-3L; deaths/hospitalisation/serious adverse events **Follow-up (maximum time after end of intervention):** 6 months
Notes	**Funding sources:** National Institute for Health Research (NIHR) Health Technology Assessment (HTA) programme

Ashburn 2018 *(Continued)*

	Conflicts of interest: During the conduct of the study, LR reports grants from: Newcastle University; Parkinson's UK; EU Marie Curie Training Network; the Medical Research Council (MRC); the Engineering and Physical Sciences Research Council; the Wellcome Trust; the Stroke Association. CB is a member of the Primary Care Community and Preventive Interventions HTA group and the associated Methods group. VG reports grants from the NIHR during the conduct of the study. SEL reports grants from the NIHR HTA programme during the conduct of the study. SEL was a member of the HTA Additional Capacity Funding Board, HTA End of life care and add-on studies, HTA Prioritisation Group, and HTA Trauma Board during this study. All other authors declared they have nothing to disclose.

Avenali 2021

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** Yes
Participants	**Number of participants (recruited/randomized/evaluated):** 40/40/34 **Country:** Italy **Age (mean in years):** 72.3 **Sex (male/female):** 21/13 (61.8% male) **Duration of disease (mean in years):** 9.6 **HY (mean):** 2.4 **UPDRS-M (mean):** 33.66; 34.15 **MMSE (mean):** 24.46; 24.36 **Physical capability:** Tinetti: 14.26; 14.78 **Inclusion criteria:** PD according to UK Parkinson's Disease Society Brain Bank Clinical Diagnostic Criteria and HY scale ≤ 3 with PD-MCI (Parkinson's disease - Mild Cognitive Impairment) single- or multiple-domain (level II criteria) **Exclusion criteria:** Pre-existing cognitive impairment (e.g. aphasia, neglect) or PD-dementia and other concomitant psychiatric, neurological, or other clinically relevant health conditions
Interventions	**Length of intervention:** 4 weeks **Intervention 1:** Physical therapy [multi-domain training]; 60 minutes, 6x/week **Intervention 2:** Control group (no specific intervention) [passive control group] **Primary setting:** Individual **Supervision by (if provided):** Physiotherapist
Outcomes	MMSE; MoCA; Corsi's block-tapping; Raven's matrices 1947; Frontal assessment battery; Attentive matrices; TMT; Phonological fluency; UPDRS-M; Tinetti; Hauser **Severity of motor signs assessed during:** on-medication state

Avenali 2021 *(Continued)*

	Follow-up (maximum time after end of intervention): 5 months
Notes	**Funding sources:** This work was supported by a grant of the Italian Ministry of Health (Ricerca Corrente 2017–2019) **Conflicts of interest:** None

Bridgewater 1996

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** No
Participants	**Number of participants (recruited/randomized/evaluated):** NR/26/26 **Country:** Australia **Age (mean in years):** 67.3; 66.5 **Sex (male/female):** 16/10 (61.5% male) **Duration of disease (mean in years):** 4 **HY (range):** 1 to 3 **UPDRS-M (mean):** NR **MMSE (mean):** NR **Physical capability:** NR **Inclusion criteria:** Healthy people with early PD; established stage of disease according to HY scale; diagnosis of idiopathic PD; ability to move to and from a recumbent position **Exclusion criteria:** People with spinal, cardiorespiratory, or neurologic pathology (other than PD) were excluded from the study
Interventions	**Length of intervention:** 12 weeks **Intervention 1:** Aerobic exercise [multi-domain training]; 55 minutes; 2x/week **Intervention 2:** Control with interest talk [passive control group]; 1x/3 weeks **Primary setting:** Group **Supervision by (if provided):** Physiotherapist
Outcomes	Webster Rating Scale for Parkinsonian Disabilities, Northwestern University Disability Scale, Human Activity Profile; Levine-Pilowsky Depression Questionnaire; Exercise Stress Test; Herz-Echo; Adjusted Activity Score **Follow-up (maximum time after end of intervention):** 4 weeks
Notes	**Funding sources:** The Physiotherapy Research Foundation

Bridgewater 1996 *(Continued)*

Conflicts of interest: NR

Burini 2006

Study characteristics	
Methods	Randomized controlled trial with cross-over after 7 weeks Single center **A priori consideration of test power:** No
Participants	**Number of participants (recruited/randomized/evaluated):** NR/26/22 **Country:** Italy **Age (mean in years):** 65.2 **Sex (male/female):** 9/17 (34.6% male) **Duration of disease (mean in years):** 10.8 **HY (range):** 2 to 3 **UPDRS-M (median):** 11;12 **MMSE (mean):** ≥ 24 (inclusion criteria) **Physical capability:** 6-MIN-W (meters) 419; 405 **Inclusion criteria:** Diagnosis of PD; HY stage 2 to 3; stable medication **Exclusion criteria:** Severe cognitive impairment (MMSE < 24); concomitant severe neurologic, cardiopulmonary, or orthopedic disorders; specific contraindication to the execution of a cardiopulmonary test or aerobic training; recent participation in any physiotherapy or rehabilitation program during the previous 2 months
Interventions	**Length of intervention:** 7 weeks **Intervention 1:** Aerobic sessions [endurance training]; 45 minutes; 3x/week **Intervention 2:** Qigong [mind-body training]; 50 minutes; 3x/week **Primary setting:** Group **Supervision by (if provided):** Physical therapist
Outcomes	UPDRS; Brown's Disability Scale; 6-Min-W; Borg Scale; BDI; PDQ-39; cardiovascular and respiratory assessments **Severity of motor signs assessed during:** on-medication state **Follow-up (maximum time after end of intervention):** 0 (post-intervention)
Notes	**Funding sources:** NR **Conflicts of interest:** NR

Cakit 2007

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** No
Participants	**Number of participants (recruited/randomized/evaluated):** 62/54/31 **Country:** Turkey **Age (mean in years):** 71.8 **Sex (male/female):** 16/15 (51.6% male) **Duration of disease (mean in years):** 5.58 **HY (range):** 2 to 3 **UPDRS-M (mean):** 18.14 **MMSE (mean):** ≥ 20 (inclusion criteria) **Physical capability:** Walking distance on treadmill (m): 266.45; 348.2 **Inclusion criteria:** Medically stable; able to walk a 10-meter distance at least three times with or without an assistive device; able to provide informed consent **Exclusion criteria:** Neurological conditions other than iPD; HY > 3; MMSE < 20; exhibition of postural hypotension, cardiovascular disorders, class C or D exercise risk by the American College of Sports Medicine criteria or musculoskeletal disorders; visual disturbance or vestibular dysfunction limiting locomotion or balance
Interventions	**Length of intervention:** 8 weeks **Intervention 1:** Stretching, range-of-motion and treadmill training [endurance training]; 30(±5) minutes; 2x/week **Intervention 2:** Control group [passive control group] **Primary setting:** Group **Supervision by (if provided):** Physiatrist
Outcomes	BBS; Dynamic Gait Index; FES; walking distance on treadmill **Follow-up (maximum time after end of intervention):** 0 (post-intervention)
Notes	**Funding sources:** NR **Conflicts of interest:** NR

Canning 2012

Study characteristics

Canning 2012 *(Continued)*

Methods	Randomized controlled trial Single center **A priori consideration of test power:** Yes
Participants	**Number of participants (recruited/randomized/evaluated):** 86/20/20 **Country:** Australia **Age (mean in years):** 60.7; 62.9 **Sex (male/female):** 11/9 (55% male) **Duration of disease (mean in years):** 6.1; 5.2 **HY (range):** 1 to 2 **UPDRS-M (mean):** 20.9; 17.9 **MMSE (mean):** 29.9; 29.7 **Physical capability:** 10-meter walk velocity (m/s): 1.30; 1.17 **Inclusion criteria:** Mild Parkinson's disease (HY 1 to 2); aged between 30 and 80 years; sedentary (< 2 hours per week of leisure time physical activity in prior three months); had a stable response to levodopa medications. Participants were accepted into the study if they walked unaided but reported a subjective gait disturbance and/or scored one or two on the gait item of the UPDRS. **Exclusion criteria:** Disabling dyskinesias or motor fluctuations; freezing while "on" medication; or significant balance impairment (> 1 on UPDRS postural stability item). People were also excluded if they: scored less than 24 on the MMSE; had fallen more than once in the prior year; experienced severe and frequent dizziness; experienced any other neurological/musculoskeletal/cardiopulmonary or metabolic conditions that affected walking; or had any other contraindications to moderate intensity, semi-supervised exercise.
Interventions	**Length of intervention:** 6 weeks **Intervention 1:** Treadmill walking [endurance training]; 30 to 40 minutes; 4x/week **Intervention 2:** Control group (usual care) [passive control group] **Primary setting:** Individual **Supervision by (if provided):** Physiotherapist
Outcomes	6-MIN-W; Exercise heart rate (heart rate end 6-MIN-W – resting heart rate); PDQ-39; 10-meter walk velocity (comfortable pace); 10-meter walk velocity (multiple task, comfortable pace); Coefficient of variation (stride time, stride length); UPDRS-M **Severity of motor signs assessed during:** on-medication state **Follow-up (maximum time after end of intervention):** 6 weeks
Notes	**Funding sources:** University of Sydney Research and Development Grant to CG Canning **Conflicts of interest:** None

Canning 2015

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** Yes
Participants	**Number of participants (recruited/randomized/evaluated):** 532/231/231 **Country:** Australia **Age (mean in years):** 71 **Sex (male/female):** 135/96 (58.4% male) **Duration of disease (mean in years):** 7.5; 8.3 **HY (range):** 2 to 4 **UPDRS-M (mean):** 25.8; 26.7 **MMSE (mean):** 28.6; 28.7 **Physical capability:** Number of participants who fell in the past year: 90; 90 **Inclusion criteria:** Diagnosis of idiopathic PD (confirmed by a medical practitioner); aged 40 years or older; ability to walk independently with or without a walking aid; stable anti-Parkinsonian medication for at least 2 weeks; and one or more falls in the past year or at risk of falls based on physical assessment **Exclusion criteria:** MMSE score of < 24; unstable cardiovascular disease or other uncontrolled chronic conditions that would interfere with the safety and conduct of the training and testing protocol
Interventions	**Length of intervention:** 6 months **Intervention 1: "**PD-WEBB program" (progressive balance and lower limb strengthening exercises and cueing strategies to reduce freezing of gait for participants reporting freezing) [gait/balance/functional training]; 40 to 60 minutes; 3x/week **Intervention 2:** Control group (usual care) [passive control group] **Primary setting:** Individual **Supervision by (if provided):** Physical therapist, medical practitioner and community services
Outcomes	PD Fall Risk score; mean knee extensor strength of both legs; coordinated stability test; Short Physical Performance Battery continuous measure; 4-meter fast walk speed; FTSTS; FOG-Q; FES-I; SF-12 physical; SF-12 mental; SF-6D utility score; exercise; ADL; PDQ-39; positive affect scale **Follow-up (maximum time after end of intervention):** 0 (post-intervention)
Notes	**Funding sources:** Australian National Health and Medical Research Council (NHMRC ID: 512326), and the Harry Secomb Foundation **Conflicts of interest:** "C. Canning has received travel expenses and honoraria for lectures and educational activities not funded by industry; and research support from the Australian Government National Health and Medical Research Council, the Harry Secomb Foundation, and Parkinson's NSW. C. Sherrington has received travel expenses and honoraria for lectures and educational activities not funded by industry; and research support from the Australian Government National Health and Medical Research Council, the Consortium national de formation en santé (Canada), Arthritis New South Wales,

Canning 2015 *(Continued)*

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Capato 2020a

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** Yes
Participants	**Number of participants (recruited/randomized/evaluated):** 201/154/154 **Country:** the Netherlands **Age (mean in years):** 74.0; 67.0; 73.0 **Sex (male/female):** 88/66 (57.1% male) **Duration of disease (median in years):** 5; 6; 8 **HY (range):** 1 to 3 **UPDRS-M (mean):** 15; 17; 19 **MMSE (mean):** 27; 26; 25 **Physical capability:** TUG 23.6; 19.4; 22.5 **Inclusion criteria:** Diagnosis of PD according to the UK Brain Bank criteria; HY stage 1 to 3; history of falls in the past year; able to walk 10 minutes continuously; MMSE ≥ 24; able to walk independently indoors without walking aid; stable medication over the past 3 months; no hearing or visual problems interfering with the tests or training; and stable deep brain stimulator settings during the past year **Exclusion criteria:** No other physiotherapy interventions or complementary exercises were allowed during the study
Interventions	**Length of intervention:** 5 weeks

Capato 2020a *(Continued)*

	Intervention 1: Rhythmical auditory stimuli (RAS)-supported Balance Training (gait training with visual cues combined with rhythmical auditory stimuli, provided by a metronome) [Gait/Balance/Functional]; 45 minutes; 2x/week **Intervention 2:** Regular Balance Training (gait training with visual cues) [gait/balance/functional training]; 45 minutes; 2x/week **Intervention 3:** Control group (general education program about PD, falls prevention and self-care) [active control group]; 45 minutes; 2x/week **Primary setting:** Group **Supervision by (if provided):** Physiotherapists
Outcomes	Mini-BESTest; UPDRS; TUG; BBS; retropulsion test of the UPDRS; push-and-release test; Rapid Turns Test; N-FOG-Q; FES-I **Severity of motor signs assessed during:** on-medication state **Follow-up (maximum time after end of intervention):** 6 months
Notes	**Funding sources:** University of Sao Paulo General Hospital **Conflicts of interest:** NR

Carroll 2018

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** Yes
Participants	**Number of participants (recruited/randomized/evaluated):** 24/21/18 **Country:** Ireland **Age (mean in years):** 71.4 **Sex (male/female):** 12/6 (66.7% male) **Duration of disease (mean in years):** 7; 10.5 **HY (range):** 1 to 3 **UPDRS-M (mean):** 17.5; 16.5 **MMSE (mean):** NR **Physical capability:** Step time (seconds): 0.02; 0.02 **Inclusion criteria:** Neurologist-confirmed diagnosis of idiopathic PD according to UK Brain Bank criteria; HY I-III; stable medication status over the past three months. Participants were required to be able to walk 10 meters three times, without assistance. **Exclusion criteria:**

Carroll 2018 *(Continued)*

	Contraindications to aquatic therapy, including cardiovascular or pulmonary conditions; previous history of deep brain stimulation or any musculoskeletal condition that affected their ability to participate in the exercise group
Interventions	**Length of intervention:** 6 weeks **Intervention 1:** Aquatic Therapy [aqua-based training]; 45 minutes; 2x/week **Intervention 2:** Control group (usual care) [passive control group] **Primary setting:** Group **Supervision by (if provided):** Physiotherapist
Outcomes	3D Gait analysis; PDQ-39; UPDRS-M; FOG-Q **Severity of motor signs assessed during:** on-medication state **Follow-up (maximum time after end of intervention):** 1 week
Notes	**Funding sources:** NR **Conflicts of interest:** NR

Carvalho 2015

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** No
Participants	**Number of participants (recruited/randomized/evaluated):** 41/22/22 **Country:** Brazil **Age (mean in years):** 64.8; 64.1; 62.1 **Sex (male/female):** 14/8 (63.6% male) **Duration of disease (mean in years):** 6.6; 6.0; 4.3 **HY (mean):** 2.6; 2.1; 2.3 **UPDRS-M (mean):** 31.0; 40.4; 34.9 **MMSE (mean):** 24.6; 25.8; 26.5 **Physical capability:** 2-Minute Step Test [repetitions]: 50.6; 46.7; 57.9; 10-Meter Walk Test: 9.0; 8.0; 7.2 **Inclusion criteria:** Aged between 45 years and 80 years, a diagnosis of PD, and stage 1 to 3 on the HY scale **Exclusion criteria:** Any disease that hindered the application of an evaluation instrument; clinical comorbidities that made it impossible to use physical effort; individuals of New York Heart Association classes III and IV; significant physical limitations; and visual or hearing impairment

Carvalho 2015 *(Continued)*

Interventions	**Length of intervention:** 12 weeks **Intervention 1:** Aerobic Training [endurance training]; 40 minutes, 2x/week **Intervention 2:** Strength training [strength/resistance training]; duration not reported, 2x/week **Intervention 3:** Physiotherapy [multi-domain training]; 30 to 40 minutes, 2x/week **Primary setting:** Individual **Supervision by (if provided):** Trained coaches
Outcomes	UPDRS-M; Senior Fitness Test; balance; walking speed; electroencephalographic activity (EEG) to examine possible central nervous system changes **Severity of motor signs assessed during:** NR **Follow-up (maximum time after end of intervention):** 0 (post-intervention)
Notes	**Funding sources:** NR **Conflicts of interest:** None

Chaiwanichsiri 2011

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** No
Participants	**Number of participants (recruited/randomized/evaluated):** NR/30/30 **Country:** Thailand **Age (mean in years):** 67.1; 67.9; 68.6 **Sex (male/female):** 30/0 (100% male) **Duration of disease (mean in years):** 3.7; 7.4; 4.4 **HY (range):** 2 to 3 **UPDRS-M (mean):** NR **MMSE (mean):** NR **Physical capability:** 6-MIN-W (meters): 426.6; 426.8; 449.3 **Inclusion criteria:** Male PD patients aged 60 to 80 years diagnosed by neurologists as idiopathic PD, HY stage 2 to 3, with good cognitive function on Thai Mental State Examination score > 23, stable symptoms with unmodified anti-Parkinsonian medication throughout the study, independent walking without using any gait aids. Good vision and hearing were required to ensure that the participants could follow the program. **Exclusion criteria:**

Chaiwanichsiri 2011 *(Continued)*

	"Patients should have no other medical conditions that could interfere with the training program and [should not have participated] in any training program during the previous two months"
Interventions	**Length of intervention:** 8 weeks **Intervention 1:** Treadmill with music and home walking [gait/balance/functional training]; 30 minutes; 3x/week and 3x/week at home **Intervention 2:** Treadmill and home walking [gait/balance/functional training]; 30 minutes; 3x/week and 3x/week at home **Intervention 3:** Home walking [active control group]; 30 minutes; 6x/week **Primary setting:** Group and individual **Supervision by (if provided):** NR
Outcomes	Step length, Stride length, Cadence, 6-meter walk time, Speed, 6-MIN-W, TUG **Follow-up (maximum time after end of intervention):** 0 (post-intervention)
Notes	**Funding sources:** Ratchadapiseksompotch Fund, Faculty of Medicine, Chulalongkorn University **Conflicts of interest:** None

Cheng 2017

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** Yes
Participants	**Number of participants (recruited/randomized/evaluated):** 46/36/36 **Country:** Taiwan **Age (mean in years):** 66.4; 65.8; 67.3 **Sex (male/female):** 25/11 (69.4% male) **Duration of disease (mean in years):** 6.5; 6.1; 8.1 **HY (mean):** 1.6; 1.8; 2.0 **UPDRS-M (mean):** NR; 19.7; 19.5 **MMSE (mean):** 28.1; 27.7; 28.1 **Physical capability:** Curved-walking: speed (cm/s): NR; 58.3; 60.6, step length (cm): NR; 38.3; 38.0, Straight-walking: speed (cm/s): NR; 83.2; 84.6, step length (cm): NR; 46.3; 46.6 **Inclusion criteria:** Participants with idiopathic PD diagnosed by a neurologist, presence of at least two of four features (resting tremor, bradykinesia, rigidity, and asymmetric onset), and one of which had to be resting tremor or bradykinesia, HY stages 1 to 3, independent walking, and a score of ≥ 24 on the MMSE **Exclusion criteria:**

Cheng 2017 *(Continued)*

	Unstable medical condition, motor fluctuations, or severe dyskinesia which might interfere with the training, and any history of other diseases known to interfere with participation in the study
Interventions	**Length of intervention:** 4 to 6 weeks **Intervention 1:** Specific exercise group (balance exercises and muscle strengthening) [gait/balance/functional training]; 30 minutes; 2 to 3x/week **Intervention 2:** Turning-based training group (turning training on a rotational treadmill) [gait/balance/functional training]; 30 minutes; 2 to 3x/week **Intervention 3:** Control group (trunk exercises combining upper limb movements in the sitting position that minimally challenged their standing balance and lower extremity muscle strength) [multi-domain training]; 40 minutes; 2 to 3x/week **Primary setting:** Group and individual **Supervision by (if provided):** Physical therapist
Outcomes	Curved-walking performance (Speed, Cadence, Step length), FOG-Q, straight-walking performance (Speed, Cadence, Step length), TUG, functional gait assessment, UPDRS-M, PDQ-39 **Severity of motor signs assessed during:** on-medication state **Follow-up (maximum time after end of intervention):** 1 month
Notes	**Funding sources:** This work was supported by grants from the Ministry of Science and Technology. **Conflicts of interest:** None

Cherup 2021

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** Yes
Participants	**Number of participants (recruited/randomized/evaluated):** 53/46/33 **Country:** USA **Age (mean in years):** 70.6 **Sex (male/female):** 21/12 (63.6% male) **Duration of disease (mean in years):** NR **HY (range):** 1 to 3 **UPDRS-M (mean):** 26.3; 30.8 **MMSE (mean):** NR **Physical capability:** TUG: 8.2; 9.7 **Inclusion criteria:** 40 to 90 years old; diagnosed with mild to moderate PD (HY stages 1 to 3); free from uncontrolled cardiovascular, musculoskeletal, or nerve disease; cleared for exercise by their physician; and not current-

Cherup 2021 *(Continued)*

	ly involved in any formal training program that targeted lower body strength, balance, or proprioception **Exclusion criteria:** NR
Interventions	**Length of intervention:** 12 weeks **Intervention 1:** Yoga meditation [mind-body training]; 90 minutes; 2x/week **Intervention 2:** Proprioception training [gait/balance/functional training]; 45 minutes; 2x/week **Primary setting:** Group and individual **Supervision by (if provided):** Certified yoga instructors; instructor
Outcomes	FES; Balance Error Scoring System; Tinetti balance assessment tool; TUG; Joint position sense; Joint kinesthesia **Follow-up (maximum time after end of intervention):** within 2 weeks
Notes	**Funding sources:** None **Conflicts of interest:** None

Cheung 2018

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** Yes
Participants	**Number of participants (recruited/randomized/evaluated):** 52/20/20 **Country:** USA **Age (mean in years):** 63.0 **Sex (male/female):** NR/NR **Duration of disease (mean in years):** 4.8 **HY (range):** 1 to 3 **UPDRS-M (mean):** 25.6; 24.4 **MMSE (mean):** NR **Physical capability:** Longitudinal Aging Study Amsterdam (LASA) Physical Activity Questionnaire level (min) 5745; 7344 **Inclusion criteria:** Individuals diagnosed with mild to moderate idiopathic PD (HY stages 1 to 3), aged 45 to 75 years, on stable dopaminergic therapy for 4 weeks prior to enrollment if taking medication, and able to ambulate 6 m with/without assistive device **Exclusion criteria:**

Cheung 2018 *(Continued)*

	Atypical parkinsonism or other significant brain conditions such as a stroke; had any medical condition that prohibited safe exercise as assessed by the Exercise Assessment and Screening for You Questionnaire; had significant cognitive impairment as indicated by scoring less than 26 in the MoCA; had a decline in immune function such as pneumonia or systemic infection; had spinal fusion or other orthopedic surgery in the past 6 months; had a significant psychiatric disease; needed greater than minimal assistance for gait and transfers; were already practicing yoga regularly; or were unable to commit to attend scheduled yoga sessions
Interventions	**Length of intervention:** 12 weeks **Intervention 1:** Yoga [mind-body training]; 60 minutes; 2x/week **Intervention 2:** Wait-list control [passive control group] **Primary setting:** Group **Supervision by (if provided):** Yoga instructor
Outcomes	UPDRS; MoCA; BDI; blood oxidative stress markers; Parkinson's Disease Quality of Life Scale; Longitudinal Aging Study Amsterdam Physical Activity Questionnaire; Parkinson's Disease Sleep Scale **Follow-up (maximum time after end of intervention):** 6 months
Notes	**Funding sources:** University of Minnesota Grant-in-Aid of Research; University of Minnesota Foundation, Artistry and Scholarship Program; and Midwest Nursing Research Society Sally Lusk Grant for the conduct of the research. Research reported in this publication was supported by the National Center for Advancing Translational Sciences of the National Institutes of Health Award Number UL1TR000114. **Conflicts of interest:** None

Choi 2013

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** No
Participants	**Number of participants (recruited/randomized/evaluated):** 30/22/20 **Country:** Korea **Age (mean in years):** 60.81; 65.54 **Sex (male/female):** NR/NR **Duration of disease (mean in years):** 5.2; 5.2 **HY (range):** 1 to 2 **UPDRS-M (mean):** 22.36; 17.67 **MMSE (mean):** NR **Physical capability:** 6-MIN-W: 442.6; 369.9 **Inclusion criteria:** HY 1 to 2; stable drug regimen

Choi 2013 *(Continued)*

	Exclusion criteria: Severe cognitive impairment; concomitant severe neurologic, cardiopulmonary, or orthopedic disorders; specific contraindications to exercise; had recently participated in any physiotherapy or rehabilitation program
Interventions	**Length of intervention:** 12 weeks **Intervention 1:** Tai chi [mind-body training]; 60 minutes; 2x/week **Intervention 2:** Control group [passive control group] **Primary setting:** Group **Supervision by (if provided):** NR
Outcomes	UPDRS, light stimulus test, one-legged stance test **Severity of motor signs assessed during:** NR **Follow-up (maximum time after end of intervention):** 0 (post-intervention)
Notes	**Funding sources:** NR **Conflicts of interest:** NR

Cholewa 2013

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** No
Participants	**Number of participants (recruited/randomized/evaluated):** NR/70/NR **Country:** Poland **Age (mean in years):** 70.2; 70.2 **Sex (male/female):** 46/28 (62.2% male) **Duration of disease (mean in years):** 8.0; 7.3 **HY (mean):** 3.0 **UPDRS-M (mean):** 21.6; 22.0 **MMSE (mean):** NR **Physical capability:** NR **Inclusion criteria:** Idiopathic PD; only people in stage 3 according to the HY scale were included **Exclusion criteria:** People with cognitive dysfunction as well as with depression

Cholewa 2013 *(Continued)*

Interventions	**Length of intervention:** 12 weeks **Intervention 1:** Rehabilitation exercises (frequent movement repetitions, coupling movements with acoustic movement initiator (step), repeating movements with different frequencies, introducing free movements stimulated by different visual, audio or sensual signals, visualizing movement prior to execution, provoking equivalent movements, realizing improper postures and correcting them) [multi-domain training]; 60 minutes; 2x/week **Intervention 2:** Control [passive control group] **Primary setting:** Group **Supervision by (if provided):** Therapist
Outcomes	UPDRS-I; UPDRS-II; UPDRS-M; Schwab and England scale; PDQ-39 **Severity of motor signs assessed during:** on-medication state **Follow-up (maximum time after end of intervention):** 0 (post-intervention)
Notes	**Funding sources:** NR **Conflicts of interest:** None

Claesson 2018

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** No
Participants	**Number of participants (recruited/randomized/evaluated):** 33/28/22 **Country:** Sweden **Age (mean in years):** 69.0 **Sex (male/female):** 11/17 (39.3% male) **Duration of disease (mean in years):** 6.8 **HY (mean):** 1.8 **UPDRS-M (median):** 23.0 **MMSE (mean):** > 22 (inclusion criteria) **Physical capability:** 10-meter walk (s) 8.05 (at comfortable speed, starting stationary) **Inclusion criteria:** Community-dwelling people with a diagnosis of idiopathic PD; early stage of Parkinson's disease defined as HY < 3 and under a stable Parkinson's disease drug therapy. Furthermore, they should have an MMSE result of > 22 and a normal bedside sensory status. **Exclusion criteria:**

Claesson 2018 *(Continued)*

	No other disease apart from Parkinson's disease affecting motor performance; attendance to exercise was less than 50% (eight out of 16 sessions) or if their Parkinson's disease medication was modified during the study period
Interventions	**Length of intervention:** 8 weeks **Intervention 1:** Balance Training [gait/balance/functional training]; 45 minutes; 2x/week **Intervention 2:** Control group (delayed start) [passive control group] **Primary setting:** Group **Supervision by (if provided):** Physiotherapist
Outcomes	BBS; Bäckstrand Dahlberg Liljenäs Balance Scale; TUG; UPDRS-M; 10-meter walk test **Follow-up (maximum time after end of intervention):** 6 months (intervention group only)
Notes	**Funding sources:** The study was supported by grants from the National Doctor School of Health Care and Sciences at Karolinska Institutet, the Stockholm City Council, the Swedish Association for People with Neurological Disabilities and the Norrbacka-Eugenia Foundation. **Conflicts of interest:** None

Colgrove 2012

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** No
Participants	**Number of participants (recruited/randomized/evaluated):** 18/13/13 **Country:** USA **Age (mean in years):** 62.8; 73.4 **Sex (male/female):** 6/7 (46.2% male) **Duration of disease (mean in years):** 3 years 2.75 months; 3 years 8.4 months **HY (range):** 1 to 2 **UPDRS-M (mean):** 19.12; 16.2 **MMSE (mean):** ≥ 24 (inclusion criteria) **Physical capability:** gait velocity (m/s): 0.92; 0.95 **Inclusion criteria:** Patients with HY 1 to 2 who could ambulate with or without an assistive device for at least 50 feet and were able to get up and down from the floor with minimal assist or less, and score 24 or above on the Folstein MMSE **Exclusion criteria:** HY ≥ 3, decline in immune function such as pneumonia or systemic infection, progressive degenerative disease besides PD, spinal fusion or other orthopedic surgery in the past six months, mental dis-

Colgrove 2012 *(Continued)*

	ease/psychosis such as dementia, greater than minimal assistance required for gait and transfers, inability to make regular time commitments to the scheduled yoga sessions, or experience with regular practice of yoga within the past year
Interventions	**Length of intervention:** 12 weeks **Intervention 1:** Yoga [mind-body training]; 60 minutes; 2x/week **Intervention 2:** Control group [passive control group] **Primary setting:** Group **Supervision by (if provided):** Certified master yoga instructor
Outcomes	UPDRS-M, BBS, measures of range of motion, strength, posture, standing postural sway, gait initiation, biomechanical measures **Severity of motor signs assessed during:** NR **Follow-up (maximum time after end of intervention):** 0 (post-intervention)
Notes	**Funding sources:** University of Kansas Medical Center's School of Allied Health Research Committee; National Center for Research Resources (NCRR), a component of the National Institutes of Health (NIH) **Conflicts of interest:** NR

Conradsson 2015

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** Yes
Participants	**Number of participants (recruited/randomized/evaluated):** 146/100/91 **Country:** Sweden **Age (mean in years):** 72.9; 73.6 **Sex (male/female):** 51/41 (55.4% male) **Duration of disease (mean in years):** 6.0; 5.6 **HY (range):** 2 to 3 **UPDRS-M (mean):** 36; 37 **MMSE (mean):** 28; 28 (reported for follow-up sample) **Physical capability:** norm velocity (m/s): 1.19; 1.16 (normal walking conditions); recurrent fallers (%): 53; 55 **Inclusion criteria:** Community-dwelling individuals with idiopathic PD with impaired balance; HY: 2/3; age ≥ 60; ability to independently ambulate indoors without a walking aid; ≥ 3 weeks of stable anti-Parkinsonian medication **Exclusion criteria:**

Conradsson 2015 *(Continued)*

	MMSE < 24; other medical conditions influencing balance performance or participation
Interventions	**Length of intervention:** 10 weeks **Intervention 1:** HiBalance training (motor-learning principles, dual task exercises combining cognitive tasks with motor tasks, balance components (sensory integration, anticipatory postural adjustments, motor agility, stability limits)) [gait/balance/functional training]; 60 minutes; 3x/week **Intervention 2:** Control group [passive control group] **Primary setting:** Group **Supervision by (if provided):** Physical therapists
Outcomes	Mini-BESTest, gait velocity, step length, cadence (each as normal condition, and while performing cognitive task), average steps/day, FES-I, UPDRS-II, modified-figure-of-eight test; adverse events **Follow-up (maximum time after end of intervention):** 12 months
Notes	**Funding sources:** Swedish Research Council, Swedish Parkinson Foundation, Karolinska Institutet, Loo and Hans Ostermans Foundation, Gun and Bertil Stohnes Foundation, Swedish NEURO Foundation, Norrbacka Eugenia Foundation, regional agreement on medical training and clinical research (ALF) between Stockholm County Council and Karolinska Institutet **Conflicts of interest:** None

Corcos 2013

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** Yes
Participants	**Number of participants (recruited/randomized/evaluated):** 70/48/38 **Country:** USA **Age (mean in years):** 58.6; 59.0 **Sex (male/female):** 28/20 (58.3% male) **Duration of disease (mean in years):** 6.5; 6.5 **HY (mean):** 2.3; 2.2 **UPDRS-M (mean):** 20.9; 21.6 **MMSE (mean):** 29.1; 29.3 **Physical capability:** 6-MIN-W: 507.5; 548.3, Modified Physical Performance Test: 31.1; 30.7, walk speed: 1.7; 1.6 (m/s) **Inclusion criteria:** People with idiopathic PD with moderate disease severity, between 50 and 67 years old, on stable medication, able to walk for 6 minutes **Exclusion criteria:**

Corcos 2013 *(Continued)*

	Neurological history other than PD, significant arthritis, failed Physical Activity Readiness Questionnaire, had cognitive impairment (MMSE < 23); were already exercising; or had undergone surgery for Parkinson's disease
Interventions	**Length of intervention:** 24 months **Intervention 1:** Modified Fitness Counts (stretches, balance exercises, breathing, and non progressive strengthening) [multi-domain training]; 60 to 90 minutes; 1x/week **Intervention 2:** Progressive Resistance Exercise (strengthening exercises) [strength/resistance training]; 60 to 90 minutes; 1x/week **Primary setting:** Individual **Supervision by (if provided):** Certified personal trainer
Outcomes	UPDRS-M, elbow flexor muscle strength and movement speed, modified Physical Performance Test, PDQ-39, TUG, BBS, 6-MIN-W, walk speed (50-feet); sit to stand test, FRT, stride length, cadence, double support time, ankle strength (on/off; comfortable/fast speed), cognition **Severity of motor signs assessed during:** on- and off-medication state **Follow-up (maximum time after end of intervention):** 0 (post-intervention)
Notes	**Funding sources:** National Institute of Neurological Disorders and Stroke **Conflicts of interest:** DMC received grant support from the National Institutes of Health (NIH) and Michael J. Fox, and receives lecture and reviewer fees from NIH. JAR, FJD, and CP received grant support from NIH. SEL was a statistical consultant for this project through the University of Illinios at Chicago. DEV received grant support from NIH, Michael J. Fox, and consults for projects at UT Southwestern Medical Center and Great Lakes NeuroTechnologies. MRR had scholarship support from the Foundation for Physical Therapy and received grant support from NIH. WMK received grant support from NIH and DoD and consulting fees from NIH. CLC received research support from Allergan Inc., Merz Pharmaceuticals, Ipsen Limited, NIH, and Parkinson Disease Foundation, and consulting fees from Neupathe, Allergan Inc., Merz Pharmaceuticals, Ipsen Limited, and Medtronic Corporation.

Cugusi 2015

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** No
Participants	**Number of participants (recruited/randomized/evaluated):** 20/20/20 **Country:** Italy **Age (mean in years):** 67.3 **Sex (male/female):** 16/4 (80% male) **Duration of disease (mean in years):** 7 **HY (mean):** 2.4; 2.3 **UPDRS-M (mean):** 25.3; 25.0 **MMSE (mean):** ≥ 24 (inclusion criteria)

Cugusi 2015 *(Continued)*

	Physical capability: TUG: 8.8; 9.2, 6-MIN-W: 330.9; 328.1 **Inclusion criteria:** Diagnosis of probable PD, performed by a neurologist (PS) with expertise in PD and other movement disorders; disease severity ranging between stage 1 to 3 on the HY staging; age between 40 to 80 years; stable medication use **Exclusion criteria:** MMSE score lower than 24 (Folstein F, Folstein, SE & McHugh, 1975); debilitating conditions or vision impairment that would impede full participation in the study; any disorder interfering with the correct assessment of clinical aspects of the disease; unavailability during the study period.
Interventions	**Length of intervention:** 12 weeks **Intervention 1:** Nordic walking [endurance training]; 60 minutes; 2x/week **Intervention 2:** Control group (Conventional care) [passive control group] **Primary setting:** Group **Supervision by (if provided):** Adapted physical activity professionals
Outcomes	UPDRS-M; HY; resting heart rate; systolic blood pressure at rest; diastolic blood pressure at rest; 6-MIN-W; FTSTS; hand-grip test; BBS; TUG; sit and reach test; back scratch test; Parkinson's Fatigue Scale; BDI-II; Starkstein Apathy Scale; non-motor Symptoms Scale **Severity of motor signs assessed during:** on-medication state **Follow-up (maximum time after end of intervention):** 0 (post-intervention)
Notes	**Funding sources:** NR **Conflicts of interest:** NR

da Silva Rocha Paz 2019

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** No
Participants	**Number of participants (recruited/randomized/evaluated):** 27/27/24 **Country:** Brazil **Age (mean in years):** 61.8; 67.4 **Sex (male/female):** 18/6 (75% male) **Duration of disease (mean in years):** 4.9; 6.4 **HY (mean):** 1.9; 2.0 **UPDRS-M (mean):** 23.5; 24.2 **MMSE (mean):** NR

da Silva Rocha Paz 2019 *(Continued)*

	Physical capability: 6-MIN-W (m): 500.7; 420.6, Gait speed (m/s): 1.16; 1.13 **Inclusion criteria:** Both genders, aged between 55 and 75 years old, diagnosed with PD according to the Brain Bank of the United Kingdom standards, and classified in stages from 1 to 3 on HY scale **Exclusion criteria:** People without an adequate drug regimen for at least three months; had undergone physiotherapy within three months before the protocol; inability to perform physical exercises; presence of other neurological disorders and/or severe impairment of the cardiorespiratory and/or musculoskeletal system. 'In cases in which patients had changes in the drug regimen during the study or missed sessions, they were disregarded [understood to mean excluded].'
Interventions	**Length of intervention:** 14 weeks **Intervention 1:** Treadmill training and kinesiotherapy [endurance training]; 50 minutes; 2x/week **Intervention 2:** Conventional physiotherapy [multi-domain training]; 50 minutes; 2x/week **Primary setting:** Group/Individual/Group and individual **Supervision by (if provided):** Physical therapists
Outcomes	TUG, 6-MIN-W, gait speed, UPDRS-total, UPDRS-II, UPDRS-M, upstairs-test and downstairs-test **Severity of motor signs assessed during:** NR **Follow-up (maximum time after end of intervention):** 0 (post-intervention)
Notes	**Funding sources:** NR **Conflicts of interest:** NR

Daneshvar 2019

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** Yes
Participants	**Number of participants (recruited/randomized/evaluated):** NR/20/20 **Country:** Iran **Age (mean in years):** 55.8; 57.0 **Sex (male/female):** NR **Duration of disease (mean in years):** NR **HY (range):** 2 to 3 **UPDRS-M (mean):** NR **MMSE (mean):** NR **Physical capability:** NR

Daneshvar 2019 *(Continued)*

	Inclusion criteria: A known case of PD in stages 2 or 3 according to Hoehn and Yahr scale; aged 20 to 50 years old; being at the onset stage of the disease (response to drugs); being at the moderate stage of the disease according to the UPDRS; and voluntary agreement of the individual to participate in the research **Exclusion criteria:** People with any history of spinal or lower limb severe injury or surgery during last year, those with any skeletal deformity who were not able to do the exercises, those who were absent in more than 30% of sessions, and those who did not agree to participate in the study were excluded.
Interventions	**Length of intervention:** 8 weeks **Intervention 1:** Rebound exercise (trampolining training) [gait/balance/functional training]; 20 to 45 minutes; 3x/week **Intervention 2:** Treadmill training [endurance training]; 20 to 45 minutes; 3x/week **Primary setting:** Individual **Supervision by (if provided):** Researcher
Outcomes	PDQ-39; Proprioception (Biodex Isokinetic testing machine), Range of motion (metal goniometer) **Follow-up (maximum time after end of intervention):** 1 week
Notes	**Funding sources:** University of Isfahan **Conflicts of interest:** None

Dashtipour 2015

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** Yes
Participants	**Number of participants (recruited/randomized/evaluated):** NR/11/11 **Country:** USA **Age (mean in years):** 63.4 **Sex (male/female):** 5/6 (45.5% male) **Duration of disease (mean in years):** 3.8 **HY (mean):** 1.8; 1.3 **UPDRS-M (mean):** 17.2; 18.4 **MMSE (mean):** NR **Physical capability:** NR **Inclusion criteria:**

Dashtipour 2015 *(Continued)*

	30 to 90 years old; stable dose of PD medications for the last 28 days; clinical condition at time of study enrollment did not require any changes of medication for the next four months; being clinically stable to attend either the outpatient physical therapy for LSVT BIG therapy or a general exercise program at the Loma Linda University Research Laboratory for sixteen 1-hour sessions over four weeks **Exclusion criteria:** Atypical PD; participation in an ongoing exercise program; history of repeated strokes with stepwise progression of Parkinsonian features; evidence of severe depression or other significant behavioral disorders; significant or unstable medical or surgical condition that may preclude safe and complete study participation
Interventions	**Length of intervention:** 4 weeks **Intervention 1:** LSVT BIG Therapy [LSVT BIG]; 60 minutes; 4x/week **Intervention 2:** General exercise (treadmill exercise and seated upper extremity exercise) [multi-domain training]; 60 minutes; 4x/week **Primary setting:** Individual **Supervision by (if provided):** LSVT BIG certified physical therapist; research investigator
Outcomes	UPDRS (total); UPDRS-M; Beck Anxiety Inventory; Modified Fatigue Impact Scale **Follow-up (maximum time after end of intervention):** 6 months
Notes	**Funding sources:** NR **Conflicts of interest:** None

De Assis 2018

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** No
Participants	**Number of participants (recruited/randomized/evaluated):** NR/20/17 **Country:** Brazil **Age (mean in years):** 65.0; 66.4 **Sex (male/female):** 13/4 (76.5% male) **Duration of disease (mean in years):** 12.3; 10.8 **HY (mean):** 3.0; 3.0 **UPDRS-M (mean):** 16; 17 **MoCA (mean):** 21.1; 20.4 **Physical capability:** NR **Inclusion criteria:** Medical permission to exercise; diagnosis of PD; HY 2 to 3

De Assis 2018 *(Continued)*

	Exclusion criteria: Inability to walk independently; lack of completion of at least 85% of the exercise program
Interventions	**Length of intervention:** 4 weeks **Intervention 1:** Water-walking program [aqua-based training]; 40 minutes, frequency not reported **Intervention 2:** Control group [passive control group] **Primary setting:** Group **Supervision by (if provided):**
Outcomes	UPDRS; Senior Fitness test battery **Severity of motor signs assessed during:** on-medication state **Follow-up (maximum time after end of intervention):** 0 (post-intervention)
Notes	**Funding sources:** NR **Conflicts of interest:** None

De Moraes Filho 2020

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** No
Participants	**Number of participants (recruited/randomized/evaluated):** 75/62/40 **Country:** Brazil **Age (mean in years):** 64.7; 64.4 **Sex (male/female):** 30/10 (75% male) **Duration of disease (mean in years):** 5.7; 7.2 **HY (range):** 1 to 3 **UPDRS-M (mean):** NR **MMSE (mean):** > 24 [> 19] (inclusion criteria) **Physical capability:** TUG: 9.2; 9.3 **Inclusion criteria:** Diagnosed with PD, HY stage 1 to 3, between 50 and 80 years old, no cognitive impairment as assessed by the MMSE, where the cut-off points for inclusion were > 24 points for literate individuals and > 19 for non-literate individuals, and attested to participate in the resistance training (RT) program **Exclusion criteria:** Diagnosed with any other neurological disease, with cardiovascular disease, hematologic or orthopedic disorders; with motor fluctuations or severe dyskinesia that could affect their ability to perform the

De Moraes Filho 2020 *(Continued)*

	experimental protocol. Moreover, participants who did not reach the minimum frequency of 75% or missed 3 consecutive training sessions were excluded from analyses.
Interventions	**Length of intervention:** 9 weeks **Intervention 1:** Resistance training program [strength/resistance training]; 50 to 60 minutes; 2x/week **Intervention 2:** Control group (lectures) [passive control group] **Primary setting:** Individual **Supervision by (if provided):** Proficient professionals
Outcomes	30-second sit to stand test; TUG; 10MWT; peak torques; bradykinesia subscale of the UPDRS-M **Follow-up (maximum time after end of intervention):** 0 (post-intervention)
Notes	**Funding sources:** NR **Conflicts of interest:** None

Dipasquale 2017

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** Yes
Participants	**Number of participants (recruited/randomized/evaluated):** 297/40/31 **Country:** Italy **Age (mean in years):** 67 **Sex (male/female):** 26/14 (65% male) **Duration of disease (mean in years):** 2.25; 2.33 **HY (mean):** 2 (inclusion criteria) **UPDRS-M (median):** 11; 8.5 **MMSE (mean):** ≥ 24 (inclusion criteria) **Physical capability:** TUG (median): 10.3;8.5 **Inclusion criteria:** Idiopathic Parkinson's disease; time from diagnosis ≥ 24 months; HY 2; medical therapy unchanged for at least one month; ability to follow the study protocol **Exclusion criteria:** Contraindications for physical activity at study's intensity level; > 85 years; MMSE < 24; > 3 in one or more Cumulative Illness Rating Scale categories; physiotherapy treatment or supervised physical activity in the past six months
Interventions	**Length of intervention:** 4 months

Dipasquale 2017 *(Continued)*

	Intervention 1: Physiotherapy program (transfers, body posture, reaching and grasping, balance and gait) [gait/balance/functional training]; 60 minutes; 2x/week **Intervention 2:** General exercise program (upper limbs, lower limbs, spine, balance, and breathing) [multi-domain training]; 60 minutes; 2x/week **Primary setting:** Group **Supervision by (if provided):** Physiotherapist; expert in physical education
Outcomes	UPDRS, UPDRS-M; Hamilton Rating Scale - Depression; Functional Independence Measure; TUG **Follow-up (maximum time after end of intervention):** 118 to 190 days
Notes	**Funding sources:** NR **Conflicts of interest:** None

Duncan 2012

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** Yes
Participants	**Number of participants (recruited/randomized/evaluated):** 123/62/3 **Country:** USA **Age (mean in years):** 69.3; 69.0 **Sex (male/female):** 30/22 (57.7% male) **Duration of disease (mean in years):** 5.8; 7.0 **HY (mean):** 2.6; 2.5 **UPDRS-M (mean):** 44.5; 48.0 **MMSE (mean):** NR **Physical capability:** Physical Activity Scale for the Elderly: 124.2; 115.4 **Inclusion criteria:** Diagnosed with idiopathic PD, HY stages I to IV, and experienced clear motor benefit from levodopa. Participants had to be able to walk independently for 3 meters with or without an assistive device **Exclusion criteria:** Serious medical condition, evidence of abnormality other than PD-related changes on brain imaging, history or evidence of neurological deficit other than PD, history or evidence of musculoskeletal problem
Interventions	**Length of intervention:** 12 months **Intervention 1:** Tango [dance]; 60 minutes; 2x/week **Intervention 2:** Control [passive control group]

Duncan 2012 *(Continued)*

	Primary setting: Group
	Supervision by (if provided): Experienced dance instructor
Outcomes	MDS-UPDRS-M, UPDRS-I, UPDRS-II, MiniBESTest balance test; FOG-Q; 6-MIN-W; gait velocity, Nine-Hole Peg Test; BDI-II; Activity Card Sort
	Severity of motor signs assessed during: off-medication state
	Follow-up (maximum time after end of intervention): 0 (post-intervention)
Notes	**Funding sources:** Parkinson's Disease Foundation
	Conflicts of interest: None

Ebersbach 2010

Study characteristics	
Methods	Randomized controlled trial
	Single center
	A priori consideration of test power: No
Participants	**Number of participants (recruited/randomized/evaluated):** NR/60/58
	Country: Germany
	Age (mean in years): 67.1; 65.5; 69.3
	Sex (male/female): 22/36 (37.9% male)
	Duration of disease (mean in years): 6.1; 7.8; 7.4
	HY (mean): 2.8; 2.6; 2.5
	UPDRS-M (mean): 21.1; 18.5; 19.1
	MMSE (mean): ≥ 25 (inclusion criteria)
	Physical capability: 10MWT (sec): 7.7; 7.9; 7.9
	Inclusion criteria:
	Idiopathic PD, HY 1 to 3, outpatient treatment, stable medication 4 weeks prior to inclusion
	Exclusion criteria:
	MMSE < 25, severe depression, disabling dyskinesia, and comorbidity affecting mobility or ability to exercise
Interventions	**Length of intervention:** 4/8 weeks
	Intervention 1: LSVT BIG [LSVT BIG]; 60 minutes; 4x/week, 4 weeks
	Intervention 2: Nordic walking [endurance training]; 60 minutes; 2x/week, 8 weeks
	Intervention 3: Control (received 1-hour instruction of domestic training with practical demonstration and training) [passive control group]; 4 weeks
	Primary setting: Group and individual

Ebersbach 2010 *(Continued)*

	Supervision by (if provided): LSVT BIG and Nordic-walking-certified physiotherapist
Outcomes	UPDRS-M, PDQ-39, TUG, Timed 10 m (sec); Test battery for Attentional Performance subtest for alertness **Severity of motor signs assessed during:** on-medication state **Follow-up (maximum time after end of intervention):** 8/12 weeks (overall 16 weeks after baseline)
Notes	**Funding sources:** Deutsche Parkinson Gesellschaft **Conflicts of interest:** Georg Ebersbach: honoraries for presentations from Boehringer Ingelheim Pharma, Cephalon, Desitin Pharma, GlaxoSmithKline, Valeant, Novartis, Orion, and Schwarz Pharma (UCB). Honoraries for consultancy and advisory board activities from Axxonis Pharma, Boehringer Ingelheim Pharma, Cephalon, Desitin Pharma, Valeant, Orion. Grants from Deutsche Parkinson Gesellschaft (DPV) and Deutsche Forschungs-Gesellschaft (DFG). Jörg Wissel: honoraries for presentations and advisory board activities from Allergan, Eisai, Ipsen Medtronic, and Merz. Andreas Kupsch: honoraries for presentations from Allergan, Boehringer Ingelheim Pharma, Desitin Pharma, GlaxoSmithKline, Ipsen, Lundbeck, Merz Pharma, Medtronic, Novartis, Orion, and Schwarz Pharma (UCB). Honoraries for advisory board activities and consultancy from Novartis and Medtronic. Grants from Deutsche Forschungs-Gesellschaft (DFG) and Fresenius-Körner-Foundation.

Ellis 2005

Study characteristics	
Methods	Randomized controlled trial with cross-over after 6 weeks Multicenter **A priori consideration of test power:** Yes
Participants	**Number of participants (recruited/randomized/evaluated):** NR/68/65 **Country:** USA, Netherlands **Age (mean in years):** 64 **Sex (male/female):** 51/17 (75% male) **Duration of disease (mean in years):** NR **HY (mean):** 2.4 **UPDRS-M (mean):** 30.2 **MMSE (mean):** ≥ 24 (inclusion criteria) **Physical capability:** comfortable walking speed (m/s): 0.77; 0.83 **Inclusion criteria:** Patients with idiopathic PD (early-middle stages); stable medication usage; HY: 2/3; at least 1 score of 2 or more for at least 1 limb for either the tremor, rigidity, or bradykinesia item of the UPDRS; ability to walk independently; aged 35 to 75 years; no severe cognitive impairments (MMSE ≥ 24); not having participated in a physical therapy or rehabilitation program in the previous 2 months **Exclusion criteria:** Other severe neurologic, cardiopulmonary, or orthopedic disorders; participation in physiotherapy or rehabilitation program in previous 2 months

Ellis 2005 *(Continued)*

Interventions	**Length of intervention:** 6 weeks **Intervention 1:** Physical therapy, rehabilitation program, and medication [multi-domain training]; 90 minutes; 2x/week **Intervention 2:** Medication only [passive control group] **Primary setting:** Group **Supervision by (if provided):** Licensed physical therapist
Outcomes	Sickness Impact Profile, the mobility portion of the Sickness Impact Profile-68, UPDRS, comfortable walking speed, UPDRS-M **Severity of motor signs assessed during:** on-medication state **Follow-up (maximum time after end of intervention):** 0 (post-cross-over)
Notes	**Funding sources:** NR **Conflicts of interest:** NR

Feng 2019

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** No
Participants	**Number of participants (recruited/randomized/evaluated):** 31/28/28 **Country:** China **Age (mean in years):** 67.5; 66.9 **Sex (male/female):** 17/13 (56.7% male) **Duration of disease (mean in years):** 7.1; 6.6 **HY (mean):** 3.0; 3.0 **UPDRS-M (mean):** 25.1; 24.7 **MMSE (mean):** 27.1; 26.3 **Physical capability:** TUG 34.2; 37.9, Functional Gait Assessment 14.7; 16.2 **Inclusion criteria:** Diagnosis of PD; improved HY classification grade 2.5 to 4, in which there is balance dysfunction but independent walking; aged 50 to 70 years old; signed informed consent **Exclusion criteria:** Other causes of tremor, such as hereditary ataxia and cerebellar or vestibular lesions; bone and joint diseases or serious diseases affecting organ function; visual or hearing disorders; unable to cooperate with the study

Feng 2019 *(Continued)*

Interventions	**Length of intervention:** 12 weeks **Intervention 1:** Virtual reality training [gait/balance/functional training]; 45 minutes; 5x/week **Intervention 2:** Conventional physical therapy [multi-domain training]; 45 minutes; 5x/week **Primary setting:** Individual **Supervision by (if provided):** Therapist
Outcomes	BBS; TUG; UPDRS-M; Functional Gait Assessment **Severity of motor signs assessed during:** on-medication state **Follow-up (maximum time after end of intervention):** 0 (post-intervention)
Notes	**Funding sources:** Heilongjiang Health and Family Planning Commission **Conflicts of interest:** NR

Ferraz 2018

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** Yes
Participants	**Number of participants (recruited/randomized/evaluated):** 76/72/62 **Country:** Brazil **Age (mean in years):** 69 **Sex (male/female):** 37/25 (59.7% male) **Duration of disease (mean in years):** 6 **HY (range):** 2 to 3 **UPDRS-M (mean):** NR **MMSE (mean):** 27.00; 27.00; 27.00 **Physical capability:** 6-MIN-W (m): 354.9; 405.2; 365.4; 10MWT (s):1.3; 1.3; 1.2 **Inclusion criteria:** ≥ 60 years; idiopathic PD; regular use of medication; MHY 2, 2.5, or 3; no walking devices **Exclusion criteria:** Visual or hearing impairment; parkinsonian syndromes other than PD; bone, joint, or muscle diseases that limit the practice of physical activity; chronic uncontrolled diseases (hypertension, diabetes mellitus, chronic pain); unstable cardiovascular disease (acute heart failure, recent myocardial infarction, unstable angina, and arrhythmias uncontrolled); current alcohol and other toxic substance use; contraindications for performing physical exercise; practicing any physical exercise program in the past 6 months, participating in regular resistance training in the previous 12 months

Ferraz 2018 *(Continued)*

Interventions	**Length of intervention:** 8 weeks **Intervention 1:** Functional group [gait/balance/functional training]; 50 minutes; 3x/week **Intervention 2:** Bike training group [endurance training]; 50 minutes; 3x/week **Intervention 3:** Exergaming Group [gaming]; 50 minutes; 3x/week **Primary setting:** Individual **Supervision by (if provided):** Physiotherapist
Outcomes	6-MIN-W, 10MWT, PDQ-39, World Health Organization Disability Assessment Schedule 2.0, sit to stand test, EQ-5D, 15-item Geriatric Depression Scale **Follow-up (maximum time after end of intervention):** 1 week
Notes	**Funding sources:** NR **Conflicts of interest:** None

Ferrazzoli 2018

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** Yes
Participants	**Number of participants (recruited/randomized/evaluated):** 250/250/234 **Country:** Italy **Age (mean in years):** 66.5; 66.9 **Sex (male/female):** 136/98 (58.1% male) **Duration of disease (mean in years):** 9.0; 7.4 **HY (mean):** 2.6; 2.6 **UPDRS-M (mean):** NR **MMSE (mean):** NR **Physical capability:** TUG (s): 13.3; NR **Inclusion criteria:** Diagnosis of idiopathic PD according to the UK Brain Bank criteria, HY stages 2 to 4 and stable pharmacological treatment in the last 6 weeks **Exclusion criteria:** Any focal brain lesion detected with brain imaging studies, psychosis (evaluated with Neuropsychiatric Inventory), auditory, visual and/or vestibular dysfunctions, and chronic diseases other than PD with a known impact on QoL
Interventions	**Length of intervention:** 4 weeks

Ferrazzoli 2018 *(Continued)*

	Intervention 1: "MIRT Group" (multidisciplinary, aerobic, motor-cognitive, intensive and goal-based rehabilitation) [multi-domain training]; 60 minutes per session; 5x/week 4 sessions and 1x/week physical exercise **Intervention 2:** Control group [passive control group] **Primary setting:** Group and individual **Supervision by (if provided):** Therapist; neuropsychologists
Outcomes	PDQ-39, UPDRS, Parkinson's Disease Disability Scale, TUG, BBS **Follow-up (maximum time after end of intervention):** 3 months
Notes	**Funding sources:** NR **Conflicts of interest:** None

Ferreira 2018

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** Yes
Participants	**Number of participants (recruited/randomized/evaluated):** 70/35/35 **Country:** Brazil **Age (mean in years):** 67.6; 64.1 **Sex (male/female):** NR **Duration of disease (mean in years):** 4.5; 6.4 **HY (range):** 1 to 3 **UPDRS-M (median):** 30; 29 **MMSE (mean):** ≥ 24 (inclusion criteria) **Physical capability:** NR **Inclusion criteria:** Diagnosis of PD; age ≥ 60 years; HY 1 to 3; stable use of medication; not have participated in any exercise protocol in the previous three months **Exclusion criteria:** MMSE < 24; unstable cardiovascular disease; other uncontrolled chronic conditions that would interfere with participants' safety, or our conducting of the training and testing protocol and interpretation of the results; ability to walk independently; other neurological, cardiopulmonary, or orthopedic disease
Interventions	**Length of intervention:** 6 months **Intervention 1:** Resistance training group [strength/resistance training]; 30 to 40 minutes; 2x/week

Ferreira 2018 *(Continued)*

	Intervention 2: Control group [passive control group]
	Primary setting: Individual
	Supervision by (if provided): Exercise specialist; neurologist
Outcomes	Beck's Anxiety Inventory, PDQ-39, UPDRS-M, TUG
	Follow-up (maximum time after end of intervention): 0 (post-intervention)
Notes	**Funding sources:** NR
	Conflicts of interest: NR

Fietzek 2014

Study characteristics	
Methods	Randomized controlled trial with cross-over after 2 weeks
	Single center
	A priori consideration of test power: Yes
Participants	**Number of participants (recruited/randomized/evaluated):** 53/23/21
	Country: Germany
	Age (mean in years): 69.8; 64.2
	Sex (male/female): 16/6 (72.7% male)
	Duration of disease (mean in years): 12.1; 13.3
	HY (mean): 3; 3
	UPDRS-M (mean): NR
	MMSE (mean): NR
	Physical capability: NR
	Inclusion criteria:
	Diagnosis of PD, a gait disorder with freezing while other motor symptoms (e.g. bradykinesia, rigidity, tremor) convincingly responded to dopaminergic medication, a HY score of less than four and the ability to walk independently outside the house
	Exclusion criteria:
	NR
Interventions	**Length of intervention:** 2 weeks
	Intervention 1: Cueing [gait/balance/functional training]; 30 minutes; 3x/week
	Intervention 2: Control [passive control group]
	Primary setting: Individual
	Supervision by (if provided): Physiotherapists

Fietzek 2014 *(Continued)*

Outcomes	Freezing score; freezing questionnaire; MDS-UPDRS question 11; PDQ-39 mobility; falls **Follow-up (maximum time after end of intervention):** 4 weeks (8 weeks after baseline)
Notes	**Funding sources:** German Parkinson Association; German Foundation Neurology **Conflicts of interest:** None

Fil-Balkan 2018

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** No
Participants	**Number of participants (recruited/randomized/evaluated):** 34/30/24 **Country:** Turkey **Age (mean in years):** 72.75; 71.83 **Sex (male/female):** 13/11 (54,2% male) **Duration of disease (mean in years):** 6.91; 6.83 **HY (range):** 2.5 to 3 **UPDRS-M (mean):** 21.66; 20.41 **MMSE (mean):** 29.25; 28.92 **Physical capability:** TUG: 16.75; 16.59 **Inclusion criteria:** Idiopathic PD diagnosis by a neurologist; HY 2 to 3; at least 26 points in the MMST; age 50+; no other neurologic disease; no changes in PD medications or dosages during the course of treatment **Exclusion criteria:** Severe mental and psychological disorders; participation in a physiotherapy program within the last 6 months
Interventions	**Length of intervention:** 6 weeks **Intervention 1:** Classic physiotherapy program (flexibility, strengthening, posture, breathing balance, walking exercises, and other functional activities) [multi-domain training]; 60 minutes; 2x/week **Intervention 2:** Classic physiotherapy program + sensorimotor integration training [gait/balance/functional training]; 90 minutes; 2x/week **Primary setting:** Individual **Supervision by (if provided):** NR
Outcomes	UPDRS-M; UPDRS-II; TUG; FRT; BBS; postural control evaluated with Computerized Dynamic Posturography

Fil-Balkan 2018 *(Continued)*

	Severity of motor signs assessed during: NR
	Follow-up (maximum time after end of intervention): 6 weeks
Notes	**Funding sources:** None
	Conflicts of interest: None

Fisher 2008

Study characteristics	
Methods	Randomized controlled trial
	Single center
	A priori consideration of test power: No
Participants	**Number of participants (recruited/randomized/evaluated):** NR/30/30
	Country: USA
	Age (mean in years): 64.0; 61.5; 63.1
	Sex (male/female): 19/11 (63.3% male)
	Duration of disease (mean in month): 14.7; 8.8; 17.7
	HY (range): 1 to 2
	UPDRS-M (mean): 27.6; 30.5; 27.6
	MMSE (mean): 28.9; 29.3; 29.6
	Physical capability: Walking velocity (m/s): 1.46; 1.40; 1.39
	Inclusion criteria:
	PD diagnosis within 3 years of study participation; HY 1 to 2; 18 years of age or older; medical clearance from the primary care physician to participate in an exercise program; ability to walk
	Exclusion criteria:
	Medical or physical screening examination showed a score of less than 24 on the MMSE; physician-determined major medical problems such as cardiac dysfunction that would interfere with participation; musculoskeletal impairments or excessive pain in any joint that could limit participation in an exercise program; insufficient endurance and stamina to participate in exercise 3 times a week for a 1-hour session
Interventions	**Length of intervention:** 8 weeks
	Intervention 1: High-intensity group (treadmill) [endurance training]; 45 minutes; 3x/week
	Intervention 2: Low-intensity group (general or traditional physical therapy) [multi-domain training]; 45 minutes; 3x/week
	Intervention 3: Zero-intensity group (education classes) [active control group]; 60 minutes; 6x/8 weeks
	Primary setting: Individual
	Supervision by (if provided): Physical therapist

Fisher 2008 *(Continued)*

Outcomes	UPDRS; HY; biomechanic analysis of self-selected and fast walking and sit to stand tasks; corticomotor excitability using transcranial magnetic stimulation **Severity of motor signs assessed during:** on-medication state **Follow-up (maximum time after end of intervention):** 0 (post-intervention)
Notes	**Funding sources:** Supported by the Kinetics Foundation and National Institute of Neurological Disorders and Stroke **Conflicts of interest:** None

Frazzitta 2012

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** Yes
Participants	**Number of participants (recruited/randomized/evaluated):** 68/50/50 **Country:** Italy **Age (mean in years):** 72;70 **Sex (male/female):** 24/26 (48% male) **Duration of disease (mean in years):** 8;9 **HY (mean):** 3 **UPDRS-M (mean):** 21; 22 **MMSE (mean):** ≥ 26 (inclusion criteria) **Physical capability:** NR **Inclusion criteria:** Diagnosis of "clinically probable" idiopathic PD, HY stage 3, ability to walk without physical assistance, no cognitive impairment (MMSE ≥ 26), no comorbidity, no vestibular/visual dysfunction limiting locomotion or balance, and anti-Parkinsonian medications stable for > 4 weeks. **Exclusion criteria:** NR
Interventions	**Length of intervention:** 2x4 weeks **Intervention 1:** Intensive rehabilitation treatment (physiotherapy) [multi-domain training]; 60 minutes; 3x/day, 5x/week **Intervention 2:** Control group (pharmacological treatment only) [passive control group] **Primary setting:** Individual **Supervision by (if provided):** NR

Frazzitta 2012 *(Continued)*

Outcomes	UPDRS-II, UPDRS-M; UPDRS-total, levodopa equivalent daily dosage **Follow-up (maximum time after end of intervention):** 0 (post-intervention)
Notes	**Funding sources:** "The author(s) received no financial support for the research, authorship, and/or publication of this article." **Conflicts of interest:** None

Frazzitta 2014

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** Yes
Participants	**Number of participants (recruited/randomized/evaluated):** 27/25/24 **Country:** Italy **Age (mean in years):** 67; 65 **Sex (male/female):** NR **Duration of disease (mean in months):** 8; 8 **HY (range):** 1 to 1.5 **UPDRS-M (mean):** 16.4; 15.6 **MMSE (mean):** ≥ 26 (inclusion criteria) **Physical capability:** NR **Inclusion criteria:** A diagnosis of “clinically probable” idiopathic PD, HY stage 1 to 1.5, no other neurological condition, rasagiline monotherapy for at least 8 weeks, MMSE score greater than 26, visual and hearing function sufficient to perceive cues, and ability to walk without any physical assistance. "We chose to evaluate patients who were all treated with the same drug (rasagiline) in order to avoid possible influences of different pharmacological classes on both motor performance and BDNF levels" **Exclusion criteria:** Postural hypotension, cardiovascular disorders, musculoskeletal disorders, vestibular dysfunctions limiting locomotion or balance, and depression (Hamilton Depression Rating Scale > 8)
Interventions	**Length of intervention:** 28 days **Intervention 1:** Intensive rehabilitation treatment (physiotherapy) [multi-domain training]; 60 minutes; 3x/day, 5x/week **Intervention 2:** Control [passive control group] **Primary setting:** Individual **Supervision by (if provided):** NR

Frazzitta 2014 *(Continued)*

Outcomes	Serum brain-derived neurotrophic factor concentration; UPDRS-M, UPDRS-II, BBS, 6-MIN-W **Severity of motor signs assessed during:** on-medication state **Follow-up (maximum time after end of intervention):** 0 (post-intervention)
Notes	**Funding sources:** "The author(s) received no financial support for the research, authorship, and/or publication of this article." **Conflicts of interest:** None

Frazzitta 2015

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** Yes
Participants	**Number of participants (recruited/randomized/evaluated):** 47/40/31 **Country:** Italy **Age (mean in years):** 69; 68 **Sex (male/female):** NR **Duration of disease (mean in years):** NR **HY (range):** 1 to 1.5 **UPDRS-M (mean):** 15.8; 11.3 **MMSE (mean):** ≥ 26 (inclusion criteria) **Physical capability:** 6-MIN-W (m): 371; 408 **Inclusion criteria:** Diagnosis of “clinically probable” idiopathic PD, HY stage 1 to 1.5, ability to walk without physical assistance, MMSE score ≥ 26, no serious comorbidity, and no vestibular/visual dysfunction limiting locomotion or balance **Exclusion criteria:** NR
Interventions	**Length of intervention:** 2x4 weeks **Intervention 1:** Multidisciplinary intensive rehabilitation treatment [multi-domain training]; 60 minutes; 3x/day, 5x/week **Intervention 2:** Control group (drug only) [passive control group] **Primary setting:** Individual **Supervision by (if provided):** Neurologists, physiatrists, psychologists, nurses, physiotherapists, occupational therapists

Frazzitta 2015 *(Continued)*

Outcomes	UPDRS-II; UPDRS-M; 6-MIN-W; TUG; self-assessment Parkinson's Disease Disability Scale; levodopa equivalent daily dosage; number of participants in monotherapy with rasagaline **Follow-up (maximum time after end of intervention):** 24 months (post-baseline)
Notes	**Funding sources:** "The author(s) received no financial support for the research, authorship, and/or publication of this article." **Conflicts of interest:** None

Ganesan 2014

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** No
Participants	**Number of participants (recruited/randomized/evaluated):** 94/60/60 **Country:** India **Age (mean in years):** 59.1; 57.7; 57.6 **Sex (male/female):** 46/14 (76.7% male) **Duration of disease (mean in years):** 5.5; 4.9; 5.7 **HY (range):** 2 to 2.5 **UPDRS-M (mean):** 30.15; 30.70; 31.95 **MMSE (mean):** 28.7; 28.8; 29.3 **Physical capability:** Tinetti Performance-Oriented Mobility Assessment: 13.0; 13.5; 12.9 **Inclusion criteria:** Diagnosis of PD confirmed by a movement disorders specialist as per the United Kingdom Brain Bank Criteria **Exclusion criteria:** People with cognitive deficits (MMSE ≤ 24), moderate to severe depression (BDI ≥ 17), severe dyskinesia (Goetz score > 3), advanced PD (HY stage > 3), unpredictable motor fluctuations, and orthopedic problems affecting gait training, as well as people who had undergone previous formal gait training or balance training, were excluded from the study.
Interventions	**Length of intervention:** 4 weeks **Intervention 1:** Control group [Passive control] **Intervention 2:** Conventional gait training [gait/balance/functional training]; 30 minutes; 4x/week **Intervention 3:** Partial weight supported treadmill gait training [gait/balance/functional training]; 30 minutes; 4x/week **Primary setting:** Group/individual

Ganesan 2014 *(Continued)*

	Supervision by (if provided): NR
Outcomes	UPDRS-total and UPDRS-M as well as further UPDRS-M subscores; dynamic posturography; BBS; Tinetti Performance-Oriented Mobility Assessment; blood pressure including mean systolic blood pressure (SBP), mean diastolic blood pressure, co-variation of SBP, low frequency component of SBP and spontaneous baroflex sensitivity; 10MWT; 2-MIN-W **Severity of motor signs assessed during:** on-medication state **Follow-up (maximum time after end of intervention):** 0 (post-intervention)
Notes	**Funding sources:** NR **Conflicts of interest:** None

Gao 2014

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** No
Participants	**Number of participants (recruited/randomized/evaluated):** 80/80/76 **Country:** China **Age (mean in years):** 69.5; 68.3 **Sex (male/female):** 50/26 (65.8% male) **Duration of disease (mean in years):** 9.2; 8.4 **HY (range):** 1 to 3 **UPDRS-M (mean):** 31.86; 30.62 **MMSE (mean):** ≥ 25 (inclusion criteria) **Physical capability:** TUG 10.89; 11.58 **Inclusion criteria:** Diagnosis as idiopathic PD; over 40 years old; could walk independently and fell at least one time during the past 12 months **Exclusion criteria:** MMSE < 24; had a serious medical problem such as heart failure and severe hypertension (equal to or greater than a systolic 180 or diastolic of 110) and could not endure moderate exercise for 60 minutes due to any reason
Interventions	**Length of intervention:** 12 weeks **Intervention 1:** Tai chi [mind-body training]; 60 minutes; 3x/week **Intervention 2:** Control group [passive control group] **Primary setting:** Group

Gao 2014 *(Continued)*

	Supervision by (if provided): Tai chi instructor
Outcomes	BBS, UPDRS, TUG, falls **Severity of motor signs assessed during:** NR **Follow-up (maximum time after end of intervention):** 6 months
Notes	**Funding sources:** "This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors." **Conflicts of interest:** None

Gobbi 2021

Study characteristics	
Methods	Randomized controlled trial with cross-over after 32 weeks of intervention and 4 months detraining period Single center **A priori consideration of test power:** Yes
Participants	**Number of participants (recruited/randomized/evaluated):** NR/152/107 **Country:** Brazil **Age (mean in years):** 69.6; 67.8; 69.5 **Sex (male/female):** 78/74 (51.3% male) **Duration of disease (mean in years):** 8.0; 5.0; 5.9 **HY (mean):** 1.9; 1.8; 1.7 **UPDRS-M (mean):** 23.7; 22.8; 22.6 **MMSE (mean):** 28.2; 28.0; 27.7 **Physical capability:** NR **Inclusion criteria:** Initially, participants from a support group (Program of Physical Activity for People with Parkinson's disease [PROPARKI]) volunteered to participate in the study. People with idiopathic PD according to the United Kingdom PD Brain Bank criteria, who walked unassisted and without ambulation aids during the intervention, did not have any other neurological (self-reported) or cognitive impairment (assessed by the MMSE) and were > 40 years old were eligible for the study. The protocol was approved by the Human Studies Ethics Committee at Sao Paulo State University (n. 1058), and all participants gave their signed informed consent. Participants who attended at least 70% of the sessions without 5 consecutive absences were included in the final analysis. **Exclusion criteria:** NR
Interventions	**Length of intervention:** 32 weeks **Intervention 1:** Multimodal (aerobic resistance; general flexibility; lower/upper limbs and trunk strength; motor coordination; balance) [gait/balance/functional training]; 60 minutes; 2x/week

Gobbi 2021 *(Continued)*

	Intervention 2: Functional mobility [gait/balance/functional training]; 60 minutes; 2x/week **Intervention 3:** Mental/leisure [active control group]; 60 minutes; 2x/week **Primary setting:** Individual **Supervision by (if provided):** NR
Outcomes	Hospital Anxiety and Depression scale; PDQ-39; Lipp's Stress Symptoms Inventory for Adults; MMSE; clock drawing test; verbal fluency; Wechsler Memory Scale; Wechsler Adult Intelligence Scale; Wisconsin Card Sort Test **Follow-up (maximum time after end of intervention):** 0 (post-intervention)
Notes	**Funding sources:** supported in part by de Cordenacao de Aperfeicoamento de Pessoal de Nıvel Superior, Brasil (CAPES), and by Conselho Nacional de Desenvolvimento Cientifico e Tecnologico (CNPq) **Conflicts of interest:** None

Goodwin 2011

Study characteristics	
Methods	Randomized controlled trial Multicenter **A priori consideration of test power:** Yes
Participants	**Number of participants (recruited/randomized/evaluated):** 204/130/124 **Country:** Great Britain **Age (mean in years):** 72.0; 70.1 **Sex (male/female):** 74/56 (56.9% male) **Duration of disease (mean in years):** 9.1; 8.2 **HY (mean):** 2.6; 2.4 **UPDRS-M (mean):** NR **MMSE (mean):** NR **Physical capability:** Median "Phone-FITT" household physical activity levels: 16.0; 19.0 **Inclusion criteria:** Diagnosis of idiopathic PD as confirmed by a PD specialist (geriatrician or neurologist) using UK Brain Bank criteria, a self-reported history of recurrent falls (two or more) in the preceding year, the ability to mobilise independently indoors, with or without a walking aid, and being resident in Devon or registered with a Devon general practitioner **Exclusion criteria:** Potential participants were excluded if they needed supervision or assistance to mobilise indoors, had a significant comorbidity or symptoms that affected ability or safety to exercise (e.g. unstable angina, significant postural hypotension, severe pain) or were unable to follow written or verbal instructions in English
Interventions	**Length of intervention:** 10 weeks

Goodwin 2011 *(Continued)*

	Intervention 1: Exercise group (physiotherapy-led, group-delivered strength and balance training program with supplementary home exercises) [multi-domain training]; 60 minutes; 1x/week + 2x/week home exercise **Intervention 2:** Usual care [passive control group] **Primary setting:** Group **Supervision by (if provided):** Physiotherapists
Outcomes	Number of falls during the 10-week group intervention period and the 10-week follow-up period (self-reported and collected via weekly diaries); FES-I, EQ-5D, "Phone-FITT", BBS, TUG **Follow-up (maximum time after end of intervention):** 10 weeks
Notes	**Funding sources:** NIHR Researcher Development Award **Conflicts of interest:** PCMD (VG, WH) and University of Exeter (AT) received funding from NIHR to undertake this research.

Gu 2013

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** No
Participants	**Number of participants (recruited/randomized/evaluated):** 49/38/35 **Country:** China **Age (mean in years):** 67.4; 69.5 **Sex (male/female):** 25/10 (71.4% male) **Duration of disease (mean in years):** 5.8; 6.2 **HY (range):** 1 to 3 **UPDRS-M (mean):** 30.5; 31.0 **MMSE (mean):** ≥ 24 (inclusion criteria) **Physical capability:** NR **Inclusion criteria:** Early and intermediate PD (HY 1 to 3); participants were required to have had Parkinson's medication for at least 2 weeks and be effective on Parkinson's medication **Exclusion criteria:** Parkinson's syndrome and Parkinson's superimposed syndrome from various causes; people who had undergone rehabilitation training in the 4 months prior to inclusion in this study; comorbid severe cognitive impairment MMSE score of less than 24; people with comorbid depression who were unable to actively participate in rehabilitation training; people with comorbid schizophrenia or other severe psychiatric disorders; people with comorbid severe heart, liver, kidney, lung disease, etc. People with organic lesions of the organs that affected activity or life.

Gu 2013 *(Continued)*

Interventions	**Length of intervention:** 8 weeks **Intervention 1:** PD WEBB (weight-bearing exercise for better balance) [gait/balance/functional training]; 40 to 60 minutes; 3x/week **Intervention 2:** Control group [passive control group] **Primary setting:** NR **Supervision by (if provided):** Physicians
Outcomes	FES; UPDRS; Mini-BESTest **Severity of motor signs assessed during:** on-medication state **Follow-up (maximum time after end of intervention):** 0 (post-intervention)
Notes	**Funding sources:** Science and Technology Plan Fund of Hunan Province, China **Conflicts of interest:** NR **Language:** Chinese

Guan 2016

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** No
Participants	**Number of participants (recruited/randomized/evaluated):** NR/62/62 **Country:** China **Age (mean in years):** 70.2; 69.7 **Sex (male/female):** 33/29 (53.2% male) **Duration of disease (mean in years):** 4.4; 4.3 **HY (mean):** 2.05; 2.07 **UPDRS-M (mean):** NR **MMSE (mean):** NR **Physical capability:** 10-meter gait speed (m/min): 55.3; 54.4 **Inclusion criteria:** Diagnosis of PD; HY stage 1 to [upper limit understood to be 3]; clear consciousness, no obvious cognitive impairment, able to learn tai chi movements; informed consent to this study and willing to cooperate **Exclusion criteria:** People with organic diseases such as psychosis, severe heart, liver, spleen, kidney, etc.; secondary Parkinson's syndrome and Parkinson's superimposed syndrome by various causes; people who have to

Guan 2016 *(Continued)*

	withdraw halfway through study; people who cannot stand or walk independently due to fractures or other reasons; participation in other rehabilitation training
Interventions	**Length of intervention:** 12 weeks **Intervention 1:** Tai chi [mind-body training]; 60 minutes; 4x/week **Intervention 2:** Control group [passive control group] **Primary setting:** NR **Supervision by (if provided):** Professional Taijiquan coaches
Outcomes	TUG; BBS; ABC; gait parameters **Follow-up (maximum time after end of intervention):** 0 (post-intervention)
Notes	**Funding sources:** NR **Conflicts of interest:** NR **Language:** Chinese

Hackney 2007

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** No
Participants	**Number of participants (recruited/randomized/evaluated):** NR/19/19 **Country:** USA **Age (mean in years):** 72.6; 69.6 **Sex (male/female):** 12/7 (63.2% male) **Duration of disease (mean in years):** 6.2; 3.3 **HY (mean):** 2.3; 2.2 **UPDRS-M (mean):** 30.6; 28.2 **MMSE (mean):** NR **Physical capability:** walking velocity (m/s): 0.86; 0.89 **Inclusion criteria:** Diagnosed with idiopathic PD; demonstrated clear benefit from PD medications **Exclusion criteria:** "Subjects in both groups were not engaged in any other dancing or group exercise activities during the course of the study"
Interventions	**Length of intervention:** 13 weeks

Hackney 2007 *(Continued)*

	Intervention 1: Tango [dance]; 60 minutes; 2x/week **Intervention 2:** Exercise classes (breathing, stretching, resistance, dexterity, core strengthening) [multi-domain training]; 60 minutes; 2x/week **Primary setting:** Group **Supervision by (if provided):** Instructor (both a professional ballroom dancer and American Council on Exercise-certified personal trainer)
Outcomes	UPDRS; BBS; FOG-Q; TUG; velocity of Walking and dual-task walking **Severity of motor signs assessed during:** on-medication state **Follow-up (maximum time after end of intervention):** 1 week
Notes	**Funding sources:** Marian Chace Foundation; American Parkinson Disease Association **Conflicts of interest:** NR

Hackney 2009

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** No
Participants	**Number of participants (recruited/randomized/evaluated):** NR/75/61 **Country:** USA **Age (mean in years):** 68.2; 66.8; 64.9; 66.5 **Sex (male/female):** 45/16 (73.8% male) **Duration of disease (mean in years):** 6.9; 9.2; 8.7; 5.9 **HY (range):** 1 to 3 **UPDRS-M (mean):** 27.6; 26.9; 26.3; 27.4 **MMSE (mean):** NR **Physical capability:** Gait velocity (m/s) 1.11; 1.11; NR; 1.07; 6-MIN-W 364.2; 358.1; NR; 368.4 **Inclusion criteria:** "Idiopathic PD using diagnostic criteria for clinically defined “definite PD”; at least 40 years of age, could stand for at least 30 minutes, and walk independently 3 or more meters with or without an assistive device. Individuals with HY stages of I to III participated. Individuals had been previously screened for dementia by their neurologists and none were diagnosed with dementia. As another measure of cognitive function and a separate part of the study not reported here, all participants were required to perform a subtraction task while simultaneously walking. All participants understood the directions and were able to complete the task with at least 85 percent accuracy, and as such we considered them to be cognitively intact for the purposes of this study." **Exclusion criteria:**

Hackney 2009 *(Continued)*

	History of neurological deficit other than PD
Interventions	**Length of intervention:** 13 weeks **Intervention 1:** Tango [dance]; 60 minutes; 2x/week **Intervention 2:** Waltz/foxtrott [dance]; 60 minutes; 2x/week **Intervention 3:** Tai chi [mind-body training]; 60 minutes; 2x/week **Intervention 4:** Control group [passive control group] **Primary setting:** Group **Supervision by (if provided):** Experienced instructor (both a professional ballroom dancer and an American Council on Exercise-certified personal trainer)
Outcomes	PDQ-39; BBS; 6-MIN-W; UPDRS; TUG; FOG; stride length; velocity **Severity of motor signs assessed during:** on-medication state **Follow-up (maximum time after end of intervention):** 1 week
Notes	**Funding sources:** American Parkinson Disease Association **Conflicts of interest:** NR

Harvey 2019

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** Yes
Participants	**Number of participants (recruited/randomized/evaluated):** 32/20/18 **Country:** United Kingdom **Age (mean in years):** 68.5 **Sex (male/female):** 12/8 (60% male) **Duration of disease (mean in years):** NR **HY (range):** 1 to 3 **UPDRS-M (mean):** NR **MoCA (mean):** 24.5; 25.5 **Physical capability:** NR **Inclusion criteria:** Diagnosis of idiopathic PD; HY 1 to 3; had not participated in an exercise study in the past 12 months; did not have a pacemaker or a history of a serious cardiac event or cardiac or cardiorespiratory dysfunction; had sufficient cognitive ability to follow an exercise protocol (based on physician assessment) and provided informed consent

Harvey 2019 *(Continued)*

	Exclusion criteria: "All participants underwent a medical assessment by a doctor (RWW, RD) prior to cardiopulmonary exercise tests to assess their suitability for high-intensity interval training. Some of those recruited were subsequently excluded on medical grounds"
Interventions	**Length of intervention:** 12 weeks **Intervention 1:** High-intensity interval training [strength/resistance training]; 45 minutes; 3x/week **Intervention 2:** Wait-list control [passive control group] **Primary setting:** Group **Supervision by (if provided):** Physiotherapist; exercise scientist
Outcomes	Maximal heart rates, recruitment rate, attendance, dropout, change in peak oxygen consumption, cardiac output, cognitive function and QoL; 6-MIN-W; MoCA; PDQ-39 **Follow-up (maximum time after end of intervention):** 6 weeks
Notes	**Funding sources:** Graham Wylie Foundation; Speedflex Europe Ltd **Conflicts of interest:** KLW was employed by Speedflex Europe Ltd as an exercise physiologist from July 2013 to January 2014, but had no involvement with the company at the time of the study

Hass 2012

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** No
Participants	**Number of participants (recruited/randomized/evaluated):** NR/18/18 **Country:** USA **Age (mean in years):** 64; 67 **Sex (male/female):** 14/4 (77.8% male) **Duration of disease (mean in years):** 11.1; 6.4 **HY (mean):** 2.3; 2.3 **UPDRS-M (mean):** NR **MMSE (mean):** NR **Physical capability:** NR **Inclusion criteria:** Diagnosed with idiopathic PD; MHY stage 1 to 3 and the ability to ambulate without assistance. All participants were on stable doses of anti-Parkinsonian medications which remained consistent throughout the testing and intervention protocol **Exclusion criteria:**

Hass 2012 *(Continued)*

	History of significant cardiovascular, musculoskeletal, vestibular or other neurological disorder, use of an assisted device while ambulating, and recent participation in a balance or resistance-training program
Interventions	**Length of intervention:** 10 weeks **Intervention 1:** Resistance training [strength/resistance training]; duration not reported; 2x/week **Intervention 2:** Control group [passive control group] **Primary setting:** Individual **Supervision by (if provided):** Certified health fitness instructor; personal trainer; certified athletic trainer
Outcomes	Displacement of the center-of-pressure during gait initiation; initial stride length and velocity **Follow-up (maximum time after end of intervention):** 0 (post-intervention)
Notes	**Funding sources:** NR **Conflicts of interest:** None

Hirsch 2003

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** No
Participants	**Number of participants (recruited/randomized/evaluated):** NR/15/NR **Country:** USA **Age (mean in years):** 75.7; 70.8 **Sex (male/female):** NR **Duration of disease (mean in years):** 8.3; 5.5 **HY (mean):** 1.9;1.8 **UPDRS-M (mean):** NR **MMSE (mean):** NR **Physical capability:** NR **Inclusion criteria:** Had been diagnosed with iPD by their neurologist and not participated in any organized balance or muscle strengthening activities before being pre-tested. All participants were ambulatory, were not acutely ill, were able to follow simple commands, and were not suffering from unstable cardiovascular disease or other uncontrolled chronic conditions that would interfere with the safety and conduct of the training and testing protocol **Exclusion criteria:**

Hirsch 2003 *(Continued)*

	NR
Interventions	**Length of intervention:** 10 weeks **Intervention 1:** Balance group [gait/balance/functional training]; 30 minutes; 3x/week **Intervention 2:** Combined group (balance and resistance training) [multi-domain training]; 45 minutes; 3x/week **Primary setting:** Individual **Supervision by (if provided):** Therapist
Outcomes	Sensory Orientation Test; latency to fall; percentage of trials resulting in falls; muscle strength **Follow-up (maximum time after end of intervention):** 4 weeks
Notes	**Funding sources:** NR **Conflicts of interest:** None

Hubble 2018

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** Yes
Participants	**Number of participants (recruited/randomized/evaluated):** 34/24/22 **Country:** Australia **Age (mean in years):** 65.4 **Sex (male/female):** 15/7 (68.2% male) **Duration of disease (mean in years):** 6.7 **HY (mean):** 1.9 **UPDRS-M (mean):** 19.4 **MMSE (mean):** NR **Physical capability:** Walking speed (m/s): 1.33; 1.31 **Inclusion criteria:** Idiopathic PD **Exclusion criteria:** An inability to walk independently; uncontrolled hypertension; a prescription for psychotropic medications; significant limitations due to osteoporosis; orthopedic surgery within the previous year; serious neck, shoulder, or back injuries (including spinal fusions); received deep brain stimulation surgery for symptom management; a neurological condition other than PD; or no history of falls or near misses within the past year
Interventions	**Length of intervention:** 12 weeks

Hubble 2018 *(Continued)*

	Intervention 1: Exercise group (trunk mobility and endurance plus education) [gait/balance/functional training]; 90 minutes; 1x/week **Intervention 2:** Education group (multidisciplinary educational brochure) [passive control group] **Primary setting:** Group **Supervision by (if provided):** Exercise scientist
Outcomes	Addenbrooke Cognitive Examination; Bailey-Lovie high-contrast visual acuity test; TUG; ABC; PDQ-39; UPDRS-M; HY score; Schwab & England ADL Scale; gait parameters (head and trunk accelerations, bilateral activation of the thoracic and lumbar erector spinae), FoG score **Follow-up (maximum time after end of intervention):** 12 weeks
Notes	**Funding sources:** Australian Catholic University **Conflicts of interest:** None

Johansson 2018

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** Yes
Participants	**Number of participants (recruited/randomized/evaluated):** 16/13/12 **Country:** Sweden **Age (mean in years):** 69.7 **Sex (male/female):** 9/4 (69.2% male) **Duration of disease (median in years):** 10.0; 7.0 **HY (range):** 2 to 3 **UPDRS-M (median):** 35.0; 32.5 **MoCA (median):** 27.0; 26.6 **Physical capability:** Falls in last year: 0; 0 **Inclusion criteria:** Diagnosis of Idiopathic PD, ≥ 60 years of age, HY stage 2 to 3, and scored ≥ 21 on MoCA **Exclusion criteria:** Magnetic resonance imaging (MRI)-incompatible implants or claustrophobia or any other neuromuscular disorder that impacted gait and balance function
Interventions	**Length of intervention:** 10 weeks **Intervention 1:** HiBalance (highly challenging balance exercises) [gait/balance/functional training]; 60 minutes; 2x/week plus 1x/week home exercise

Johansson 2018 *(Continued)*

	Intervention 2: HiCommunication control (training program for speech and communication) [active control group]; 60 minutes; 2x/week plus 1x/week home exercise **Primary setting:** Group **Supervision by (if provided):** Physical therapists; speech and language pathologist
Outcomes	Mini-BESTest; ABC; gait speed; EQ-5D; PDQ-39; Hospital Anxiety and Depression Scale; MDS-UPDRS-I, MDS-UPDRS-II; structural and functional magnetic resonance imaging, blood sampling, neuropsychological assessment, and speech/voice assessment **Follow-up (maximum time after end of intervention):** within 3 weeks
Notes	**Funding sources:** Swedish Research Council **Conflicts of interest:** None

Kanegusuku 2017

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** Yes
Participants	**Number of participants (recruited/randomized/evaluated):** 44/30/27 **Country:** Brazil **Age (mean in years):** 67; 63 **Sex (male/female):** 22/5 (81.5% male) **Duration of disease (mean in years):** 8.5; 9.0 **Modified HY (range):** 2 to 3 **UPDRS-M (mean):** NR **MMSE (mean):** NR **Physical capability:** NR **Inclusion criteria:** Diagnosis of PD; age ≥ 50 years; MHY stages between 2 and 3 **Exclusion criteria:** Presence of other neurologic disorders, hypertension, or any other diagnosed cardiovascular disease; use of medications that could affect the cardiovascular system except for those used for the treatment of PD; presence of musculoskeletal problems that preclude resistance training; presence of cardiovascular abnormalities at rest or on exercise electrocardiograms; change in medication during participation in the study; and practicing any regular physical activity except for physical therapy for PD
Interventions	**Length of intervention:** 12 weeks **Intervention 1:** Resistance training [strength/resistance training]; duration not reported; 2x/week **Intervention 2:** Control group [passive control group]

Kanegusuku 2017 *(Continued)*

	Intervention 3: Healthy control **Primary setting:** Individual **Supervision by (if provided):** Exercise specialist
Outcomes	Spectral analysis of heart rate variability and cardiovascular responses to autonomic stress tests (deep breathing, Valsalva maneuver, orthostatic stress) **Follow-up (maximum time after end of intervention):** 0 (post-intervention)
Notes	**Funding sources:** Supported by the Brazilian Council for the Scientific and Technological Development (CNPQ) and the Brazilian Federal Agency for Support and Evaluation of Graduate Education (CAPES) and Program with Academic Excellence (PROEX) **Conflicts of interest:** None

King 2013

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** Yes
Participants	**Number of participants (recruited/randomized/evaluated):** 94/51/39 **Country:** USA **Age (mean in years):** 65.7; 65.1 **Sex (male/female):** 25/14 (64.1% male) **Duration of disease (mean in years):** NR **HY (mean):** 2.5; 2.4 **UPDRS-M (mean):** 33.4; 32.3 **MMSE (mean):** NR **Physical capability:** NR **Inclusion criteria:** Diagnosis of idiopathic PD by a movement disorders neurologist, treatments with levodopa, between the ages of 45 and 85, and willing and able to come to the clinic 4 times per week for 4 weeks **Exclusion criteria:** Unable to ambulate unassisted, had other neurologic, cardiovascular, or orthopedic problems which could impact mobility, or had cognitive impairments that would limit participation in the intervention
Interventions	**Length of intervention:** 4 weeks **Intervention 1:** Agility boot camp [multi-domain training]; 75 minutes; 4x/week **Intervention 2:** Treadmill training [gait/balance/functional training]; 75 minutes; 4x/week **Primary setting:** Individual

King 2013 *(Continued)*

	Supervision by (if provided): Specially trained physical therapists
Outcomes	PDQ-39; ABC; UPDRS-II; Mini-BESTest; BBS; UPDRS-M; turn duration; stride velocity; peak arm speed; ROM trunk horizontal; sway range **Follow-up (maximum time after end of intervention):** 0 (post-intervention)
Notes	**Funding sources:** Kinetics Foundation, Foundation for Physical Therapy, and Oregon Clinical Translational Institute **Conflicts of interest:** NR

King 2020

Study characteristics	
Methods	Randomized controlled trial with cross-over after 6 weeks Single center **A priori consideration of test power:** No
Participants	**Number of participants (recruited/randomized/evaluated):** 108/46/42 **Country:** USA **Age (mean in years):** 68.0 **Sex (male/female):** NR **Duration of disease (mean in years):** 7.3; 9.7 **HY (mean):** 2.4; 2.6 **MDS-UPDRS-M (mean):** 44.9; 50.0 **MoCA (mean):** 26.6; 24.3 **Physical capability:** NR **Inclusion criteria:** Mild to moderate severity of idiopathic PD (HY Levels 2 to 3 and FoG, defined as > 0 on the N-FOG-Q); 50 to 90 years old, without major musculoskeletal or peripheral or central nervous system disorders (other than PD) that could significantly affect their balance and gait, without recent changes in medication, excessive use of alcohol or recreational drugs, without history of structural brain disease, active epilepsy, stroke, or dementia that would interfere with ability to follow intervention and testing procedures, able to stand or walk for 2 min without an assistive device, without a medical condition that precludes exercise, without claustrophobia, severe tremor, or any health history (i.e. implanted devices, deep brain stimulation) that would put the participant at risk near the magnetic resonance imaging (MRI) scanner **Exclusion criteria:** NR
Interventions	**Length of intervention:** 6 weeks **Intervention 1:** Agility boot camp-Cognition [multi-domain training]; 80 minutes; 3x/week

King 2020 *(Continued)*

	Intervention 2: Education group [active control group]; 80 minutes; 1x/week and 30 minutes 5x/week at home **Primary setting:** Group **Supervision by (if provided):** Trained and experienced exercise trainer with oversight from a licensed physical therapist
Outcomes	FOG ratio; N-FOG-Q; dual task cost gait speed; balance; executive function; functional magnetic resonance imaging: right supplementary motor cortex-pedunculopontine nucleus connectivity, MDS-UPDRS-M, PDQ-39 **Severity of motor signs assessed during:** off-medication state **Follow-up (maximum time after end of intervention):** 1 week
Notes	**Funding sources:** Department of Veterans Affairs grant; National Institutes of Health (NIH): NIA grant Collins Trust grant; Oregon Clinical and Translational Research Institute (OCTRI), NIH grant **Conflicts of interest:** Dr. Horak has an equity interest in APDM, a company that may have a commercial interest in the results of this study. This potential conflict of interest has been reviewed and managed by the Research & Development Committee at the VA Portland Health Care System and Oregon Health & Science University. They have put in place a plan to help ensure that this research study is not affected by the financial interest.

Kunkel 2017

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** Yes
Participants	**Number of participants (recruited/randomized/evaluated):** 103/51/45 **Country:** UK **Age (mean in years):** 71.3; 69.7 **Sex (male/female):** 25/26 (49% male) **Duration of disease (mean in years):** 4.7; 7.0 **HY (range):** 1 to 3 **UPDRS-M (mean):** 12.9; 10.6 **MoCA (mean):** 25.1; 26.0 **Physical capability:** 6-MIN-W: 347.3; 394.5 **Inclusion criteria:** Diagnosis of Parkinson's disease, HY 1 to 3 indicating mild to moderate disease severity, lived at home, could understand and follow commands, had previous falls recorded **Exclusion criteria:** Lacked sufficient stability to dance with another person

Kunkel 2017 *(Continued)*

Interventions	**Length of intervention:** 10 weeks **Intervention 1:** Partnered ballroom dancing [dance]; 60 minutes; 2x/week **Intervention 2:** Control group [passive control group] **Primary setting:** Group **Supervision by (if provided):** Professional dance teachers
Outcomes	BBS, PDQ-39, TUG, 6-MIN-W, ABC, standing-start 180° turn test **Follow-up (maximum time after end of intervention):** 3.5 months
Notes	**Funding sources:** National Institute for Health Research (NIHR) Research for Patient Benefit (RfPB) programme **Conflicts of interest:** None

Kurt 2018

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** No
Participants	**Number of participants (recruited/randomized/evaluated):** 64/40/40 **Country:** Turkey **Age (mean in years):** 62.41; 63.61 **Sex (male/female):** 24/16 (60% male) **Duration of disease (mean in years):** NR **HY (range):** 2 to 3 **UPDRS-M (mean):** 30.09; 28.06 **MMSE (mean):** ≥ 24 (inclusion criteria) **Physical capability:** TUG: 19.2;14.0 **Inclusion criteria:** Idiopathic PD; ability to follow a stable medication regimen; HY 2 to 3; lack of dementia (MMSE ≥ 24) **Exclusion criteria:** Physical therapy in the previous 6 months; fear of water; allergy to chlorine; inability to walk independently; having undergone surgical treatment for PD; history or evidence of neurological deficit other than PD (stroke, neuromuscular disease, etc.); uncontrolled hypertension; diabetes; incontinence; open wounds; osteoarthritis; osteoporosis at a level that impaired walking and balance
Interventions	**Length of intervention:** 5 weeks **Intervention 1:** Ai Chi [aqua-based training]; 60 minutes; 5x/week

Kurt 2018 *(Continued)*

	Intervention 2: Land-based exercise control (stretching of spine and limbs, articular mobilization, gait exercises) [multi-domain training]; 60 minutes; 5x/week
	Primary setting: Group
	Supervision by (if provided): Physiotherapist experienced in both neurologic rehabilitation and Ai Chi
Outcomes	BBS; TUG; PDQ-39; UPDRS-M; dynamic balance measures
	Severity of motor signs assessed during: on-medication state
	Follow-up (maximum time after end of intervention): 0 (post-intervention)
Notes	**Funding sources:** Ahi Evran University Medical Faculty Educational and Research Hospital
	Conflicts of interest: None

Kurtais 2008

Study characteristics	
Methods	Randomized controlled trial
	Single center
	A priori consideration of test power: No
Participants	**Number of participants (recruited/randomized/evaluated):** 30/27/24
	Country: Turkey
	Age (mean in years): 63.8; 65.7
	Sex (male/female): 12/12 (50% male)
	Duration of disease (mean in years): 5.3; 5.4
	HY (mean): 2.5; 2.2
	UPDRS-M (mean): NR
	MMSE (mean): NR
	Physical capability: 20-meter walking time (s): 20.2; 18.9, Timed U-turn task (s): 14.2; 13.9
	Inclusion criteria:
	On stable anti-Parkinsonian medication, ability to walk independently, and not having participated in a rehabilitation program in the previous 3 months
	Exclusion criteria:
	Severe cognitive impairments and other disorders that might interfere with or contraindicate the exercise program
Interventions	**Length of intervention:** 6 weeks
	Intervention 1: Treadmill [gait/balance/functional training]; 40 minutes; 3x/week
	Intervention 2: Control group [passive control group]; minutes; x/week
	Primary setting: Individual

Kurtais 2008 *(Continued)*

	Supervision by (if provided): Supervisor
Outcomes	20-meter walking time; timed U-turn task; turning around a chair; climbing up and down a flight of stairs; arising from an armless chair; standing on one foot (right and left); ergospirometric exercise test (exercise duration, peak oxygen consumption (VO_2), metabolic equivalents, maximal heart rate, systolic and diastolic blood pressure) **Follow-up (maximum time after end of intervention):** 0 (post-intervention)
Notes	**Funding sources:** NR **Conflicts of interest:** NR

Kwok 2019

Study characteristics	
Methods	Randomized controlled trial Multicenter **A priori consideration of test power:** Yes
Participants	**Number of participants (recruited/randomized/evaluated):** 187/138/138 **Country:** China/Hong Kong **Age (mean in years):** 63.6 **Sex (male/female):** 65/73 (47.1% male) **Duration of disease (mean in years):** NR **HY (range):** 1 to 3 **MDS-UPDRS-M (mean):** 34.9; 31.64 **MMSE (mean):** NR **Physical capability:** TUG (mean): 17.54; 14.05 **Inclusion criteria:** Clinical diagnosis of idiopathic PD; HY 1 to 3; age above 18 years old; ability to stand unaided and walk with or without an assistive device; participants who can give written consent **Exclusion criteria:** Currently receiving treatment for mental disorders or with uncontrolled mood disorders; current participation in any other behavioral or pharmacological trial or instructor–led exercise program; cognitive impairment as indicated by the "Abbreviated mental test" lower than 6; other debilitating conditions except PD, e.g. hearing or vision impairment, that can impede full participation in the study
Interventions	**Length of intervention:** 8 weeks **Intervention 1:** Mindfulness yoga for PD [mind-body training]; 90 minutes; 1x/week **Intervention 2:** Stretching and resistance training exercises [multi-domain training]; 60 minutes; 1x/week **Primary setting:** Group

Kwok 2019 *(Continued)*

	Supervision by (if provided): Yoga instructor with mindfulness-based stress reduction teacher qualifications
Outcomes	Hospital Anxiety and Depression scale; MDS-UPDRS-M; TUG; holistic well-being scale; PDQ-8; adverse events **Severity of motor signs assessed during:** on-medication state **Follow-up (maximum time after end of intervention):** 3 months
Notes	**Funding sources:** Professional Development Fund, Association of Hong Kong Nursing Staff **Conflicts of interest:** None

Landers 2016

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** Yes
Participants	**Number of participants (recruited/randomized/evaluated):** 96/49/44 **Country:** USA **Age (mean in years):** 72.2; 70.2; 70.1; 74.3 **Sex (male/female):** 25/16 (61% male) **Duration of disease (mean in years):** NR **HY (range):** 1.5 to 4 **UPDRS-M (mean):** NR **MMSE (mean):** 27.6; 26.6; 29.6; 28.5 **Physical capability:** Self-Selected Gait Velocity (m/s): 1.22; 1.26; 1.26; 1.18 **Inclusion criteria:** Idiopathic PD **Exclusion criteria:** Non-ambulatory or if significant comorbidities were present (e.g. stroke, total hip/knee replacement); history of surgical intervention for Parkinson's disease.
Interventions	**Length of intervention:** 4 weeks **Intervention 1:** Balance training external focus instructions [gait/balance/functional training]; 45 minutes; 3x/week **Intervention 2:** Balance training internal focus instructions [gait/balance/functional training]; 45 minutes; 3x/week **Intervention 3:** Balance training no focus [gait/balance/functional training]; 45 minutes; 3x/week **Intervention 4:** Control [passive control group]

Landers 2016 *(Continued)*

	Primary setting: Individual
	Supervision by (if provided): Research assistants
Outcomes	BBS; Sensory Organization Test, Self-Selected Gait Velocity, Dynamic Gait Index, ABC, and obstacle course completion time
	Follow-up (maximum time after end of intervention): 8 weeks
Notes	**Funding sources:** American Parkinson's Disease Association Research Grant
	Conflicts of interest: None

Lee HJ 2018

Study characteristics	
Methods	Randomized controlled trial
	Single center
	A priori consideration of test power: Yes
Participants	**Number of participants (recruited/randomized/evaluated):** 35/32/26
	Country: Korea
	Age (mean in years): 65.7
	Sex (male/female): 17/24 (41.5% male)
	Duration of disease (mean in years): NR
	HY (range): 1 to 3
	UPDRS-M (mean): 14.8; 11.9
	MMSE (mean): 26.2; 26.1 (Korean MMSE)
	Physical capability: NR
	Inclusion criteria:
	PD, aged between 50 and 80 years, stage 1 to 3 on the HY scale, no other neurological, or cognitive impairments (Korean-MMSE > 20), and not having received any exercise therapy within the 3 months prior to the study
	Exclusion criteria:
	NR
Interventions	**Length of intervention:** 8 weeks
	Intervention 1: Turo PD program [mind-body training]; 60 minutes; 2x/week
	Intervention 2: Waiting list [passive control group]
	Primary setting: Group
	Supervision by (if provided): Qigong instructor
Outcomes	UPDRS, PDQ-L, BDI, BBS

Lee HJ 2018 *(Continued)*

	Severity of motor signs assessed during: on-medication state
	Follow-up (maximum time after end of intervention): 0 (post-intervention)
Notes	**Funding sources:** This research was supported by grants from the National Research Foundation of Korea funded by the Korean government (Grant nos. NRF-2005–0049404 and NRF- 2017R1A2B4009963)
	Conflicts of interest: NR

Lehman 2005

Study characteristics	
Methods	Randomized controlled trial
	Single center
	A priori consideration of test power: No
Participants	**Number of participants (recruited/randomized/evaluated):** NR/11/11
	Country: USA
	Age (mean in years): 77.6; 74.3
	Sex (male/female): 8/3 (72.7% male)
	Duration of disease (mean in years): 6.5
	HY (range): 2 to 2.5
	UPDRS-M (mean): NR (subscale scores reported for each participant)
	MMSE (mean): 28
	Physical capability: NR
	Inclusion criteria:
	Gait impairments due to Parkinson Disease
	Exclusion criteria:
	Persons with other neurological and/or orthopadic impairments that could not walk the distances required of the training program were excluded
Interventions	**Length of intervention:** 2 weeks
	Intervention 1: Treatment group (walking 1800 feet per day) [gait/balance/functional training]; duration not reported; 5x/week
	Intervention 2: Control group [passive control group]
	Primary setting: Individual
	Supervision by (if provided): Instructor
Outcomes	Step length of left extremity
	Follow-up (maximum time after end of intervention): 1 month
Notes	**Funding sources:** NR

Lehman 2005 *(Continued)*

	Conflicts of interest: NR

Li 2012

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** Yes
Participants	**Number of participants (recruited/randomized/evaluated):** 309/195/195 **Country:** USA **Age (mean in years):** 68; 69; 69 **Sex (male/female):** 122/73 (62.6% male) **Duration of disease (mean in years):** 8; 8; 6 **HY (range):** 1 to 4 **UPDRS-M (mean):** 15.28; 15.32; 15.06 **MMSE (mean):** ≥ 25 (inclusion criteria) **Physical capability:** gait velocity (cm/s) on 4.3-meter (15 ft) walkway ("GAITrite"): 110.1; 109.2; 110.9 **Inclusion criteria:** Clinical diagnosis of Parkinson's disease, HY 1 to 4; 40 to 85 years of age; at least one score of 2 or more for at least one limb for the tremor, rigidity, postural stability, or bradykinesia items in the motor section of the UPDRS-M; stable medication use; ability to stand unaided and walk with or without an assistive device; medical clearance for participation; and willingness to be assigned to any of the three interventions **Exclusion criteria:** Current participation in any other behavioral or pharmacologic study or instructor-led exercise program; MMSE < 24 (indicating some degree of cognitive impairment); debilitating conditions or vision impairment that would impede full participation in the study; unavailability during the study period
Interventions	**Length of intervention:** 24 weeks **Intervention 1:** Tai chi [mind-body training]; 60 minutes; 2x/week **Intervention 2:** Resistance training [strength/resistance training]; 60 minutes; 2x/week **Intervention 3:** Stretching control [flexibility training]; 60 minutes; 2x/week **Primary setting:** Group **Supervision by (if provided):** Trained and certified tai chi instructors; certified exercise instructors
Outcomes	Postural stability (measured by computerized dynamic posturography); maximum excursion; directional control; movement accuracy; gait (stride length, walking velocity); strength of bilateral knee extensors and flexors; FRT; TUG; UPDRS-M; falls (fall calendars); adverse events; PDQ-8, Vitality plus scale **Severity of motor signs assessed during:** on-medication state

Li 2012 *(Continued)*

	Follow-up (maximum time after end of intervention): 3 months
Notes	**Funding sources:** National Institute of Neurological Disorders and Stroke **Conflicts of interest:** None

Liao 2015

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** No
Participants	**Number of participants (recruited/randomized/evaluated):** NR/36/36 **Country:** Taiwan **Age (mean in years):** 67.3; 65.1; 64.6 **Sex (male/female):** 17/19 (47.2% male) **Duration of disease (mean in years):** 7.9; 6.9; 6.4 **HY (range):** 1 to 3 **UPDRS-M (mean):** NR **MMSE (mean):** 29.5; 29.8; 29.7 **Physical capability:** obstacle crossing velocity (cm/s): 75.2; 77.5; 80.4 **Inclusion criteria:** Idiopathic PD; at least 2 of the 4 features (resting tremor, bradykinesia, rigidity, and asymmetric onset) in which the resting tremor or bradykinesia must be present; HY 1 to 3; ability to walk independently without any walking aids; stable medication usage; with or without deep brain stimulation; MMSE score ≥ 24 **Exclusion criteria:** Unstable medical condition; history of other neurological, cardiopulmonary, or orthopedic diseases known to interfere with participation in the study; past history of seizure; use of cardiac pacemaker; vision deficits
Interventions	**Length of intervention:** 6 weeks **Intervention 1:** Virtual-reality-based WiiFit exercise and treadmill training [multi-domain training]; 60 minutes; 2x/week **Intervention 2:** Traditional exercise and treadmill training [multi-domain training]; 60 minutes; 2x/week **Intervention 3:** Control [passive control group] **Primary setting:** Group **Supervision by (if provided):** Physical therapist

Liao 2015 *(Continued)*

Outcomes	Obstacle crossing performance (crossing stride length, crossing stride velocity, vertical toe-obstacle clearance); dynamic balance performance (limits of stability, movement velocity, maximum excursion, directional control); sensory organization test (sensory integration ability); PDQ-39; FES-I; TUG; muscle strength **Follow-up (maximum time after end of intervention):** 30 days
Notes	**Funding sources:** National Science Council and Aim for the Top University Plan of the Ministry of Education of the Republic of China **Conflicts of interest:** None

Liu 2016

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** No
Participants	**Number of participants (recruited/randomized/evaluated):** NR/54/41 **Country:** China **Age (mean in years):** 65.8; 62.5 **Sex (male/female):** 25/29 (46.3% male) **Duration of disease (mean in years):** NR **HY (mean):** NR **UPDRS-M (mean):** NR **MMSE (mean):** NR **Physical capability:** TUG 10.19 **Inclusion criteria:** Mild or moderate PD, ability to walk independently, normal state of mental health, ability to follow instructions, absence of other complications, and ability to participate in physical exercise **Exclusion criteria:** Any previous practical experience with Health Qigong, a recent or planned change in medication, and signs of a central nervous system disease other than PD, such as aphasia or dementia (as defined by the MMSE)
Interventions	**Length of intervention:** 10 weeks **Intervention 1:** Health Qigong [mind-body training]; 60 minutes; 5x/week **Intervention 2:** Control [passive control group] **Primary setting:** Group **Supervision by (if provided):** NR

Liu 2016 *(Continued)*

Outcomes	TUG; hand-eye coordination (turn-over-jars) test; physical stability (9-holed instrument) test; one-legged blind balance test **Follow-up (maximum time after end of intervention):** 0 (post-intervention)
Notes	**Funding sources:** NR **Conflicts of interest:** None

Mak 2008

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** Yes
Participants	**Number of participants (recruited/randomized/evaluated):** NR/60/52 **Country:** China **Age (mean in years):** 63.0; 66.1; 62.9 **Sex (male/female):** NR **Duration of disease (mean in years):** 5.9; 6.1; 5.9 **HY (mean):** NR **UPDRS-M (mean):** NR **MMSE (mean):** NR **Physical capability:** NR **Inclusion criteria:** PD diagnosis; stable on anti-Parkinsonian medications and with no dyskinesia, orthopaedic, arthritic, and heart problems; aged 50 to 75 years; can stand up from a chair independently **Exclusion criteria:** NR
Interventions	**Length of intervention:** 4 weeks **Intervention 1:** Audio-visual group [gait/balance/functional training]; 20 minutes; 3x/week **Intervention 2:** Exercise group [multi-domain training]; 45 minutes; 2x/week **Intervention 3:** Control [passive control group] **Primary setting:** Individual **Supervision by (if provided):** Physiotherapist
Outcomes	Three-dimensional kinematics data; vertical, antero-posterior, and medio-lateral components of ground reaction force

Mak 2008 *(Continued)*

	Follow-up (maximum time after end of intervention): 2 weeks
Notes	**Funding sources:** NR **Conflicts of interest:** NR

Mak 2021

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** Yes
Participants	**Number of participants (recruited/randomized/evaluated):** 154/70/64 **Country:** Hong Kong **Age (mean in years):** 61.9; 62.7 **Sex (male/female):** 20/44 (31.3% male) **Duration of disease (mean in years):** 5.8; 5.0 **MHY (mean):** 2.4; 2.5 **MDS-UPDRS-M (mean):** 29.7; 28.7 **MoCA (mean):** 27.5; 27.5 **Physical capability:** TUG: 10.9; 10.1 **Inclusion criteria:** Aged 30 years or over, diagnosed with idiopathic PD, stable on anti-Parkinsonian medications, and able to walk independently for 30 meters without aid **Exclusion criteria:** Significant cardiopulmonary, neurological (other than PD) or musculoskeletal conditions, had received neurosurgery, had cognitive impairment with a MoCA score < 25, or had joined a structured exercise program in past three months
Interventions	**Length of intervention:** 6 months **Intervention 1:** Brisk walking [endurance training]; 90 minutes; 1x/week of supervised practice and 2x/week self-practice in the first 6 weeks, then 1x/month supervised session and 2 to 3x/week self-practice (monitored by smartwatch) **Intervention 2:** Upper limb training [active control group]; 90 minutes; 1x/week of supervised practice and 2x/week self-practice **Primary setting:** Group **Supervision by (if provided):** Physiotherapist and an assistant
Outcomes	MDS-UPDRS-M; 6-MIN-W; Mini-BESTest; fast gait speed; TUG **Severity of motor signs assessed during:** on-medication state

Mak 2021 *(Continued)*

	Follow-up (maximum time after end of intervention): 0 (post-intervention)
Notes	**Funding sources:** Shun Hing Education and Charity Fund **Conflicts of interest:** None

Martin 2015

Study characteristics	
Methods	Randomized controlled trial with cross-over after 6 months Single center **A priori consideration of test power:** Yes
Participants	**Number of participants (recruited/randomized/evaluated):** 29/21/16 **Country:** New Zealand **Age (mean in years):** 72 **Sex (male/female):** 13/8 (61.9% male) **Duration of disease (mean in years):** 11 **HY (mean):** 2.8 **UPDRS-M (mean):** NR **MMSE (mean):** ≥ 25 (inclusion criteria) **Physical capability:** NR **Inclusion criteria:** PD diagnosis confirmed by a movement disorder specialist neurologist; aged over 65 years, presence of FOG as indicated by answering "yes" to question 1 on N-FOG-Q, independently mobile with or without walking aid, stable PD medication regimen at the time of recruitment **Exclusion criteria:** Significant cognitive impairment (MMSE of < 24), had comorbidities that would prohibit safe participation in exercise, were unable to press metronome buttons, or hear a metronome adequately
Interventions	**Length of intervention:** 6 months **Intervention 1:** Cued Up! program (home-based exercise and education program designed to address FOG and falls that may result from FOG) [gait/balance/functional training]; 30 to 60 minutes; 6 home visits within the first 4 weeks, followed by weekly phone calls and independent completion of the exercises **Intervention 2:** Control group [passive control group] **Primary setting:** Individual **Supervision by (if provided):** Physical therapist with experience in PD and FOG and the use of cues
Outcomes	Feasibility questionnaire, N-FOG-Q; falls diary **Follow-up (maximum time after end of intervention):** 6 months

Martin 2015 *(Continued)*

Notes	**Funding sources:** Physiotherapy New Zealand's Older Adult and Neurology Special Interest Groups; Hope Foundation for Research on Ageing **Conflicts of interest:** None

Medijainen 2019

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** No
Participants	**Number of participants (recruited/randomized/evaluated):** 50/24/24 **Country:** Estonia **Age (mean in years):** 71.1; 69.9 **Sex (male/female):** 10/14 (41.7% male) **Duration of disease (mean in years):** 8.0; 7.7 **HY (mean):** 2.2; 2.3 **UPDRS-M (mean):** 39.1; 36.4 **MMSE (mean):** 28.0; 27.2 **Physical capability:** Short Physical Performance Battery (SPPB) - total score: 10.8; 10.6; standing to walking transition gait speed calculated based on SPPB gait test performance (m/s): 1.0; 0.9 **Inclusion criteria:** Diagnosis of mild to moderate idiopathic PD according to the HY scale; aged over 60 and under 81 years old; able to walk without an assistive device in their home setting (usage of assistive device for community-based ambulation was not an exclusion criteria); no other untreated medical conditions that might affect gait or postural stability; no participation in physiotherapy during the previous year; MMSE score above 24 **Exclusion criteria:** NR
Interventions	**Length of intervention:** 8 weeks **Intervention 1:** Physical therapy (physical capacity, transfers, manual activities, balance, gait) [multi-domain training]; 60 minutes; 2x/week **Intervention 2:** Control group [passive control group] **Primary setting:** Group **Supervision by (if provided):** Specialist in neurological physiotherapy
Outcomes	FOG, Short Physical Performance Battery; dominant side hip flexion range of motion; dominant side hip abduction range **Follow-up (maximum time after end of intervention):** 1 week

Medijainen 2019 *(Continued)*

Notes	**Funding sources:** Estonian Research Council **Conflicts of interest:** None

Michels 2018

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** No
Participants	**Number of participants (recruited/randomized/evaluated):** 14/13/13 **Country:** USA **Age (mean in years):** 69.2 **Sex (male/female):** 6/7 (46.2% male) **Duration of disease (mean in years):** NR **HY (mean):** 2.11; 2.50 **UPDRS-M (mean):** 31.6 **MoCA (mean):** 27.0; 25.25 **Physical capability:** TUG: 8.41; 14.43 **Inclusion criteria:** Diagnosis of idiopathic PD, any HY stage or disease severity, stable PD medication regimen for at least one month prior to the study and continue that regimen without any changes throughout the course of the study **Exclusion criteria:** Therapeutic dance intervention within three months before the start of the study or initiated any new PD treatments or involvement in other PD-focused interventions throughout the course of the study; cognitive impairment MoCA < 24; < 18 years of age
Interventions	**Length of intervention:** 10 weeks **Intervention 1:** Dance therapy [dance]; 60 minutes; 1x/week **Intervention 2:** Control (group discussions) [active control group]; duration not reported; 1x/week **Primary setting:** Group **Supervision by (if provided):** Board-certified dance therapists and licensed clinical counselors
Outcomes	MDS-UPDRS, MDS-UPDRS-M, MoCA, TUG, BBS, PDQ-39, visual analogue fatigue scale, fatigue severity scale, BDI, HY **Severity of motor signs assessed during:** on-medication state **Follow-up (maximum time after end of intervention):** 1 to 2 weeks

Michels 2018 *(Continued)*

Notes	**Funding sources:** NR **Conflicts of interest:** Kristi Michels has no financial disclosures. Ornella Dubaz MD has no financial disclosures. Danny Bega MD MSCI has received royalties from the British Medical Journal. He has served as a contractor for Medscape, LLC. He is on the speaker's bureau for Neurocrine, Adamas, and Teva Pharmaceuticals.

Miyai 2000

Study characteristics	
Methods	Randomized controlled trial with cross-over after 4 weeks Single center **A priori consideration of test power:** No
Participants	**Number of participants (recruited/randomized/evaluated):** NR/10/10 **Country:** Japan **Age (mean in years):** 67.6 **Sex (male/female):** 5/5 (50% male) **Duration of disease (mean in years):** 4.2 **HY (range):** 2.5 to 3 **UPDRS-M (mean):** 18.2; 17.0 **MMSE (mean):** 28.5 **Physical capability:** Walking endurance (m): 381.2; 372.5; Gait speed (sec/10 m): 10.0; 9.5; Steps (steps/10 m): 22.3; 21.5 **Inclusion criteria:** PD patients with HY between 2.5 and 3; not demented (MMSE > 27) **Exclusion criteria:** NR
Interventions	**Length of intervention:** 4 weeks **Intervention 1:** Body weight–supported treadmill training (BWSTT) [gait/balance/functional training]; 45 minutes; 3x/week **Intervention 2:** Physical therapy [multi-domain training]; 45 minutes; 3x/week **Primary setting:** Individual **Supervision by (if provided):** NR
Outcomes	UPDRS-M, UPDRS-I, UPDRS-II, UPDRS-complications, UPDRS-total; overground ambulation endurance, gait speed; number of steps taken for 10-meter walk **Follow-up (maximum time after end of intervention):** 0 (post-intervention)

Miyai 2000 *(Continued)*

Notes	**Funding sources:** Fund for Comprehensive Research on Aging and Health from the Ministry of Health and Welfare, Japan **Conflicts of interest:** None

Miyai 2002

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** No
Participants	**Number of participants (recruited/randomized/evaluated):** 24/24/20 **Country:** Japan **Age (mean in years):** 69.5; 69.8 **Sex (male/female):** 10/10 (50% male) **Duration of disease (mean in years):** 4.1; 4.5 **HY (range):** 2.5 to 3 **UPDRS-M (mean):** 18.5; 18.6 **MMSE (mean):** 28.3; 28.7 **Physical capability:** Gait speed (sec/10 m): 10.8; 11.5; Steps (steps/10 m): 23.4; 22.8 **Inclusion criteria:** PD patients with HY between 2.5 and 3; PD diagnosis based on the presence of rest tremor, bradykinesia, rigidity, positive response to levodopa, and no evidence of vascular lesions on magnetic resonance imaging; not demented (MMSE > 27) **Exclusion criteria:** NR
Interventions	**Length of intervention:** 1 month **Intervention 1:** Body weight–supported treadmill training (BWSTT) [gait/balance/functional training]; 45 minutes; 3x/week **Intervention 2:** Physical therapy [multi-domain training]; 45 minutes; 3x/week **Primary setting:** Individual **Supervision by (if provided):** NR
Outcomes	UPDRS-M, UPDRS-I, UPDRS-II, UPDRS-complications, UPDRS-total; gait speed; number of steps taken for 10-meter walk **Severity of motor signs assessed during:** on-medication state **Follow-up (maximum time after end of intervention):** 0 (post-intervention)

Miyai 2002 *(Continued)*

Notes	**Funding sources:** Fund for Comprehensive Research on Aging and Health from the Ministry of Health and Welfare, Japan **Conflicts of interest:** None

Morris 2009

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** Yes
Participants	**Number of participants (recruited/randomized/evaluated):** 124/28/28 **Country:** Australia **Age (mean in years):** 66; 68 **Sex (male/female):** NR **Duration of disease (mean in years):** NR **HY (range):** 2 to 3 **UPDRS-M (mean):** NR **MMSE (mean):** > 23 (inclusion criteria) **Physical capability:** 10MWT(s): 7.7; 8.4; 2-MIN-W (m): 150.7; 139.1 **Inclusion criteria:** 21 to 80 years of age and medically stable, with a diagnosis of idiopathic PD confirmed by a neurologist; more than 23 out of 30 on the MMSE with a minimum of two of three on the recall question. Needed to have disease severity of HY stage 2 or 3 and be able to walk 10 m three times without assistance **Exclusion criteria:** Unsafe to participate in the therapy programs, other neurological conditions in addition to PD, musculoskeletal, visual, or cardiopulmonary conditions that affected mobility, cognitive impairment, not in hospital for 2 weeks or unable or unwilling to consent to participate in the study
Interventions	**Length of intervention:** 2 weeks **Intervention 1:** Musculoskeletal exercises [multi-domain training]; up to 45 minutes; 7x/week **Intervention 2:** Movement strategy training [gait/balance/functional training]; up to 45 minutes; 7x/week **Primary setting:** Individual **Supervision by (if provided):** Physiotherapist; occupational therapist
Outcomes	UPDRS (only motor and ADL components combined); PDQ-39; TUG; 10MWT, 2-MIN-W; Balance pull test **Follow-up (maximum time after end of intervention):** 3 months
Notes	**Funding sources:** NR

Morris 2009 *(Continued)*

	Conflicts of interest: None

Morris 2015

Study characteristics	
Methods	Randomized controlled trial Multicenter **A priori consideration of test power:** Yes
Participants	**Number of participants (recruited/randomized/evaluated):** 245/210/195 **Country:** Australia **Age (mean in years):** 67.9 **Sex (male/female):** 140/70 (66.7% male) **Duration of disease (mean in years):** 6.7 **HY (range):** 0 to 4 **UPDRS-M (mean):** 14.6; 14.9; 16.2 **MMSE (mean):** 28.2 **Physical capability:** Walking speed (m/s): 1.18; 1.23; 1.13 **Inclusion criteria:** Diagnosis of PD; MMSE ≥ 24; HY < 5, medically able and safe to perform the interventions **Exclusion criteria:** People who received deep brain stimulation
Interventions	**Length of intervention:** 8 weeks **Intervention 1:** Progressive resistance strength training [strength/resistance training]; 120 minutes; 1x/week + 1x/week home exercise program **Intervention 2:** Movement strategy training (walking, turning, reaching in standing, sit to stand, transfer from chair to chair, getting up from bed, protective stepping in standing, complex walking tasks) [gait/balance/functional training]; 120 minutes; 1x/week + 1x/week home exercise program **Intervention 3:** Control group (social activities, practical advice, information sessions and group discussions but not any content related to falls or mobility; brochures, DVDs, booklets, audiotapes) [active control group]; 120 minutes; 1x/week + 1x/week home exercise program **Primary setting:** Group **Supervision by (if provided):** Occupational therapists, physical therapists, speech pathologists, social workers
Outcomes	Falls, fallers, UPDRS-M, UPDRS-II, walking speed, PDQ-39, EQ-5D visual analogue scale, TUG **Severity of motor signs assessed during:** on-medication state **Follow-up (maximum time after end of intervention):** 12 months

Morris 2015 *(Continued)*

Notes	**Funding sources:** Michael J. Fox Foundation (US) Clinical Discovery Grant. HBM is a National Health and Medical Research Council Senior Research Fellow **Conflicts of interest:** None

Morris 2017

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** No
Participants	**Number of participants (recruited/randomized/evaluated):** 143/133/120 **Country:** Australia **Age (mean in years):** 71 **Sex (male/female):** 80/53 (60.2% male) **Duration of disease (mean in years):** NR **HY (range):** 1 to 4 **UPDRS-M (mean):** 35.0; 36.0 **MMSE (mean):** 28.3 **Physical capability:** Fallen in last year (n): 38;35 **Inclusion criteria:** Idiopathic PD; modified HY stage ≤ 4, MMSE ≥ 24, and community dwelling **Exclusion criteria:** Other health conditions that preclude safe participation in the exercise program, insufficient English to follow instructions, and unwillingness to be assessed and treated at home
Interventions	**Length of intervention:** 6 weeks **Intervention 1:** Exercise group (progressive resistance strength training, movement strategy training, and education about methods with which to prevent falls) [multi-domain training]; 60 minutes; 1x/week + 1x/week at home **Intervention 2:** Control group (guided education and discussion sessions on topics of interest that were selected by participants from a predefined syllabus) [active control group]; 60 minutes; 1x/week + 1x/week at home **Primary setting:** Individual **Supervision by (if provided):** Physiotherapist or trained clinician; trained allied health professionals, including occupational therapists, physiotherapists, and speech pathologists
Outcomes	Rate of falls; disability and health-related QoL; MDS-UPDRS; EQ-5D; PDQ-39 **Severity of motor signs assessed during:** on-medication state

Morris 2017 *(Continued)*

	Follow-up (maximum time after end of intervention): 12 months
Notes	**Funding sources:** National Health and Medical Research Council **Conflicts of interest:** None

Muller 1997

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** No
Participants	**Number of participants (recruited/randomized/evaluated):** NR/29/NR **Country:** Germany **Age (mean in years):** 62.7; 61.5 **Sex (male/female):** 20/9 (69% male) **Duration of disease (mean in years):** 7.7; 9.0 **HY (mean):** 2.13; 2.07 **UPDRS-M (mean):** 1.37; 1.24 **MMSE (mean):** NR **Physical capability:** NR **Inclusion criteria:** Diagnosis of idiopathic PD; all participants were prescribed a combination of levodopa with either a dopamine agonist and/or a monoamine oxidase inhibitor. There was no change in medication at least 4 weeks prior to treatment. Average levodopa doses were 300 mg/day in both groups **Exclusion criteria:** People suffering from depression, dementia, or other psychiatric disorders according to the Diagnostic and Statistical Manual of Mental Disorders (DSM-Ill-R); none of the participants had a history of alcohol or drug abuse nor any other significant physical illness
Interventions	**Length of intervention:** 10 weeks **Intervention 1:** Behavioral group (walking, standing in an upright position, getting up from a chair, turning in bed, and handwriting) [gait/balance/functional training]; 90 minutes; 2x/week **Intervention 2:** Control group (nonspecific treatment; information about the disease; breathing exercise; physical exercises discussion of disease-related problems) [active control group]; 90 minutes; 2x/week **Primary setting:** Individual **Supervision by (if provided):** NR
Outcomes	Posture and gait initiation by using an optoelectronic motion analyzer; UPDRS; HY; BDI **Severity of motor signs assessed during:** on-medication state

Muller 1997 *(Continued)*

	Follow-up (maximum time after end of intervention): 0 (post-intervention)
Notes	**Funding sources:** Robert Bosch Foundation **Conflicts of interest:** NR Please note that the values in UPDRS-M are relatively small. It is unclear whether they represent total scores or, potentially, average scores per item.

Mulligan 2018

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** No
Participants	**Number of participants (recruited/randomized/evaluated):** NR/41/41 **Country:** New Zealand **Age (mean in years):** 69.4; 69.8 **Sex (male/female):** 26/15 (63.4% male) **Duration of disease (mean in years):** 7.9; NR **HY (mean):** NR **UPDRS-M (mean):** 32.5; 28.4 **MMSE (mean):** NR **Physical capability:** 6-MIN-W (m): 304.6; 293.6 **Inclusion criteria:** Diagnosed with idiopathic PD; adults (> 60 years of age); without any other atypical movement disorders; Conversion to Dementia score of > 5%, meaning they were at risk of developing dementia in the next four years, but were not yet classified as having mild cognitive impairment **Exclusion criteria:** Current involvement in any longitudinal studies on cognitive changes in Parkinson's; involved in other studies that included pharmacological intervention; were currently using any medications that could impact cognition; had any other current or past neurological or psychiatric conditions; had a poor comprehension of the English language; history of major illness in the past year, alcohol or substance abuse or learning disability
Interventions	**Length of intervention:** 8 months **Intervention 1:** Intervention group (aerobic, progressive resistance, and balance exercises) [multi-domain training]; 60 minutes; 1x/week **Intervention 2:** Control group [passive control group] **Primary setting:** Group **Supervision by (if provided):** Physiotherapists

Mulligan 2018 *(Continued)*

Outcomes	Individual or group interviews; 6-MIN-W; Mini-BESTest **Follow-up (maximum time after end of intervention):** 0 (post-intervention)
Notes	**Funding sources:** NR **Conflicts of interest:** None

Myers 2020

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** No
Participants	**Number of participants (recruited/randomized/evaluated):** NR/28/26 **Country:** USA **Age (mean in years):** 70.5; 65.0 **Sex (male/female):** 15/11 (57.7% male) **Duration of disease (mean in years):** NR **HY (range):** 2 to 3 **UPDRS-M (median):** 24; 29 **MMSE (median):** 29; 29 **Physical capability:** NR **Inclusion criteria:** Clinical diagnosis of Parkinson's disease, able to stand for at least 30 minutes, normal peripheral nervous system function, no history of vestibular disease, and MMSE score > 24. **Exclusion criteria:** Diagnosis of any other major medical condition, having deep brain stimulation or neural implants, diagnosis of peripheral neuropathy, use of neuroleptic or dopamine-blocking medications, and has a current, regular yoga practice.
Interventions	**Length of intervention:** 12 weeks **Intervention 1:** Yoga [mind-body training]; 60 minutes; 2x/week **Intervention 2:** Control (usual routines) [passive control group] **Primary setting:** Group **Supervision by (if provided):** Yoga instructor
Outcomes	BESTest, Beck Anxiety Inventory, and Revised Oswestry Disability Index **Follow-up (maximum time after end of intervention):** within 2 weeks

Myers 2020 *(Continued)*

Notes	**Funding sources:** US National Institutes of Health
	Conflicts of interest: None

Nadeau 2014

Study characteristics	
Methods	Randomized controlled trial
	Single center
	A priori consideration of test power: No
Participants	**Number of participants (recruited/randomized/evaluated):** 297/93/34
	Country: Canada
	Age (mean in years): 64.0; 60.1; 64.3
	Sex (male/female): 27/7 (79.4% male)
	Duration of disease (mean in years): NR
	HY (mean): 1.92; 1.95; 1.86
	UPDRS-M (mean): 29.1; 21.9; 17.9
	MMSE (mean): 27.8; 28.7; 28.6
	Physical capability: 6-MIN-W: 422.9; 520.2; 497.6; Gait speed (cm/s): 102.5;122.7; 125.8
	Inclusion criteria:
	Diagnosis of idiopathic PD; ≤ 2 HY; aged 40 to 80; no musculoskeletal impairments or excessive pain in any joints that could limit participation in an exercise program; no signs of dementia (MMSE > 24); living up to 45 min away from the university
	Exclusion criteria:
	Major health problem (cancer, heart/lung problem, etc.)
Interventions	**Length of intervention:** 24 weeks
	Intervention 1: Speed treadmill training [endurance training]; 60 minutes; 3x/week
	Intervention 2: Mixed treadmill training [endurance training]; 60 minutes; 3x/week
	Intervention 3: Control (Viactive program; low intensity exercises with elements of tai chi, Latin dance, resistance band exercises and coordination movements) [multi-domain training]; 60 minutes; 2x/week + 1x/week at home
	Primary setting: Group and individual
	Supervision by (if provided): Exercise trainer
Outcomes	MDS-UPDRS; MMSE; BDI-II; PDQ-39; gait parameters; 6-MIN-W
	Severity of motor signs assessed during: NR
	Follow-up (maximum time after end of intervention): 1 week

Nadeau 2014 *(Continued)*

Notes	**Funding sources:** Clinique Ste-Anne ‘‘Me´moire et Mouvement’’; Natural Sciences and Engineering Research Council (NSERC) **Conflicts of interest:** None

Ni 2016

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** Yes
Participants	**Number of participants (recruited/randomized/evaluated):** 64/41/37 **Country:** USA **Age (mean in years):** 72.2 **Sex (male/female):** 24/13 (64.9% male) **Duration of disease (mean in years):** 6.6; 6.9; 5.9 **HY (mean):** 2.2; 2.2; 2.1 **UPDRS-M (mean):** 32.9; 28.2; 27.6 **MMSE (mean):** 29.1; NR; 29.4 **Physical capability:** 10-meter maximal walking speed (m/s): 1.52; 1.49; 1.41 and 10-meter usual walking speed (m/s): 1.03; 1.06; 1.04 **Inclusion criteria:** Diagnosis of idiopathic PD with mild to moderate impairment (HY stages 1 to 3), aged 60 to 90 years, capable of ambulation for at least 50 feet with or without an assistive device, able to get up and down from the floor with minimal assistance, and with no cognitive impairment (MMSE < 24) **Exclusion criteria:** Unstable cardiovascular disease or other uncontrolled chronic conditions which would affect either their safety, the conduct of testing, or the interpretation of the results. Additionally, they may not have regularly practiced (1 to 2 times weekly) high-intensity resistance training within the past year.
Interventions	**Length of intervention:** 12 weeks **Intervention 1:** Power-based resistance training [strength/resistance training]; duration not reported; 2x/week **Intervention 2:** Yoga [mind-body training]; 60 minutes; 2x/week **Intervention 3:** Control [passive control group] **Primary setting:** Group and individual **Supervision by (if provided):** NR

Ni 2016 *(Continued)*

Outcomes	UPDRS-M; BBS; Mini-BESTest; TUG; PDQ-39; bradykinesia scores; 1 repetition maximum & peak power; 10-meter usual and maximal walking speed tests, 1 repetition maximum and peak power for leg press; postural sway test **Severity of motor signs assessed during:** on-medication state **Follow-up (maximum time after end of intervention):** 2 weeks
Notes	**Funding sources:** No financial support **Conflicts of interest:** None

Nieuwboer 2007

Study characteristics	
Methods	Randomized controlled trial with cross-over after 3 weeks Multicenter **A priori consideration of test power:** Yes
Participants	**Number of participants (recruited/randomized/evaluated):** 289/153/153 **Country:** Belgium **Age (median in years):** 67.5; 69.0 **Sex (male/female):** 88/65 (57.5% male) **Duration of disease (median in years):** 7; 8 **HY (range):** 2 to 4 **UPDRS-M (median):** 31.0; 34.0 **MMSE (median):** 28.5; 29.0 **Physical capability:** Walking speed (m/s); Median: 0.86; 0.83 **Inclusion criteria:** Showing mild to severe gait disturbance with score 0.1 on the UPDRS (item 29); diagnosis of idiopathic Parkinson's disease; stable drug usage; HY stage 2 to 4; and aged 18 to 80 years **Exclusion criteria:** Had undergone deep brain stimulation or other stereotactic neurosurgery; had cognitive impairment (MMSE < 24); had disorders interfering with participation in cueing training, including neurological (stroke, multiple sclerosis, tumour), cardiopulmonary (chronic obstructive disorders, angina pectoris) and orthopaedic (osteoarthritis, rheumatoid arthritis, and back pain) conditions; had unpredictable and long-lasting off periods (score 1 on item 37 and score 0.2 on item 39 of the UPDRS) and had participated in a physiotherapy program 2 months before starting the trial
Interventions	**Length of intervention:** 3 weeks **Intervention 1:** Cueing ("RESCUE"; with rhythmical cueing modalities) [gait/balance/functional training]; 30 minutes; 3x/week **Intervention 2:** Control group [passive control group]

Nieuwboer 2007 *(Continued)*

	Primary setting: Individual **Supervision by (if provided):** Therapist
Outcomes	PDQ-39; posture and gait scores; Carer Strain Index; TUG; gait analysis; FES; FOG-Q; Nottingham Extended ADL Index **Follow-up (maximum time after end of intervention):** 6 weeks
Notes	**Funding sources:** European Commission Framework V funding **Conflicts of interest:** "The proceeds of the sale of the CD-Rom will be used to fund completion of analysis of the full RESCUE dataset. We may be involved in this further work."

Ortiz-Rubio 2018

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** No
Participants	**Number of participants (recruited/randomized/evaluated):** 50/46/46 **Country:** Spain **Age (mean in years):** 74.2; 75.4 **Sex (male/female):** 33/13 (71.7% male) **Duration of disease (mean in years):** 4.00; 4.27 **HY (range):** 2 to 3 **MDS-UPDRS-M (mean):** 24.1; 26.4 **MMSE (mean):** 26.7; 26.7 **Physical capability:** NR **Inclusion criteria:** Clinical diagnosis of PD according to UK Brain Bank Criteria in the 2 to 3 HY stages; age 65+; stable medication usage; ability to walk 10 m without assistance from another person or a walking frame **Exclusion criteria:** Cognitive impairment (MMSE lower than 24); comprehension deficits that prevented them from following verbal commands; visual or acoustic limitations; diagnosis of a neurological condition other than PD; clinically significant comorbidities likely to affect gait
Interventions	**Length of intervention:** 8 weeks **Intervention 1:** Resistance training program [strength/resistance training]; 60 minutes; 2x/week **Intervention 2:** Control group (low-intensity exercise program) [active control group]; duration and frequency not reported **Primary setting:** Group

Ortiz-Rubio 2018 *(Continued)*

	Supervision by (if provided): NR
Outcomes	Mini-BESTest; Revised Paper Fatigue Scale **Follow-up (maximum time after end of intervention):** 0 (post-intervention)
Notes	**Funding sources:** None **Conflicts of interest:** None

Palmer 1986

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** No
Participants	**Number of participants (recruited/randomized/evaluated):** NR/14/14 **Country:** USA **Age (mean in years):** 63.9; 65.9 **Sex (male/female):** 12/2 (85.7% male) **Duration of disease (mean in years):** NR **HY (mean):** NR **UPDRS-M (mean):** NR **MMSE (mean):** NR **Physical capability:** NR **Inclusion criteria:** Idiopathic PD; stabilization on a regimen of pharmacologic therapy; ability to attend the scheduled evaluation and exercise sessions **Exclusion criteria:** Physical problems that might cause them to risk injury during the exercises
Interventions	**Length of intervention:** 12 weeks **Intervention 1:** United Parkinson Foundation exercise program (slow stretching exercises) [flexibility training]; 60 minutes; 3x/week **Intervention 2:** Karate training program [mind-body training]; 60 minutes; 3x/week **Primary setting:** Group **Supervision by (if provided):** Corrective therapist; rehabilitation nursing student who had a black belt in karate
Outcomes	Parkinson's Disease Motor Battery (Walk index, Arm tremor, Activated rigidity, Resting rigidity, Pursuit score, Pronation-supination rate); ADL (grip strength, 9-hole coordination test, placing and turning test, arm swing test, rapid arm movement, button board, putting shirt on and off, putting shoes and socks

Palmer 1986 *(Continued)*

	on and off, getting up from chair); Arm acceleration; long-latency stretch response; Patient questionnaire (asking their impressions of the benefits of the exercise program for specific Parkinson symptoms) **Follow-up (maximum time after end of intervention):** 0 (post-intervention)
Notes	**Funding sources:** NR **Conflicts of interest:** NR

Park 2014

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** No
Participants	**Number of participants (recruited/randomized/evaluated):** NR/31/31 **Country:** USA **Age (mean in years):** 59.9 **Sex (male/female):** 20/11 (64.5% male) **Duration of disease (mean in years):** 0-10 **HY (range):** 1 to 2 **UPDRS-M (mean):** 14.00; 16.60 **MMSE (mean):** NR **Physical capability:** Timed walk (s): 6.04; 6.26 **Inclusion criteria:** Aged 40 to 70 years diagnosed with PD within three years of symptom onset with a HY stage 1 or 2; met the UK Parkinson's Disease Brain Bank criteria; could be on either no anti-Parkinsonian medications, or could be taking amantadine, monoamine oxidase B inhibitors, and/or dopamine agonists; adequate vision and English sufficient for compliance with testing and surveys **Exclusion criteria:** HY stage 3 or higher; atypical or secondary parkinsonism; any other condition (other than the primary indications) which in the opinion of the investigators might contribute to gait or balance impairments or complicate its assessment; have been or are on any formulation of levodopa
Interventions	**Length of intervention:** 24 weeks **Intervention 1:** Early start group exercise (cardiovascular, core strength and joint integrity plan) [multi-domain training]; 60 minutes; 3x/week; 24 weeks **Intervention 2:** Delayed start group [passive control group] **Primary setting:** Group **Supervision by (if provided):** Personal trainer

Park 2014 *(Continued)*

Outcomes	UPDRS, TUG, Tinetti Mobility Test, PDQ-39, BDI **Severity of motor signs assessed during:** NR **Follow-up (maximum time after end of intervention):** 0 (post-intervention)
Notes	**Funding sources:** Madden Center Development Fund. OSU Parkinson's Disease Our Goal is a Cure Fund. Columbus branch of the National Parkinson's Foundation. OSU Center for Clinical and Translational Science **Conflicts of interest:** NR Participants in intervention 2 received same intervention as the intervention group, beginning after 24 weeks

Paul 2014

Study characteristics	
Methods	Randomized controlled trial Multicenter **A priori consideration of test power:** Yes
Participants	**Number of participants (recruited/randomized/evaluated):** 72/40/36 **Country:** Australia **Age (mean in years):** 68.1; 64.5 **Sex (male/female):** 25/15 (62.5% male) **Duration of disease (mean in years):** 7.8 **HY (mean):** 2.0; 1.9 **MDS-UPDRS-M (mean):** 37.1; 35.7 **MMSE (mean):** 29.1; 28.9 **Physical capability:** Preferred walking speed (m/s): 1.27; 1.17 Fast walking speed (m/s): 1.77; 1.67 **Inclusion criteria:** Idiopathic PD; aged over 40 years and were able to walk independently with or without an aid **Exclusion criteria:** Significant cognitive impairment (MMSE < 24) or suffered from any unstable cardiovascular, orthopaedic, or neurological conditions that would interfere with the safety of assessment and/or interpretation of results
Interventions	**Length of intervention:** 12 weeks **Intervention 1:** Muscle power training [strength/resistance training]; 45 minutes; 2x/week **Intervention 2:** Low intensity control group (exercises at home) [passive control group] **Primary setting:** Group

Paul 2014 *(Continued)*

	Supervision by (if provided): Physiotherapist
Outcomes	Peak power of four leg muscle groups; muscle strength, mobility, balance and falls; fast and preferred walking pace; TUG; one-legged stance test; tests of stepping; maximum balance range; N-FOG-Q; number of falls **Follow-up (maximum time after end of intervention):** 0 to 1 week
Notes	**Funding sources:** Parkinson's NSW Unity Walk Research Grant and a University of Sydney Bridging Support Grant **Conflicts of interest:** SS Paul received financial assistance from a National Health and Medical Research Council (NHMRC) of Australia postgraduate scholarship. C Sherrington receives salary funding from the NHMRC. VSC Fung is on advisory boards and/or has received travel grants from Abbott, Allergan, Boehringer-Ingelheim, Hospira, Lundbeck and Novartis. CG Canning and J Song declare no competing interests.

Pazzaglia 2020

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** Yes
Participants	**Number of participants (recruited/randomized/evaluated):** NR/51/NR **Country:** Italy **Age (mean in years):** 71 **Sex (male/female):** 35/16 (68.6% male) **Duration of disease (mean in months):** 73.2 **HY (mean):** NR **UPDRS-M (mean):** 23; 25 **MMSE (mean):** > 25 (inclusion criteria) **Physical capability:** NR **Inclusion criteria:** Diagnosis of PD; ability to perform the rehabilitation programme with a low risk of falling; ability to perform motor rehabilitation independently; absence of cognitive impairment (MMSE > 25); and no changes in drug therapy for PD during the rehabilitation programme **Exclusion criteria:** People with secondary Parkinsonism or Parkinson's plus; severe hearing loss and/or visual deficit; and serious comorbidities making it impossible to perform rehabilitation (e.g. postural hypotension, heart disease, stroke, severe shoulder–hip disease)
Interventions	**Length of intervention:** 6 weeks **Intervention 1:** Virtual reality [gaming]; 40 minutes; 3x/week

Pazzaglia 2020 *(Continued)*

	Intervention 2: Conventional rehabilitation programme [gait/balance/functional training]; 40 minutes; 3x/week **Primary setting:** Individual **Supervision by (if provided):** Physiotherapist
Outcomes	BBS; Dynamic Gait Index; Disabilities of the Arm, Shoulder and Hand scale to measure performance of the upper limb; SF-36 **Follow-up (maximum time after end of intervention):** 0 (post-intervention)
Notes	**Funding sources:** BTS Spa **Conflicts of interest:** None

Pedreira 2013

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** No
Participants	**Number of participants (recruited/randomized/evaluated):** 71/44/32 **Country:** Brazil **Age (mean in years):** 61.1; 66.2 **Sex (male/female):** 22/9 (71% male) **Duration of disease (mean in years):** 8.6; 7.3 **HY (mean):** 2.5; 2.4 **UPDRS-M (mean):** NR **MMSE (mean):** NR **Physical capability:** NR **Inclusion criteria:** Clinical diagnosis of PD; any sex; aged between 45 and 80 years; HY 1 to 3 **Exclusion criteria:** Cognitive impairment (dementia); poorly controlled arterial hypertension; poorly controlled cardiopathy; psychiatric disorders, and illnesses that prevented exercise understanding and performance
Interventions	**Length of intervention:** 4 weeks **Intervention 1:** Nintendo Wii [gaming]; 50 minutes; 3x/week **Intervention 2:** Traditional physical therapy [multi-domain training]; 12 minutes; 3x/week **Primary setting:** Individual **Supervision by (if provided):** NR

Pedreira 2013 *(Continued)*

Outcomes	PDQ-39; UPDRS **Follow-up (maximum time after end of intervention):** 4 weeks
Notes	**Funding sources:** Federal University of Bahia **Conflicts of interest:** NR

Peloggia Cursino 2018

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** Yes
Participants	**Number of participants (recruited/randomized/evaluated):** 93/26/21 **Country:** Brazil **Age (mean in years):** 63.29; 70; 72 **Sex (male/female):** 12/9 (57.1% male) **Duration of disease (mean in years):** 2.86; 4.14; 6.29 **HY (mean):** 2; 1.71; 2.29 **UPDRS-M (mean):** NR **MMSE (mean):** 27.29; 27.86; 25.57 **Physical capability:** Step length (cm): 65.83; 66.69; 59.20; Gait speed (m/s): 1.20; 1.16; 0.99 **Inclusion criteria:** Idiopathic PD; ability to walk without the use of aid devices; no participation in a pharmacological adaptation phase; carry out the evaluations and interventions during on-medication state **Exclusion criteria:** Pain, fracture, serious injury to soft tissue in the six months before the study, severe osteoporosis, history of cognitive and other neurological impairments, or uncontrolled cardiovascular or respiratory changes or other chronic uncontrolled conditions that may interfere with the safety and performance of the training protocol and testing
Interventions	**Length of intervention:** 6 weeks **Intervention 1:** Group with partial body weight support [gait/balance/functional training]; 30 minutes; 3x/week **Intervention 2:** Group with auditory stimulus [gait/balance/functional training]; 30 minutes; 3x/week **Intervention 3:** Treadmill group [endurance training]; 30 minutes; 3x/week **Primary setting:** Individual **Supervision by (if provided):** NR

Peloggia Cursino 2018 *(Continued)*

Outcomes	PDQ-39; step length; step length variability; step width; step width variability; gait speed **Follow-up (maximum time after end of intervention):** 0 (post-intervention)
Notes	**Funding sources:** None **Conflicts of interest:** None

Picelli 2016

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** No
Participants	**Number of participants (recruited/randomized/evaluated):** 45/17/17 **Country:** Italy **Age (mean in years):** 70.0 **Sex (male/female):** 12/5 (70.6% male) **Duration of disease (mean in years):** 9.9 **HY (mean):** 3 (inclusion criteria) **UPDRS-M (mean):** NR **MoCA (median):** 24.0; 23.0 **Physical capability:** 6-MIN-W (m): 310.2; 298.8 **Inclusion criteria:** Confirmed diagnosis of idiopathic PD; HY stage 3, determined in the “on” phase; and a MMSE score greater than 24 **Exclusion criteria:** Severe dyskinesias or “on-off” fluctuations; important modifications of PD medication during the study (i.e. drug changes); deficits of somatic sensation involving the lower limbs; vestibular disorders or paroxysmal vertigo; other neurological or orthopedic conditions involving the lower limbs (musculoskeletal diseases, severe osteoarthritis, peripheral neuropathy, joint replacement); and cardiovascular comorbidity (recent myocardial infarction, heart failure, uncontrolled hypertension, orthostatic hypotension)
Interventions	**Length of intervention:** 4 weeks **Intervention 1:** Treadmill training [gait/balance/functional training]; 45 minutes; 3x/week **Intervention 2:** Control group [passive control group] **Primary setting:** Individual **Supervision by (if provided):** NR

Picelli 2016 *(Continued)*

Outcomes	UPDRS; Frontal Assessment Battery-Italian version; 6-MIN-W; MoCA; TMT; memory with interference test; BDI; 10MWT (fastest speed) **Follow-up (maximum time after end of intervention):** 0 (post-intervention)
Notes	**Funding sources:** NR **Conflicts of interest:** NR

Pohl 2013

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** Yes
Participants	**Number of participants (recruited/randomized/evaluated):** 193/18/16 **Country:** Sweden **Age (mean in years):** 68.2 **Sex (male/female):** 8/10 (44.4% male) **Duration of disease (mean in years):** 8.8 **HY (mean):** 2.4 **UPDRS-M (mean):** 19.0; 17.5 **MMSE (mean):** NR **Physical capability:** TUG: 10.5; 10.0 **Inclusion criteria:** Diagnosis of PD; any duration of PD; any PD therapy or treatment, but stable; able to get down in a squatting position and to walk at least 10 meters without support; correctable auditory and visual capability and able to access transportation to and from research sessions **Exclusion criteria:** Secondary or atypical PD; colour blindness; severe depression; participating in any other ongoing study or having ≥ 3 points per question in UPDRS-I, in question numbers 13 to 15 in UPDRS-II and in question numbers 24 to 30 in UPDRS-M
Interventions	**Length of intervention:** 6 weeks **Intervention 1:** Ronnie Gardiner Rhythm and Music Method (RGRM) [dance]; 60 minutes; 2x/week **Intervention 2:** Control group [passive control group] **Primary setting:** Group **Supervision by (if provided):** RGRM practitioner
Outcomes	Posturo-Locomotion-Manual-test; TUG; UPDRS-M; Text recall test; Symbol Digit Modalities Test; Clox and Cube; Naming 30 items; Stroop test; Parallel Serial Mental Operations; PDQ-39

Pohl 2013 *(Continued)*

	Severity of motor signs assessed during: on-medication state
	Follow-up (maximum time after end of intervention): 0 (post-intervention)
Notes	**Funding sources:** Ostergotland County Council and Department of Neurology
	Conflicts of interest: None

Pohl 2020

Study characteristics	
Methods	Randomized controlled trial
	Single center
	A priori consideration of test power: Yes
Participants	**Number of participants (recruited/randomized/evaluated):** 59/51/46
	Country: Sweden
	Age (mean in years): 69.7; 70.4
	Sex (male/female): 32/14 (69.6% male)
	Duration of disease (mean in years): 6.0; 6.8
	HY (range): 1 to 3
	UPDRS-M (mean): 34.0; 28.6
	MoCA (mean): 25.5; 25.0
	Physical capability: TUG: 18.5; 19.9
	Inclusion criteria:
	Community-dwelling individuals from 18 years of age with a diagnosis of Parkinson's disease and HY up to stage 3, stable medication for 4 months, and capacity to walk 10 meters without gait assistance. To enhance the generalizability of the findings, any medical treatment, even surgical, was accepted
	Exclusion criteria:
	Other neurological deficits or serious health conditions that would compromise participation; significant visual or hearing impairments that would make participation impossible; or severe motor fluctuations
Interventions	**Length of intervention:** 12 weeks
	Intervention 1: Ronnie Gardiner Method [dance]; 60 minutes; 2x/week
	Intervention 2: Control [passive control group]
	Primary setting: Group
	Supervision by (if provided): Physiotherapists (certified Ronnie Gardiner practitioners)
Outcomes	TUG, subtracting serial-7s measuring the effect of cognitive demands on functional mobility (motor-cognitive dual-tasking); MoCA; three parts of the Cognitive Assessment Battery; Stroop test; Symbol Digit Modalities Test; Mini-BESTest; FES-I; FOG-Q; PDQ-39

Pohl 2020 *(Continued)*

	Follow-up (maximum time after end of intervention): 3 month
Notes	**Funding sources:** Region Östergötland, the Henry and Ella Margareta Ståhls Foundation, the Tornspiran Foundation, Neuro Sweden, Swedish Parkinson's foundation, and Linköping University Hospital Research Fund **Conflicts of interest:** PP is a non-practicing certified practitioner of the Ronnie Gardiner Method. She was blind to the results of the outcome evaluations of all participants and did not take part in the interviews. EW, FL, PE and ND report no conflicts of interest.

Poier 2019

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** Yes
Participants	**Number of participants (recruited/randomized/evaluated):** NR/29/21 **Country:** Germany **Age (mean in years):** 68.5; 68.9 **Sex (male/female):** 12/17 (41.4% male) **Duration of disease (range in years):** 0 to 10 **HY (mean):** NR **UPDRS-M (mean):** NR **MMSE (mean):** NR **Physical capability:** NR **Inclusion criteria:** Diagnosed with PD; aged between 50 and 90 years and with signed informed consent **Exclusion criteria:** People with significant cognitive impairments (no independent completing of questionnaires) and/or who are permanently bound to a wheelchair/walker were not included
Interventions	**Length of intervention:** 10 weeks **Intervention 1:** Tango Argentino [dance]; 60 minutes; 1x/week **Intervention 2:** Tai chi [mind-body training]; 60 minutes; 1x/week **Primary setting:** Group **Supervision by (if provided):** Professional teacher
Outcomes	PDQ-39; Brief Multidimensional Life Satisfaction Scale; Inner Correspondence and feelings of Peaceful Relief; perceived impairment in everyday life via Numeric Rating Scale **Follow-up (maximum time after end of intervention):** 10 weeks

Poier 2019 *(Continued)*

Notes	**Funding sources:** Stiftung Helixor
	Conflicts of interest: None

Poliakoff 2013

Study characteristics	
Methods	Randomized controlled trial
	Multicenter
	A priori consideration of test power: No
Participants	**Number of participants (recruited/randomized/evaluated):** 56/32/21
	Country: UK
	Age (mean in years): 66.6; 63.7
	Sex (male/female): 21/11 (65.6% male)
	Duration of disease (mean in years): 7.39; 4.68
	HY (mean): NR
	UPDRS-M (mean): 18.5; 15.2
	MMSE (mean): NR
	Physical capability: 6-foot walk (s): 11.0; 10.9
	Inclusion criteria:
	People with PD
	Exclusion criteria:
	Diagnosed or suspected dementia, attendance of a group exercise class for PD or other neurodegenerative disease and > 2 weeks holiday booked during the study period
Interventions	**Length of intervention:** 10 weeks
	Intervention 1: Gym training (cardiovascular activity, including treadmill, recumbent bikes, bikes, cross trainers and rowers) [multi-domain training]; 60 minutes; 2x/week
	Intervention 2: Wait-list control [passive control group]
	Primary setting: Group
	Supervision by (if provided): Gym staff with previous experience working with PD patients
Outcomes	PDQ-39; reaction times, UPDRS-M; Brief Illness Perception Questionnaire; 6-foot walk; chair stand test; Timed hand (10x pronation-supination); Timed leg (10x heel taps)
	Severity of motor signs assessed during: on-medication state
	Follow-up (maximum time after end of intervention): 10 weeks
Notes	**Funding sources:** Parkinson's UK

Poliakoff 2013 *(Continued)*

	Conflicts of interest: NR

Protas 2005

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** Yes
Participants	**Number of participants (recruited/randomized/evaluated):** NR/18/18 **Country:** USA **Age (mean in years):** 71.3; 73.7 **Sex (male/female):** 18/0 (100% male) **Duration of disease (mean in years):** 7.1; 8.1 **HY (mean):** 2.8; 2.9 **UPDRS-M (mean):** 28.3; 30.4 **MMSE (mean):** NR **Physical capability:** Gait speed (m/s): 1.28; 1.26 **Inclusion criteria:** Postural instability-gait difficulty predominant PD; experiences with freezing episodes, and/or a history of falls; stable regimen of anti-Parkinsonian medications; ability to stand and walk with or without assistance; stage 2 or 3 of the HY staging; scores of moderate or higher on all scales of the Neurobehavioral Cognitive Status Examination (Cognistat) **Exclusion criteria:** NR
Interventions	**Length of intervention:** 8 weeks **Intervention 1:** Training group (treadmill; gait, step training) [gait/balance/functional training]; 60 minutes; 3x/week **Intervention 2:** Control group [passive control group] **Primary setting:** Individual **Supervision by (if provided):** Physical therapist
Outcomes	Gait speed, cadence, stride length right and left, step test, provocative test for freezing and motor blocks **Follow-up (maximum time after end of intervention):** 0 (post-intervention)
Notes	**Funding sources:** NR **Conflicts of interest:** NR

Pérez de la Cruz 2017

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** Yes
Participants	**Number of participants (recruited/randomized/evaluated):** 38/30/30 **Country:** Spain **Age (mean in years):** 66.80; 67.53 **Sex (male/female):** 13/16 (44.8% male) **Duration of disease (mean in years):** 6.2; 6.7 **HY (mean):** 2.82; 2.66 **UPDRS-M (mean):** 15.23 **MMSE (mean):** ≥ 24 (inclusion criteria) **Physical capability:** TUG: 11.6;11.5 **Inclusion criteria:** Diagnosed with PD, HY 1 to 3; > 40 years of age; during off-medication state and with a score greater, or equal to, 24 on the MMSE; in addition, there were no medical contradictions, and all participants accepted the study norms (regular assistance and active participation); "we decided to perform the assessment 12 h after withdrawing medication, therefore we eliminated the probability of motor fluctuations appearing that were dependent on the medication" **Exclusion criteria:** Individuals who did not comply with the above mentioned criteria or who had articular and/or muscular lesions in the lower limbs affecting their independent gait
Interventions	**Length of intervention:** 10 weeks **Intervention 1:** Aquatic Ai Chi [aqua-based training]; 45 minutes; 2x/week **Intervention 2:** Dry land therapy (strength training and aerobic exercises) [multi-domain training]; 45 minutes; 2x/week **Primary setting:** Group **Supervision by (if provided):** Expert physiotherapist trained in clinical Ai Chi
Outcomes	Visual analogue scale; BBS; Tinetti scale; FTSTS; TUG; UPDRS; PDQ-39; Short-Form Health Survey; Geriatric depression scale **Severity of motor signs assessed during:** off-medication state **Follow-up (maximum time after end of intervention):** 1 month
Notes	**Funding sources:** This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors. **Conflicts of interest:** None

Qutubuddin 2013

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** No
Participants	**Number of participants (recruited/randomized/evaluated):** NR/33/19 **Country:** USA **Age (mean in years):** 68.2 **Sex (male/female):** NR **Duration of disease (mean in years):** 7.2 **HY (mean):** NR **UPDRS-M (mean):** 15.7; 16.9 **MMSE (mean):** ≥ 23 (inclusion criteria) **Physical capability:** NR **Inclusion criteria:** Three-year confirmed PD diagnosis with good response to standard Parkinson's medications and a UP-DRS-M score of > 30 **Exclusion criteria:** Nonambulating; demented; already enrolled in an ongoing PD drug research study; uncontrolled di-abetes or hypertension; chronic obstructive pulmonary disease; history of coronary artery disease or congestive heart failure
Interventions	**Length of intervention:** 8 weeks **Intervention 1:** Exercise group (cycling program) [endurance training]; 30 minutes (+ warm up and cool down, duration not specified); 2x/week **Intervention 2:** Control group [passive control group] **Primary setting:** Individual **Supervision by (if provided):** NR
Outcomes	BBS; UPDRS-M; PDQ-39; finger tapping test **Severity of motor signs assessed during:** on-medication state **Follow-up (maximum time after end of intervention):** 4 months
Notes	**Funding sources:** NR **Conflicts of interest:** None

Reuter 2011

Study characteristics	
Methods	Randomized controlled trial Unclear if single center or multicenter **A priori consideration of test power:** Yes
Participants	**Number of participants (recruited/randomized/evaluated):** NR/90/90 **Country:** Germany **Age (mean in years):** 62; 63; 62.1 **Sex (male/female):** 45/45 (50% male) **Duration of disease (mean in years):** 64.1; 71.9; 62.33 (in months) **HY (range):** 2 to 3 **UPDRS-M (mean):** NR **MMSE (mean):** > 24 **Physical capability:** 12-meter Webster Walking Test: 8.4; 8.0; 8.6 **Inclusion criteria:** PD patients, both sexes, HY stage 2 and 3 **Exclusion criteria:** Severe concomitant diseases, which limit physical performances; a second neurological disease
Interventions	**Length of intervention:** 6 months **Intervention 1:** Nordic walking training [endurance training]; 70 minutes; 3x/week **Intervention 2:** Walking training [endurance training]; 70 minutes; 3x/week **Intervention 3:** Flexibility exercises and relaxation training [flexibility training]; 70 minutes; 3x/week **Primary setting:** Group **Supervision by (if provided):** Physiotherapists
Outcomes	UPDRS; PDQ-39; pain (visual analogue scale for several body regions); BBS; walking (12-/24-meter Webster Walking Test); gait parameters assessment on a treadmill including stride time, stride length; maximal exercise test on a treadmill; telephone interview on current activity level **Severity of motor signs assessed during:** NR **Follow-up (maximum time after end of intervention):** 6 months (telephone interview on current activity level)
Notes	**Funding sources:** NR **Conflicts of interest:** NR

Ribas 2017

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** No
Participants	**Number of participants (recruited/randomized/evaluated):** 30/20/20 **Country:** Brazil **Age (mean in years):** 61.7; 60.2 **Sex (male/female):** 8/12 (40% male) **Duration of disease (mean in years):** 6.5; 7.0 **HY (mean):** 1.5 **UPDRS-M (median):** 22.5; 20.5 **MMSE (median):** 27.5; 27.5 **Physical capability:** 6-MIN-W (m): 352; 384 **Inclusion criteria:** Clinical diagnosis of PD according to the UK Parkinson's Disease Society Brain Bank criteria for idiopathic Parkinson's disease confirmed by a neurologist; aged 40 to 80 years; disease stage 1, 2, or 3 based on the modified HY scale; low risk of falls (Berg score > 45); and being recruited from the Paraná State Parkinson's Disease Association between August 2013 and December 2013 **Exclusion criteria:** Any type of dementia or cognitive deficit (assessed by the MMSE using a cutoff of 24); acute pain or comorbid conditions (e.g. orthopedic disease, severe or unstable heart disease and other neurologic diseases); visual impairment; use of any assistive device that could prevent performing the exercises correctly; having attended any other rehabilitation program (physical or occupation therapy) in the last three months; and having used a Wii balance board at any time in the past
Interventions	**Length of intervention:** 12 weeks **Intervention 1:** Exergames group (seven Wii Fit games) [gait/balance/functional training]; 30 minutes; 2x/week **Intervention 2:** Conventional exercise group (warming, stretching, active exercises, resistance exercises for the limbs, diagonal exercises for the trunk, neck, and limbs) [multi-domain training]; 30 minutes; 2x/week **Primary setting:** Group and individual **Supervision by (if provided):** Physiotherapists
Outcomes	PDQ-39; BBS; 6-MIN-W, Fatigue Severity Scale **Follow-up (maximum time after end of intervention):** 60 days
Notes	**Funding sources:** NR **Conflicts of interest:** NR

Ridgel 2019

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** No
Participants	**Number of participants (recruited/randomized/evaluated):** 88/16/16 **Country:** USA **Age (mean in years):** 69.9; 70.0 **Sex (male/female):** 9/7 (56.3% male) **Duration of disease (mean in years):** 4.5; 6.38 **HY (mean):** 1.4; 1.9 **UPDRS-M (mean):** 14.13; 14.38 **MMSE (mean):** NR **Physical capability:** Physical activity (steps/day): 4096.18; 4207.26 **Inclusion criteria:** Diagnosis of idiopathic PD; HY 1 to 3; 50 to 79 years of age; no contraindications to exercise including untreated cardiovascular disease or stroke **Exclusion criteria:** High risk for a cardiovascular event; unpredictable motor fluctuations
Interventions	**Length of intervention:** 15 days **Intervention 1:** High-cadence cycling [endurance training]; 40 minutes; 3x/week **Intervention 2:** Stretching [flexibility training]; 40 minutes; 3x/week **Primary setting:** Individual **Supervision by (if provided):** NR
Outcomes	UPDRS-M; bradykinesia and gait assessment ("Kinesia ONE"; speed and amplitude); TUG **Severity of motor signs assessed during:** on-medication state **Follow-up (maximum time after end of intervention):** 2 days
Notes	**Funding sources:** NR **Conflicts of interest:** Angela Ridgel is a co-inventor on two patents which are related to the device used in this study: “Bike System for Use in Rehabilitation of a Patient,” US 10,058,736 and US 9,802,081. No royalties have been distributed from this patent.

Rios Romenets 2015

Study characteristics

Rios Romenets 2015 *(Continued)*

Methods	Randomized controlled trial Single center **A priori consideration of test power:** No
Participants	**Number of participants (recruited/randomized/evaluated):** 40/33/33 **Country:** Canada **Age (mean in years):** 63.2; 64.3 **Sex (male/female):** 19/14 (57.6% male) **Duration of disease (mean in years):** 5.5; 7.7 **HY (mean):** 1.7; 2.0 **MDS-UPDRS-M (mean):** 20.7; 27.5 **MoCA (mean):** 27.0; 26.7 **Physical capability:** NR **Inclusion criteria:** Idiopathic PD with HY 1 to 3; all participants spoke either English or French sufficiently to fill out questionnaires and understand the instructions for dance classes **Exclusion criteria:** People who could not stand for at least 30 min or walk for ≥3 m without an assistive device; dementia (defined according to MDS dementia criteria); severe hearing and vision problems; change in dopaminergic therapy over the preceding three months; serious medical conditions which precluded dancing or could be worsened by exercise; more than 3 falls in the 12 preceding months (to ensure safety of intervention); other medical conditions which could affect study participation (e.g. drug abuse/alcoholism)
Interventions	**Length of intervention:** 12 weeks **Intervention 1:** Tango [dance]; 60 minutes; 2x/week **Intervention 2:** Wait-list control [passive control group] **Primary setting:** Group **Supervision by (if provided):** Professional tango instructors without expertise in PD
Outcomes	MDS-UPDRS-M; off fluctuations and dyskinesia; Mini-BESTest; TUG; falls questionnaire; FOG-Q; Purdue pegboard test for assessment of upper extremity function; MoCA; BDI; apathy scale; Krupp Fatigue severity scale; PDQ-39; clinical global impression of change; exit questionnaire; adverse events and side effects (cramps, fatigue, falls) **Severity of motor signs assessed during:** on-medication state **Follow-up (maximum time after end of intervention):** 0 (post-intervention)
Notes	**Funding sources:** Parkinson Society of Canada; Fonds de recherché santé Québec **Conflicts of interest:** Dr. Ronald B. Postuma received personal compensation for travel and speaker fees from Novartis Canada and Teva Neurosciences, and is funded by grants from the Fonds de la Recherche en Santé du Québec, the Parkinson Society of Canada, the Webster Foundation, and by the Canadian Institutes of Health Research

Santos 2017a

Study characteristics	
Methods	Randomized controlled trial Multicenter **A priori consideration of test power:** Yes
Participants	**Number of participants (recruited/randomized/evaluated):** 41/28/28 **Country:** Spain **Age (mean in years):** 73.38; 73.8 **Sex (male/female):** 15/13 (53.6% male) **Duration of disease (mean in years):** 10.84; 10.46 **HY (mean):** 1.92; 1.86 **MDS-UPDRS-M (mean):** 7.61; 8.8 **MMSE (mean):** 28.69; 29 **Physical capability:** speed (mm/s): 3.95; 3.97; 10MWT (m/s, preferred rhythm): 0.87; 0.98; 10MWT (m/s, fast rhythm): 1.20; 1.24 **Inclusion criteria:** Diagnosis with akinesia and rigidity subtype PD; HY 1 to 2; no type of dementia as assessed by MMSE; able to stand for 2 min without assistance; able to walk 10 meters without assistance **Exclusion criteria:** Neurological disease other than PD or if they did not meet the eligibility criteria
Interventions	**Length of intervention:** 8 weeks **Intervention 1:** Progressive resistance exercise [strength/resistance training]; 60 to 70 minutes; 2x/week **Intervention 2:** Control group [passive control group] **Primary setting:** Individual **Supervision by (if provided):** Conditioning coaches
Outcomes	Static posturography; 10MWT; FOG-Q; MDS-UPDRS; PDQ-39; 6-20 Borg scale (perceived exertion); adverse events **Severity of motor signs assessed during:** on-medication state **Follow-up (maximum time after end of intervention):** 4 weeks
Notes	**Funding sources:** University of Oviedo **Conflicts of interest:** None

Santos 2017b

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** Yes
Participants	**Number of participants (recruited/randomized/evaluated):** 62/40/40 **Country:** Brazil **Age (mean in years):** 67.0; 68.5 **Sex (male/female):** 18/8 (69.2% male) **Duration of disease (mean in years):** 5.6; 5.4 **HY (mean):** 2.3; 2.3 **UPDRS-M (mean):** 21.7; 21.3 **MMSE (mean):** 27.8; 27.2 **Physical capability:** NR **Inclusion criteria:** Idiopathic PD, HY 1.5 to 3, aged 50 years old or older, able to walk independently, and not enrolled in any other therapeutic program besides medication **Exclusion criteria:** Neurological or musculoskeletal diseases, associated or cognitive disorders that would potentially interfere in the assessment
Interventions	**Length of intervention:** 8 weeks **Intervention 1:** Resistance training [strength/resistance training]; 60 minutes; 2x/week **Intervention 2:** Balance training/neurofunctional training [gait/balance/functional training]; 60 minutes; 2x/week **Primary setting:** Individual **Supervision by (if provided):** Physiotherapist
Outcomes	Center of pressure sway measures in different balance conditions on a force platform, BESTest; UPDRS-M; PDQ-39 **Severity of motor signs assessed during:** on-medication state **Follow-up (maximum time after end of intervention):** 0 (post-intervention)
Notes	**Funding sources:** Universidade Estadual de Londrina **Conflicts of interest:** None

Santos 2017c

Study characteristics	

Santos 2017c *(Continued)*

Methods	Randomized controlled trial Single center **A priori consideration of test power:** No
Participants	**Number of participants (recruited/randomized/evaluated):** NR/22/20 **Country:** Spain **Age (mean in years):** 73.09; 78.09 **Sex (male/female):** 11/11 (50% male) **Duration of disease (mean in years):** 10.72; 10.90 **HY (mean):** 2.18; 1.9 **MDS-UPDRS-M (mean):** 9.72; 9.18 **MMSE (mean):** > 27 **Physical capability:** NR **Inclusion criteria:** Idiopathic PD diagnosis; HY 1 to 3; absence of dementia (MMSE); ability to stand on two feet for ≥ 2 min; ability to walk ≥ 10 meters without assistance **Exclusion criteria:** Previous history of neurological disease; severe dyskinesias or on-off phenomenon; any alteration in the Parkinson's medication regimen
Interventions	**Length of intervention:** 6 weeks **Intervention 1:** Slackline training program [gait/balance/functional training]; 23 minutes; 2x/week **Intervention 2:** Control [passive control group] **Primary setting:** Individual **Supervision by (if provided):** Therapist
Outcomes	Center of pressure; FOG-Q; FES; rate perceived exertion (Borg's 6–20 scale); local muscle perceived exertion **Follow-up (maximum time after end of intervention):** 4 weeks
Notes	**Funding sources:** NR **Conflicts of interest:** None

Santos 2019

Study characteristics	
Methods	Randomized controlled trial Single center

Santos 2019 *(Continued)*

	A priori consideration of test power: Yes
Participants	**Number of participants (recruited/randomized/evaluated):** 66/45/41 **Country:** Brasil **Age (mean in years):** 64.3 **Sex (male/female):** 31/10 (75.6% male) **Duration of disease (mean in years):** 7.1 **HY (mean):** 1.4; 1.3; 1.5 **UPDRS-M (mean):** NR **MMSE (mean):** ≥ 24 (inclusion criteria) **Physical capability:** TUG: 11.5; 10.7; 13.9 **Inclusion criteria:** Participants with PD certified by a neurologist according to the United Kingdom Brain Bank Criteria with moderate motor impairment (stages 1 to 3 on HY scale); between 40 and 80 years of age; ability to walk independently; absence of visual or auditory deficits that impede the performance of activities, as reported by the individual **Exclusion criteria:** Cognitive impairment (< 24 MMSE); other associated neurological dysfunctions; uncontrolled orthopedic or chronic injuries that make it impossible to carry out the proposed activities; participation in other physical interventions
Interventions	**Length of intervention:** 8 weeks **Intervention 1:** Nintendo Wii [gaming]; 50 minutes; 2x/week **Intervention 2:** Conventional exercises [multi-domain training]; 50 minutes; 2x/week **Intervention 3:** Nintendo Wii & conventional Exercises; minutes; 50 minutes; 2x/week **Primary setting:** Individual **Supervision by (if provided):** Physiotherapists
Outcomes	BBS; Dynamic Gait Index; TUG; PDQ-39 **Follow-up (maximum time after end of intervention):** 0 (post-intervention)
Notes	**Funding sources:** Federal University of Bahia **Conflicts of interest:** None

Schaible 2021

Study characteristics	
Methods	Randomized controlled trial Single center

Schaible 2021 *(Continued)*

	A priori consideration of test power: Yes
Participants	**Number of participants (recruited/randomized/evaluated):** 60/44/39 **Country:** Germany **Age (mean in years):** 63.29; 66.20 **Sex (male/female):** 13/16 (44.8% male) **Duration of disease (mean in years):** 5.4; 5.3 **HY (mean):** 2.0; 1.7 **UPDRS-M (mean):** 26.8; 22.6 **MMSE (mean):** 29.1; 28.9 **Physical capability:** Walking velocity (m/s): 1.44; 1.43 **Inclusion criteria:** HY stages 1 to 3, aged between 35 and 80 years, no walking aids, stable medication 4 weeks prior to and during the study **Exclusion criteria:** Dementia (PANDA (Parkinson's Neuropsychometric Dementia Assessment) < 14), depression (BDI > 28), antidepressive or antipsychotic medication, participation in an LSVT BIG therapy in the past year, disabling bradykinesia to ensure participants are able to participate in the intensive physiotherapy (based on clinical impression and in accordance to UPDRS-M Item 14) and prior history of cardiovascular, neurological or musculoskeletal disorders known to interfere with testing PD features
Interventions	**Length of intervention:** 4/8 weeks **Intervention 1:** LSVT BIG [LSVT BIG]; 60 minutes; 4x/week, 4 weeks **Intervention 2:** Intense physiotherapy [multi-domain training]; 60 minutes; 4x/week, 4 weeks **Intervention 3:** Normal physiotherapy; 60 minutes; 2x/week, 8 weeks **Primary setting:** Individual **Supervision by (if provided):** Qualified LSVT BIG therapist; physiotherapists
Outcomes	Non-motor symptom assessment scale for Parkinson's disease; UPDRS-M; chair stand test; force-measuring gangway; PDQ-39; BDI-II; Apathy Evaluation Scale, Parkinson Neuropsychometric Dementia Assessment, MMSE **Severity of motor signs assessed during:** on-medication state **Follow-up (maximum time after end of intervention):** 4 weeks
Notes	**Funding sources:** None **Conflicts of interest:** TVE received grants from the German Research Foundation and honoraria from Lilly Germany. LT received payments as a consultant for Medtronic Inc., Boston Scientific Inc. LT received honoraria as a speaker on symposia sponsored by Bial Inc., Zambon Pharma Inc., UCB Pharma Inc., Desitin Pharma, Medtronic Inc., Boston Scientific Inc., Abbott Inc. CE received payments as a consultant for Abbvie Inc. CE received honoraria as a speaker from Abbvie Inc., Daiichi Sankyo Inc., Bayer Vital Inc. CE received payments as a consultant for Abbvie Inc. and Philyra Inc.

Schenkman 1998

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** Yes
Participants	**Number of participants (recruited/randomized/evaluated):** 147/51/46 **Country:** USA **Age (mean in years):** 70.6; 71.2 **Sex (male/female):** 34/12 (73.9% male) **Duration of disease (mean in years):** NR **HY (range):** 2 to 3 **UPDRS-M (mean):** NR **MMSE (mean):** ≥ 23 (inclusion criteria) **Physical capability:** 6-MIN-W (ft): 1426; 1295, 10MWT (comfortable pace, sec): 9.7; 10.1 **Inclusion criteria:** PD diagnosis from a neurologist; HY 2 to 3; FAR-p (functional axial rotation-physical) ≤ 120 to either side **Exclusion criteria:** Hospitalization within the past 3 months; changes in PD medications within the past month; other neurological disorders; MMSE < 23
Interventions	**Length of intervention:** 10 to 13 weeks **Intervention 1:** Exercise group (moving in a relaxed manner, with the participation of appropriate muscle groups only) [multi-domain training]; 45 to 60 minutes; 3x/week **Intervention 2:** Wait-list control [passive control group] **Primary setting:** Individual **Supervision by (if provided):** Physical therapist
Outcomes	Functional axial rotation; Functional Reach; Supine to stand (sec); Stand to supine (sec); 360° turn test; 6-MIN-W; 10MWT; cervical range of motion; lumbar range of motion; spine configuration; extremity range of motion; turning while standing **Follow-up (maximum time after end of intervention):** 0 (post-intervention)
Notes	**Funding sources:** National Institutes of Aging, National Center for Research Resources **Conflicts of interest:** NR

Schenkman 2012

Study characteristics	
Methods	Randomized controlled trial

Schenkman 2012 *(Continued)*

	Multicenter
	A priori consideration of test power: Yes
Participants	**Number of participants (recruited/randomized/evaluated):** 162/121/96
	Country: USA
	Age (mean in years): 64.5; 63.4; 66.3
	Sex (male/female): 76/45 (62.8% male)
	Duration of disease (mean in years): 4.9; 3.9; 4.5
	HY (range): 1.5 to 3
	UPDRS-M (mean): 23.7
	MMSE (mean): 28.8; 28.3; 28.8
	Physical capability: Continuous Scale–Physical Functional Performance Test: 48.8
	Inclusion criteria:
	PD diagnosis by a movement disorders specialist (UK Brain Bank criteria); HY 1 to 3; living in the community; ambulating independently
	Exclusion criteria:
	Uncontrolled hypertension; on-state freezing or exercise limitations from other disorders; MMSE < 24
Interventions	**Length of intervention:** 16 months
	Intervention 1: Flexibility/balance/function exercise [multi-domain training]; duration not reported; 3x/week
	Intervention 2: Supervised aerobic exercise [endurance training]; 40 to 50 minutes; 3x/week
	Intervention 3: Control (exercises in the home setting); duration not reported; 5x to 7x/week at home; 1x/month supervised
	Primary setting: Group and individual
	Supervision by (if provided): Physical therapist
Outcomes	UPDRS total, UPDRS-M; UPDRS-II; Continuous Scale-Physical Functional Performance score; FRT; oxygen uptake; PDQ-39
	Severity of motor signs assessed during: on-medication state
	Follow-up (maximum time after end of intervention): 0 (post-intervention)
Notes	**Funding sources:** National Institutes of Health, Parkinson's Disease Foundation
	Conflicts of interest: NR

Schenkman 2018

Study characteristics	
Methods	Randomized controlled trial

Schenkman 2018 *(Continued)*

	Multicenter **A priori consideration of test power:** Yes
Participants	**Number of participants (recruited/randomized/evaluated):** 384/128/128 **Country:** USA **Age (mean in years):** 64 **Sex (male/female):** 73/55 (57% male) **Duration of disease (median in years):** 0.3; 0.3; 0.4 (since PD diagnosis) and 1.5; 1.5; 1.4 (duration of symptoms) **HY (range):** 1 to 2 **UPDRS-M (mean):** 17; 16; 17 **MoCA (mean):** 28; 28; 28 **Physical capability:** NR **Inclusion criteria:** Idiopathic PD; aged 40 to 80 years; HY 1 to 2; within 5 years of diagnosis; not exercising at moderate intensity more than 3 times per week, and were not expected to need dopaminergic medication within 6 months **Exclusion criteria:** NR
Interventions	**Length of intervention:** 26 weeks **Intervention 1:** High-intensity exercise (treadmill) [endurance training]; 50 minutes; 4x/week **Intervention 2:** Moderate-intensity exercise (treadmill) [endurance training]; 50 minutes; 4x/week **Intervention 3:** Usual care [passive control group] **Primary setting:** Individual **Supervision by (if provided):** NR
Outcomes	UPDRS; UPDRS-M; adherence to prescribed heart rate and exercise frequency of 3 days per week and safety; maximal aerobic power **Severity of motor signs assessed during:** off-medication state **Follow-up (maximum time after end of intervention):** 0 (post-intervention)
Notes	**Funding sources:** National Institute of Neurologic Disease and Stroke (Drs Schenkman and Corcos) and received additional support from the University of Pittsburgh Clinical and Translational Science Institute (Dr Delitto), the University of Colorado Clinical and Translational Science Award program (Drs Kohrt and Melanson), the Nutrition and Obesity Research Center (Drs Kohrt and Melanson), the National Institutes of Health (Dr Christiansen), and the Parkinson's Disease Foundation (Drs Hall and Comella). **Conflicts of interest:** None

Schilling 2010

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** No
Participants	**Number of participants (recruited/randomized/evaluated):** NR/18/15 **Country:** USA **Age (mean in years):** 61.3; 57.0 **Sex (male/female):** 9/6 (60% male) **Duration of disease (mean in years):** NR **HY (range):** 1.5 to 2.5 **UPDRS-M (mean):** NR **MMSE (mean):** ≥ 24 (inclusion criteria) **Physical capability:** 6-MIN-W (m): 537.7; 468.8 **Inclusion criteria:** Mild to moderate PD; have the ability to walk a 20-foot path, turn, and return to the start without use of an assistive device; not participating in a structured exercise program; primary PD with a HY stage of 1 to 2.5 when in an on-medication state; none were receiving deep-brain stimulation **Exclusion criteria:** Orthostatic hypotension, dementia (MMSE Scores < 24), or other significant comorbidities (i.e. stroke, musculoskeletal problems in the lower extremity)
Interventions	**Length of intervention:** 8 weeks **Intervention 1:** Training group (leg press, seated leg curl, and calf press) [strength/resistance training]; duration not reported; 2x/week **Intervention 2:** Control group [passive control group]; minutes **Primary setting:** Individual **Supervision by (if provided):** Certified strength and conditioning specialist
Outcomes	Leg press strength relative to body mass; TUG; 6-MIN-W; ABC **Follow-up (maximum time after end of intervention):** 0 (post-intervention)
Notes	**Funding sources:** Life Fitness, Inc. **Conflicts of interest:** NR

Schlenstedt 2015

Study characteristics	
Methods	Randomized controlled trial

Schlenstedt 2015 *(Continued)*

	Single center **A priori consideration of test power:** Yes
Participants	**Number of participants (recruited/randomized/evaluated):** 172/40/32 **Country:** Germany **Age (mean in years):** 75.7; 75.7 **Sex (male/female):** 21/11 (65.6% male) **Duration of disease (mean in years):** 10.1; 9.3 **HY (mean):** 2.8; 2.7 **UPDRS-M (mean):** 23.6; 22.3 **MMSE (mean):** 27.3; 27.7 **Physical capability:** Gait velocity (cm/sec): 104.4; 106.9 **Inclusion criteria:** Diagnosed with idiopathic PD; postural instability (Fullerton Advanced Balance scale ≤ 25 points); able to follow exercise instructions (assessed during a pre-examination during which the Fullerton Advanced Balance scale was performed). **Exclusion criteria:** Deep brain stimulation; other diseases that could influence stance and gait performance; participation in a specific resistance training or balance training program (beside usual physical therapy) during the last 6 months; participation in any other medical, behavioral or exercise treatment (additional to the usual received therapeutic treatment) during the study period; unstable medication; cardiopulmonary/metabolic diseases that could interfere with the safe conduct of the study protocol. Cognitive impairments (assessed with MMSE) were not defined as exclusion criteria so that a representative sample of affected participants could be included.
Interventions	**Length of intervention:** 7 weeks **Intervention 1:** Resistance training [strength/resistance training]; 60 minutes; 2x/week **Intervention 2:** Balance training [gait/balance/functional training]; 60 minutes; 2x/week **Primary setting:** Group **Supervision by (if provided):** Sport scientist
Outcomes	Fullerton Advanced Balance scale; TUG; UPDRS; Clinical Global Impression; gait analysis; maximal isometric leg strength, PDQ-39, BDI, center of mass analysis during surface perturbations **Severity of motor signs assessed during:** on-medication state **Follow-up (maximum time after end of intervention):** 5 weeks
Notes	**Funding sources:** Coppenrath-Stiftung, Geeste/Groß-Hesepe, Niedersachsen, Germany; Krumme-Stiftung, Eckernförde, Schleswig-Holstein, Germany **Conflicts of interest:** None

Schmitz-Hubsch 2006

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** Yes
Participants	**Number of participants (recruited/randomized/evaluated):** 96/56/52 **Country:** Germany **Age (mean in years):** 63.8 **Sex (male/female):** 43/13 (76.8% male) **Duration of disease (mean in years):** 5.8 **HY (range):** 1 to 4 **UPDRS-M (mean):** 15.45; 16.9 **MMSE (mean):** ≥ 24 (inclusion criteria) **Physical capability:** NR **Inclusion criteria:** PD diagnosis (UK brain bank criteria); HY: all stages; with or without motor complications **Exclusion criteria:** Previous practical experience with Qigong; recent (≤ 1 month) or planned change of medication; signs of central nervous system disease other than PD; MMSE < 24
Interventions	**Length of intervention:** 16 (2 x 8 weeks - pause in between) **Intervention 1:** Qigong [mind-body training]; 60 minutes; 1x/week (except during 8 weeks' break) **Intervention 2:** Control group [passive control group] **Primary setting:** Group **Supervision by (if provided):** Experienced teacher
Outcomes	UPDRS-M; PDQ-39; Montgomery-Asberg Depression Rating Scale; structured interview for assessment of depressive symptoms in PD patients; structured interview to assess the presence of non-motor symptoms (sleep disturbance, daytime sleepiness, dizziness, urinary dysfunction, sexual dysfunction, constipation, loss of appetite, or nausea and pain) **Severity of motor signs assessed during:** on-medication state **Follow-up (maximum time after end of intervention):** 24 weeks
Notes	**Funding sources:** German Parkinson's patients' organization (dPV) **Conflicts of interest:** NR

Sedaghati 2016

Study characteristics	

Sedaghati 2016 *(Continued)*

Methods	Randomized controlled trial Unclear if single center or multicenter **A priori consideration of test power:** Yes
Participants	**Number of participants (recruited/randomized/evaluated):** 47/44/41 **Country:** Iran **Age (mean in years):** 59.13; 58.77; 57.22 **Sex (male/female):** 30/14 (68.2% male) **Duration of disease (mean in years):** 4.9; 5.2; 4.9 **HY (mean):** 2.53; 2.57; 2.6 **UPDRS-M (mean):** NR **MMSE (mean):** 27.0; 26.7; 26.4 **Physical capability:** TUG: 13.53; 14.23; 13.26 **Inclusion criteria:** Diagnosis of idiopathic PD for three years; being able to walk independently; aged between 50 and 70 years; consumed the same anti-Parkinsonian medication for past 2 weeks; history of falling in the past year **Exclusion criteria:** Significant cognitive impairment (MMSE < 24); other neurological/musculoskeletal/ cardiopulmonary/metabolic conditions that would interfere with safe conduction of training or exercise program
Interventions	**Length of intervention:** 10 weeks **Intervention 1:** Exercise group with balance pad [gait/balance/functional training]; 60 minutes; 3x/week **Intervention 2:** Exercise group without balance pad [gait/balance/functional training]; 60 minutes; 3x/week **Intervention 3:** Control group [passive control group] **Primary setting:** Group **Supervision by (if provided):** NR
Outcomes	Number of falls; FES-I; BBS; TUG **Follow-up (maximum time after end of intervention):** 0 (post-intervention)
Notes	**Funding sources:** NR **Conflicts of interest:** NR

Shahmohammadi 2017

Study characteristics

Shahmohammadi 2017 *(Continued)*

Methods	Randomized controlled trial Single center **A priori consideration of test power:** Yes
Participants	**Number of participants (recruited/randomized/evaluated):** 27/22/20 **Country:** Iran **Age (mean in years):** 60.5; 63.2 **Sex (male/female):** 22/0 (100% male) **Duration of disease (mean in years):** NR **HY (range):** 2 to 3 **UPDRS-M (mean):** 22.5 **MMSE (mean):** > 24 (inclusion criteria) **Physical capability:** NR **Inclusion criteria:** Males with PD; stage 2 or 3 according to HY; no signs of dementia (MMSE > 24) **Exclusion criteria:** History of fracture or have had orthopedic surgery within the last year
Interventions	**Length of intervention:** 8 weeks **Intervention 1:** Aquatic exercise [aqua-based training]; 60 minutes; 3x/week **Intervention 2:** Land exercise [gait/balance/functional training]; 60 minutes; 3x/week **Primary setting:** Individual **Supervision by (if provided):** Expert physical trainer
Outcomes	Postural sway (force plate); PDQ-L **Follow-up (maximum time after end of intervention):** 0 (post-intervention)
Notes	**Funding sources:** None **Conflicts of interest:** None

Shanahan 2017

Study characteristics	
Methods	Randomized controlled trial Multicenter **A priori consideration of test power:** Yes
Participants	**Number of participants (recruited/randomized/evaluated):** 99/90/41

Shanahan 2017 *(Continued)*

	Country: Republic of Ireland **Age (mean in years):** 69; 69 **Sex (male/female):** 26/15 (63.4% male) **Duration of disease (mean in years):** 5.5; 6 **HY (mean):** 1.25; 2.0 **UPDRS-M (mean):** NR **MMSE (mean):** NR **Physical capability:** NR **Inclusion criteria:** Diagnosis of idiopathic PD, stages 1 to 2.5 on the MHY scale. They were able to walk 3 meters unaided and had a DVD player to enable participation in the home dance program. **Exclusion criteria:** Serious cardiovascular/pulmonary condition, neurological deficit other than PD, evidence of a musculoskeletal problem, issues contraindicating participation in exercise, or a cognitive or hearing problem which affected their ability to follow instructions or hear music; attendance of regular dance classes in the six months prior to the trial
Interventions	**Length of intervention:** 10 weeks **Intervention 1:** Irish set dancing [dance]; 90 minutes; 1x/week **Intervention 2:** Control group [passive control group] **Primary setting:** Group **Supervision by (if provided):** Dancing teachers who were also clinicians or experienced teaching clinical populations
Outcomes	UPDRS-M, 6-MIN-W, Mini-BESTest, PDQ-39; feasibility **Follow-up (maximum time after end of intervention):** 0 (post-intervention)
Notes	**Funding sources:** John and Pauline Ryan Postgraduate Scholarship; and the Mid-Western Branch of the Irish Society of Chartered Physiotherapists Research Bursary **Conflicts of interest:** NR

Shen 2021

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** No
Participants	**Number of participants (recruited/randomized/evaluated):** 121/32/30 **Country:** China

Shen 2021 *(Continued)*

	Age (mean in years): 68.67; 66.93 **Sex (male/female):** 20/10 (66.7% male) **Duration of disease (mean in years):** 6.27; 7.0 **HY (mean):** 1.86; 2.2 **UPDRS-M (mean):** 26.67; 18.0 **MMSE (mean):** ≥ 24 (inclusion criteria) **Physical capability:** TUG: 12.52; 12.80 **Inclusion criteria:** Clinical diagnosis of PD, aged between 55 and 80 years, and with a disease severity from mild to moderate level (rating from 1 to 3 out 5) according to the HY scale; drug treatment is stable; can walk independently or with the aid of walkers **Exclusion criteria:** Currently involved in any behavioural or pharmacological intervention study or instructor-led exercise training program; serious organic diseases (heart disease, hypertension, tuberculosis, nephritis, etc.) in the past two years; history of alcoholism, smoking, and visual or hearing impairment; an MMSE score lower than 24 and deep brain stimulation surgery
Interventions	**Length of intervention:** 12 weeks **Intervention 1:** Wuqinxi Exercise (coordination of body movements, breathing and mind, loosening the limbs, and relaxing the spirit) [mind-body training]; 90 minutes; 2x/week **Intervention 2:** Stretching [flexibility training]; 90 minutes; 2x/week **Primary setting:** Group **Supervision by (if provided):** Professional trainer; coach
Outcomes	Frontal assessment battery; Stroop test; MoCA; UPDRS-M; TUG **Severity of motor signs assessed during:** on-medication state **Follow-up (maximum time after end of intervention):** 0 (post-intervention)
Notes	**Funding sources:** Outstanding Clinical Discipline Project of Shanghai Pudong and Shanghai Science Popularization Project **Conflicts of interest:** None

Shulman 2013

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** Yes
Participants	**Number of participants (recruited/randomized/evaluated):** 945/80/67 **Country:** USA

Shulman 2013 *(Continued)*

	Age (mean in years): 65.8 **Sex (male/female):** 50/17 (74.6% male) **Duration of disease (mean in years):** 6.2 **HY (mean):** 2.2 **UPDRS-M (mean):** 32.1 **MMSE (mean):** 27.4 **Physical capability:** 6-MIN-W (ft): 1374.2; 1446.7; 1395.5 **Inclusion criteria:** PD diagnosis (asymmetrical onset of at least 2 of 3 cardinal signs (resting tremor, bradykinesia, or rigidity); no atypical signs or exposure to dopamine-blocking drugs; HY 1 to 3 (on-medication state for motor fluctuators); mild to moderate gait or balance impairment (UPDRS-gait/UPDRS-postural stability = 1 to 2; ≥ 40 years; MMSE ≥ 23 **Exclusion criteria:** Unstable medical/psychiatric comorbidities; orthopedic conditions restricting exercise; performance of > 20 minutes of aerobic exercise > 3x/week (to avoid prior training effect)
Interventions	**Length of intervention:** 3 months **Intervention 1:** Higher-intensity treadmill training [gait/balance/functional training]; 15 to 30 minutes; 3x/week **Intervention 2:** Lower-intensity treadmill training [gait/balance/functional training]; 15 to 50 minutes; 3x/week **Intervention 3:** Stretching and resistance training [multi-domain training]; duration not reported; 3x/week **Primary setting:** Group **Supervision by (if provided):** Exercise physiologists
Outcomes	UPDRS-total; UPDRS-M; TUG; BDI; PD Fatigue Scale; PDQ-39-Summary Index; FES; Schwab and England ADL scale; number of steps per day; 6-MIN-W; 10MWT (comfortable pace, fast pace); 50-foot walk (fast pace); peak oxygen consumption per unit time; muscle strength (1-repetition maximum strength) **Severity of motor signs assessed during:** on-medication state **Follow-up (maximum time after end of intervention):** 0 (post-intervention)
Notes	**Funding sources:** Michael J. Fox Foundation for Parkinson's Research **Conflicts of interest:** Dr Shulman serves as Editor-in-Chief of the American Academy of Neurology's Neurology Now Patient Book Series, receives royalties from Johns Hopkins University Press, and receives research support from the National Institutes of Health (NIH; grant U01AR057967-01), the Michael J. Fox Foundation, Teva Pharmaceuticals, and the Rosalyn Newman Foundation. Dr Katzel serves as site visitor for the Association for the Accreditation of Human Research Protection Programs and receives research support from NIH grants P30 AG028747-01, K30HL04518, 1R01HL095136-01, RO1 AG034161, and RO1 DK090401-01A1, the Department of Veterans Affairs (VA), and the Michael J Fox Foundation. Dr Ivey receives government research support through VA Rehabilitation Research and Development on 2 VA Merit Awards. Dr Sorkin receives research support from the Baltimore VA Medical Center Geriatric Research Educational and Clinical Center, the Claude D. Pepper Older Americans Independence Center (grant 5T32AG000219-18), and the Michael J. Fox Foundation. Dr Anderson receives research support from the Department of VA (merit grant E7158R) and the Michael J. Fox Foundation and is a consultant for Guidepoint Global, HD Drug-works, the Huntington's Disease Society of Ameri-

Shulman 2013 *(Continued)*

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Silva 2019

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** Yes
Participants	**Number of participants (recruited/randomized/evaluated):** 36/28/25 **Country:** Brazil **Age (mean in years):** 63.12; 64.23 **Sex (male/female):** 11/14 (44% male) **Duration of disease (mean in years):** NR **HY (mean):** 3; 3 **UPDRS-M (mean):** 17.53; 16.45 **MMSE (mean):** NR **Physical capability:** TUG: 15.69; 14.33 **Inclusion criteria:** Clinical diagnosis of idiopathic PD, stages 1 to 4 in the HY scale and had a medical certificate to perform aquatic exercises and to use a heated swimming pool **Exclusion criteria:** Did not present independent gait (whether or not this was related to PD); diagnosed with another disease that could interfere in the physical assessments (for example, people with body balance alterations of vestibular origin); visual or auditory impairment; unable to follow verbal and visual instructions (determined by MMSE); contraindications to use a heated swimming pool, such as fever, incontinence, severe blood pressure change, and open wounds; presented alterations in the parameters of medication intake, based on levodopa, during the study period; or did not agree with the informed consent terms
Interventions	**Length of intervention:** 10 weeks **Intervention 1:** Dual task aquatic exercises [aqua-based training]; 60 minutes; 2x/week **Intervention 2:** Control group [passive control group] **Primary setting:** Group

Silva 2019 *(Continued)*

	Supervision by (if provided): NR
Outcomes	TUG; FTSTS; balance; BBS; Dynamic Gait Index **Follow-up (maximum time after end of intervention):** 3 months
Notes	**Funding sources:** Brazilian Coordination for the Improvement of Higher Education Personnel (CAPES). The authors would like to thank the Pontificia Universidad Catolica for yielding the heated swimming pool and the Academic Publishing Advisory Center (Centro de Assessoria de Publicação Acadêmica, CAPA - www.capa.ufpr.br) of the Federal University of Paraná for assistance with English language editing. **Conflicts of interest:** None

Silva-Batista 2018

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** No
Participants	**Number of participants (recruited/randomized/evaluated):** 91/39/39 **Country:** Brazil **Age (mean in years):** 64.1; 64.2; 64.2 **Sex (male/female):** 29/10 (74.4% male) **Duration of disease (mean in years):** 9.6; 10.5; 10.7 **HY (mean):** 2.5; 2.5; 2.5 **UPDRS-M (mean):** 43.7; 45.1; 43.4 **MMSE (mean):** 28.5; 28.8; 28.5 **Physical capability:** TUG (s) 9.4; 9.5; 9.2 **Inclusion criteria:** Diagnosis of idiopathic PD, HY 2 to 3, stable use of medication, 50 to 80 years of age, not participating in structured physical training in the last 3 years, not presenting neurological disorders other than PD, significant arthritis, and cardiovascular disease, and not having a MMSE score < 23 **Exclusion criteria:** NR
Interventions	**Length of intervention:** 12 weeks **Intervention 1:** Resistance training [strength/resistance training]; 50 minutes; 2x/week **Intervention 2:** Resistance training instability (with increase in load/resistance and degree of instability of the exercises) [strength/resistance training]; 50 minutes; 2x/week **Intervention 3:** Control group [passive control group] **Primary setting:** Individual

Silva-Batista 2018 *(Continued)*

	Supervision by (if provided): Investigators
Outcomes	BESTest; MoCA; overall stability index; FES-I; neuromuscular outcomes: quadriceps muscle cross-sectional area, root mean square and mean spike frequency of electromyographic signal, peak torque, rate of torque development, and half relaxation time of the knee extensors and plantarflexors during maximum ballistic voluntary isometric contractions; Total Training Volume calculated for lower limb exercises **Follow-up (maximum time after end of intervention):** 0 (post-intervention)
Notes	**Funding sources:** Associacao Brasil Parkinson (ABP), Fundacao de Amparo a Pesquisa do Estado de Sao Paulo (FAPESP), Coordenacao de Aperfeicoamento de Pessoal de Nivel Superior (CAPES), Conselho Nacional de Desenvolvimento Cientifico e Tecnologico (CNPQ), Premio Pemberton Coca-Cola, Diagnosticos das Americas S/A (DASA), and Center for Psychobiology and Exercise Studies. **Conflicts of interest:** None

Silveira 2018

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** No
Participants	**Number of participants (recruited/randomized/evaluated):** 311/76/58 **Country:** Canada **Age (mean in years):** 70.63; 69.76; 67.60 **Sex (male/female):** 41/16 (71.9% male) **Duration of disease (mean in years):** 5.95; 6.09; 5.60 **HY (mean):** NR **UPDRS-M (mean):** 25.38; 27.64; 21.76 **MoCA (mean):** 25.22; 24.57; 25.80 **Physical capability:** NR **Inclusion criteria:** Confirmed diagnosis of idiopathic PD by a neurologist **Exclusion criteria:** History of neurological diseases other than PD; uncontrolled diabetes; uncontrolled hypertension; history of cardiovascular disease; history of chronic obstructive pulmonary disease; uncorrected visual impairments
Interventions	**Length of intervention:** 12 weeks **Intervention 1:** Aerobic training [endurance training]; 60 minutes; 3x/week

Silveira 2018 *(Continued)*

	Intervention 2: Goal-based training (walking exercises coordinating upper and lower limbs, non-progressive muscle-toning exercises, whole body stretching exercises) [multi-domain training]; 60 minutes; 3x/week **Intervention 3:** Control group [passive control group] **Primary setting:** Group **Supervision by (if provided):** NR
Outcomes	Digit Span (forward and backward), Corsi Block test; executive functions: TMT, Stroop test; Short-form of the California Verbal Learning Test, Rey-Osterrieth Complex Figure Test (immediate recall, and delayed recall); verbal fluency tasks (phonemic and semantic), Short-form of the Boston Naming Test; Intersecting Pentagons, Benton Line Orientation Test; oxygen uptake peak at test termination **Follow-up (maximum time after end of intervention):** 0 (post-intervention)
Notes	**Funding sources:** National Council for Scientific and Technological Development CNPq/Brazil; Canada Foundation for Innovation; Natural Sciences and Engineering Research Council of Canada **Conflicts of interest:** None

Smania 2010

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** Yes
Participants	**Number of participants (recruited/randomized/evaluated):** 130/64/55 **Country:** Italy **Age (mean in years):** 67.6; 67.3 **Sex (male/female):** 29/26 (52.7% male) **Duration of disease (mean in years):** 10.4; 8.6 **HY (mean):** 3.0; 3.1 **UPDRS-M (mean):** NR **MMSE (mean):** > 23 (inclusion criteria) **Physical capability:** Number of falls within one month: 4.6; 46.1 **Inclusion criteria:** Idiopathic PD and postural instability; HY stage 3 to 4; all participants were outpatients, did not require assistance to rise from chairs or beds, not affected by unstable cardiovascular disease or other chronic conditions that could interfere with their safety during testing or training procedures; no other neurological conditions or mental deterioration (MMSE > 23); no severe dyskinesias or on-off phases **Exclusion criteria:** NR
Interventions	**Length of intervention:** 7 weeks

Smania 2010 *(Continued)*

	Intervention 1: Balance training [gait/balance/functional training]; 50 minutes; 3x/week **Intervention 2:** Control training (active joint mobilization, muscle stretching, and motor coordination exercises) [multi-domain training]; 50 minutes; 3x/week **Primary setting:** Individual **Supervision by (if provided):** Physiotherapist
Outcomes	BBS; ABC; postural transfer test, self-destabilization of the center of foot pressure test, number of falls, UPDRS, modified HY; Geriatric Depression Scale **Severity of motor signs assessed during:** on-medication state **Follow-up (maximum time after end of intervention):** 1 month
Notes	**Funding sources:** None **Conflicts of interest:** None

Solla 2019

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** Yes
Participants	**Number of participants (recruited/randomized/evaluated):** 36/20/19 **Country:** Italy **Age (mean in years):** 67.4 **Sex (male/female):** 13/7 (65% male) **Duration of disease (mean in years):** 4.4; 5.0 **HY (mean):** 2.1; 2.3 **UPDRS-M (mean):** 13.0; 14.7 **MMSE (mean):** ≥ 24 (inclusion criteria) **Physical capability:** 6-MIN-W (m): 330.7; 333.3 **Inclusion criteria:** Clinical diagnosis of PD; a score ≤ 3 on the HY scale, ability to walk without walking aids, stable medication regimen in the 4 weeks before the study, and a score ≥ 24 on the MMSE **Exclusion criteria:** HY stage > 3, diagnosis of dementia according to Diagnostic and Statistical Manual of Mental Disorders 5 criteria, atypical parkinsonism, pharmacologic treatment with drugs not approved for PD, the presence of any complementary disability or autonomic problems that precluded the training program, or any specific health condition for which exercise was contraindicated. A history of falls in the previous 3-month period, as well as the presence of dyskinesias, freezing, and static–dynamic postural instability, was also verified before enrollment.

Solla 2019 *(Continued)*

Interventions	**Length of intervention:** 12 weeks **Intervention 1:** Sardinian folk dance [dance]; 90 minutes; 2x/week **Intervention 2:** Control group [passive control group] **Primary setting:** Group **Supervision by (if provided):** Physiotherapist assisted by two APA specialists; Sardinian folk dance teacher
Outcomes	UPDRS-M; 6-MIN-W; BBS; TUG; FTSTS; Back Scratch Test; sit and reach test; instrumented gait analysis; Parkinson's Disease Fatigue Scale; BDI; Starkstein Apathy Scale; MoCA **Severity of motor signs assessed during:** on-medication state **Follow-up (maximum time after end of intervention):** 0 (post-intervention)
Notes	**Funding sources:** Fondazione Banco di Sardegna **Conflicts of interest:** None

Sparrow 2016

Study characteristics	
Methods	Randomized controlled trial with cross-over after 3 months Single center **A priori consideration of test power:** No
Participants	**Number of participants (recruited/randomized/evaluated):** 58/23/16 **Country:** USA **Age (mean in years):** 66.7 **Sex (male/female):** 10/6 (62.5% male) **Duration of disease (mean in years):** 4.3 **HY (range):** 2 to 3 **MDS-UPDRS-M (mean):** 36.0 **MMSE (mean):** > 25 (inclusion criteria) **Physical capability:** NR **Inclusion criteria:** Diagnosis of idiopathic PD; HY 2 to 3 in the on-medication state; on a stable dose of PD medications for 2 weeks prior to enrollment; experienced 1 fall in the past 3 months and 2 falls in the past year; were able to walk without physical assistance or an assistive device for at least 5 continuous minutes **Exclusion criteria:** Diagnosis of atypical Parkinsonism; MMSE < 26; previous surgical management of PD, or serious comorbidities that may interfere with ability to participate in the exercise program

Sparrow 2016 *(Continued)*

Interventions	**Length of intervention:** 3 months **Intervention 1:** Balance group [gait/balance/functional training]; 90 minutes; 3x/week **Intervention 2:** Control group [passive control group] **Primary setting:** Group **Supervision by (if provided):** Physical therapists with expertise in PD
Outcomes	Falls; Mini-BESTest; FES-I; ABC; 6-MIN-W; FOG; UPDRS; PDQ-39; Beck Anxiety Inventory; Penn State Worry Questionnaire; Anxiety Sensitivity Index; changes in Social Phobia Inventory; changes in Social Interaction Anxiety Scale **Follow-up (maximum time after end of intervention):** 12 weeks
Notes	**Funding sources:** Boston University Charles River Campus **Conflicts of interest:** None

Stack 2012

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** No
Participants	**Number of participants (recruited/randomized/evaluated):** 47/47/35 **Country:** UK **Age (median in years):** 74.0 **Sex (male/female):** 35/12 (74.5% male) **Duration of disease (median in years):** 7.0 **HY (range):** 1 to 4 **UPDRS-M (mean):** NR **MMSE (mean):** NR **Physical capability:** 12-month fall history: 6; 6 (single fall)/14; 10 (repeated falls) **Inclusion criteria:** Diagnosis of PD, stages 1 to 4: stage 1 indicating mild unilateral symptoms; stage 2, bilateral symptoms without balance impairment; stage 3, postural instability but independently mobile; stage 4, severe PD although able to stand and walk with assistance; fulfilling the UKPDS Brain Bank diagnostic criteria; self-reported chair transfers as being excessively slow and/or requiring much effort, assistance, or repeated attempts and/or associated with a previous fall; scored at least 8/12 on the Middlesex Elderly Assessment of Mental State; were willing and able to undertake all aspects of the intervention; were willing and able to complete the outcome measures (albeit with help from another person in completing questionnaires, if handwriting was problematic **Exclusion criteria:**

Stack 2012 *(Continued)*

	NR
Interventions	**Length of intervention:** 4 weeks **Intervention 1:** Home-based physiotherapy [gait/balance/functional training]; up to 60 minutes; 3x/week **Intervention 2:** Control group [passive control group] **Primary setting:** Individual **Supervision by (if provided):** Physiotherapist
Outcomes	Sit to stand test; Parkinson's Activity Scale chair transfer; UPDRS posture; 15D instrument of health-related quality of life; Standing-start 180 degree turn test; PD Self-Assessed Disability Scale **Follow-up (maximum time after end of intervention):** 8 weeks
Notes	**Funding sources:** Parkinson's UK **Conflicts of interest:** NR

Stozek 2016

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** No
Participants	**Number of participants (recruited/randomized/evaluated):** NR/64/61 **Country:** Poland **Age (mean in years):** 64.0; 67.0 **Sex (male/female):** 29/32 (47.5% male) **Duration of disease (mean in years):** 4.6; 4.3 **HY (mean):** 2.3; 2.3 **UPDRS-M (mean):** 19.7; 23.2 **MMSE (mean):** NR **Physical capability:** 10-meter walk test (at normal preferred speed): 10.52; 13.11 **Inclusion criteria:** PD diagnosis (UK PD Society Brain Bank criteria); HY 1.5 to 3.0; unchanged pharmacological treatment for ≥ 3 months preceding study **Exclusion criteria:** Severe gait disability with inability to walk unassisted; neurological, vascular or systemic disorders that may have caused permanent or intermittent weakness or instability; severe hepatic or renal insufficiency, cancer, a history of orthopedic hip or knee surgery which led to gait difficulties; other chronic disor-

Stozek 2016 *(Continued)*

	ders of the musculoskeletal system leading to restricted mobility; all other contraindications to exercise
Interventions	**Length of intervention:** 4 weeks **Intervention 1:** Rehabilitation group [gait/balance/functional training]; 120 minutes; 11x/week (first two weeks); 3x/week (last two weeks) **Intervention 2:** Control [passive control group] **Primary setting:** Group **Supervision by (if provided):** NR
Outcomes	Pastor test (shoulder tug); Tandem stance; 10-meter walk at preferred speed; 360° turn; Physical Performance Test; timed motor activities; range of spinal rotation **Follow-up (maximum time after end of intervention):** 1 month
Notes	**Funding sources:** NR **Conflicts of interest:** None

Sujatha 2019

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** No
Participants	**Number of participants (recruited/randomized/evaluated):** 12/10/10 **Country:** India **Age (mean in years):** NR **Sex (male/female):** NR **Duration of disease (mean in years):** NR **HY (mean):** NR **UPDRS-M (mean):** NR **MMSE (mean):** NR **Physical capability:** NR **Inclusion criteria:** NR **Exclusion criteria:** Cardiovascular diseases and other orthopedic conditions
Interventions	**Length of intervention:** 12 weeks **Intervention 1:** Endurance exercise [endurance training]; 20 to 45 minutes; 3x/week

Sujatha 2019 *(Continued)*

	Intervention 2: Stretch-balance training [multi-domain training]; 20 to 45 minutes; 3x/week
	Primary setting: Group
	Supervision by (if provided): NR
Outcomes	"HADS-D"; Digit-Symbol-Task
	Follow-up (maximum time after end of intervention): 0 (post-intervention)
Notes	**Funding sources:** NR
	Conflicts of interest: NR

Szefler-Derela 2020

Study characteristics	
Methods	Randomized controlled trial
	Single center
	A priori consideration of test power: No
Participants	**Number of participants (recruited/randomized/evaluated):** 40/40/40
	Country: Poland
	Age (median in years): 64
	Sex (male/female): 20/20 (50% male)
	Duration of disease (median in years): 6.0
	HY (range): 2 to 3
	UPDRS-M (median): 21.0; 24.0
	MMSE (mean): ≥ 24 (inclusion criteria)
	Physical capability: TUG median: 7.09; 7.49
	Inclusion criteria:
	Idiopathic PD (typical clinical presentation, good response to levodopa, and a full differential diagnosis, also involving neuroimaging techniques, diagnosed according to the UK Parkinson's Disease Society Brain Bank clinical diagnostic criteria and HY disease stages 2 to 3, selected from an outpatients' database in our center
	Exclusion criteria:
	People with dementia (MMSE < 24), severe motor fluctuations, freezing, orthostatic hypotension, disabling dyskinesia, severe depression, or other medical conditions significantly affecting mobility or ability to exercise were excluded
Interventions	**Length of intervention:** 6 weeks
	Intervention 1: Nordic walking [endurance training]; 90 minutes; 2x/week
	Intervention 2: Standard rehabilitation [multi-domain training]; 45 minutes; 2x/week
	Primary setting: Group and individual

Szefler-Derela 2020 *(Continued)*

	Supervision by (if provided): Physiotherapist with qualification in Nordic walking; physiotherapist
Outcomes	UPDRS-M; Dynamic Gait Index; TUG; PDQ-39 **Follow-up (maximum time after end of intervention):** 0 (post-intervention)
Notes	**Funding sources:** None **Conflicts of interest:** MA is an employee of Novartis

Szymura 2020

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** No
Participants	**Number of participants (recruited/randomized/evaluated):** NR/NR/29 **Country:** Poland **Age (mean in years):** 65.69 **Sex (male/female):** 19/10 (65.5% male) **Duration of disease (mean in years):** NR **HY (range):** 2 to 3 **UPDRS-M (mean):** NR **MMSE (mean):** ≥ 25 (inclusion criteria) **Physical capability:** NR **Inclusion criteria:** The inclusion criteria for participants with PD were age ≥ 60 years, diagnosis of idiopathic PD (HY stage between 2 and 3), no changes regarding the applied pharmacotherapy in the month preceding the test, no orthopaedic conditions limiting physical exercise or deep brain stimulation surgery, independent gait, and physical fitness enabling participation in the training program. Inclusion criteria for healthy older people were age ≥ 60 years, no medication affecting the functioning of central nervous system (e.g. neuroleptics, antidepressants), no neurological or orthopedic disorders limiting physical exercise, independent gait and physical fitness allowing participation in the training program **Exclusion criteria:** Exclusion criteria were lack of informed consent to participate in the study, musculoskeletal injuries (e.g. fractures and prostheses), diabetes, diagnosed dementia (MMSE < 25), previous stroke or severe traumatic brain injury, other CNS diseases and participation in regular physical exercises
Interventions	**Length of intervention:** 12 weeks **Intervention 1:** PD balance training [gait/balance/functional training]; 30 to 60 minutes; 3x/week **Intervention 2:** Non-training PD group [passive control group] **Intervention 3:** Healthy people balance training; 30 to 60 minutes; 3x/week

Szymura 2020 *(Continued)*

	Intervention 4: Healthy non-training group **Primary setting:** Individual **Supervision by (if provided):** Physiotherapist
Outcomes	Performance-Oriented Mobility Assessment (Tinetti Performance-Oriented Mobility Assessment); concentration of selected cytokines, neutrophic factors and CD200 proteins as well as fractalkine **Follow-up (maximum time after end of intervention):** 2 days
Notes	**Funding sources:** National Science Centre, Poland **Conflicts of interest:** None

Taheri 2011

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** No
Participants	**Number of participants (recruited/randomized/evaluated):** NR/24/24 **Country:** Iran **Age (mean in years):** 62.5 **Sex (male/female):** 12/12 (50% male) **Duration of disease (mean in years):** NR **HY (mean):** 3 (inclusion criteria) **UPDRS-M (mean):** NR **MMSE (mean):** NR **Physical capability:** NR **Inclusion criteria:** Idiopathic PD; HY stage 3; perform daily tasks independently; avoidance of secondary complications such as cardiovascular disease, osteoarthritis, or cognitive impairment; participants did not engage in exercise or physical therapy at the time of the study **Exclusion criteria:** If a person did not participate in training programs on a regular basis, he or she would be excluded from the study
Interventions	**Length of intervention:** 10 weeks **Intervention 1:** Stretching group [flexibility training]; 60 minutes; 4x/week **Intervention 2:** Control group [passive control group] **Primary setting:** NR

Taheri 2011 *(Continued)*

	Supervision by (if provided): NR
Outcomes	BBS; Tinetti scale; Gait balance scale **Follow-up (maximum time after end of intervention):** 0 (post-intervention)
Notes	**Funding sources:** NR **Conflicts of interest:** NR **Language:** Persian

Terrens 2020

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** No
Participants	**Number of participants (recruited/randomized/evaluated):** 208/59/30 **Country:** Australia **Age (mean in years):** 72.0 **Sex (male/female):** 24/6 (80% male) **Duration of disease (mean in years):** 5.5 **HY (median):** 3 **UPDRS-M (median):** 50.5 **MMSE (mean):** 27.5 **Physical capability:** Number of falls in past 12 months: 0; 3; 1 (single fall)/ 6; 2; 4 (≥ 2 falls) **Inclusion criteria:** Participants were required to have a diagnosis of idiopathic PD confirmed by a neurologist, transfer and walk without assistance with or without gait aid (as participants are required to independently transfer in and out of the pool via steps), and have a MMSE score of 24 or above so that they can follow instructions **Exclusion criteria:** Those with unstable medical conditions or a self-reported history of any musculoskeletal, cardiothoracic, other neurological or psychological condition that might potentially affect participation were excluded.
Interventions	**Length of intervention:** 12 weeks **Intervention 1:** Halliwick Aquatic exercises (core-specific exercises and exercises from the Halliwick concept) [aqua-based training]; 60 minutes; 1x/week **Intervention 2:** Traditional aquatic exercise [aqua-based training]; 60 minutes; 1x/week **Intervention 3:** Land-based exercise [multi-domain training]; 60 minutes; 1x/week

Terrens 2020 *(Continued)*

	Primary setting: Group
	Supervision by (if provided): Physiotherapist and allied health assistant experienced in treating people with PD
Outcomes	Falls; adverse events; UPDRS-M; BBS; Mini-BESTest; fear of falling measured by FES
	Severity of motor signs assessed during: on-medication state
	Follow-up (maximum time after end of intervention): 1 week
Notes	**Funding sources:** Lee Silverman Voice Treatment (LSVT)
	Conflicts of interest: NR

Tollar 2018

Study characteristics	
Methods	Randomized controlled trial
	Single center
	A priori consideration of test power: Yes
Participants	**Number of participants (recruited/randomized/evaluated):** 88/74/74
	Country: Hungary
	Age (mean in years): 70; 70.6; 67.5
	Sex (male/female): 36/38 (48.6% male)
	Duration of disease (mean in years): 7.5; 7.5; 7.3
	HY (mean): 2.3; 2.4; 2.4
	UPDRS-M (mean): 18.2; 18.9; 19.0
	MMSE (mean): ≥ 24 (inclusion criteria)
	Physical capability: 6-MIN-W (m): 204.6; 222.4; 270.2
	Inclusion criteria:
	PD diagnosis (UK Brain Bank criteria); HY 2 to 3; neurologically and pharmacologically stable condition for ≥ 6 months; presence of mobility, balance, and postural problems
	Exclusion criteria:
	MMSE < 24; BDI score > 40; severe cardiac disease; uncontrolled diabetes; a history of stroke; traumatic brain injury; a seizure disorder; deep brain stimulator; ongoing orthopedic surgeries; pacemaker; hemophilia; clinically significant motor fluctuations; LD-induced dyskinesia; current participation in a self-directed or formal group exercise program
Interventions	**Length of intervention:** 5 weeks
	Intervention 1: Agility exergaming [gait/balance/functional training]; 60 minutes; 5x/week
	Intervention 2: Stationary cycling [endurance training]; 60 minutes; 5x/week
	Intervention 3: Wait-list control [passive control group]

Tollar 2018 *(Continued)*

	Primary setting: Group **Supervision by (if provided):** Physical therapists
Outcomes	UPDRS-II; PDQ-39; BDI; Schwab and England ADL scale; EQ-5D; BBS; BESTest; Tinetti Assessment Tool; Dynamic Gait Index; 6-MIN-W; standing posturography **Follow-up (maximum time after end of intervention):** 0 (post-intervention)
Notes	**Funding sources:** Department of Neurology, Somogy County Kaposi Mór Teaching Hospital **Conflicts of interest:** None

Tollar 2019

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** Yes
Participants	**Number of participants (recruited/randomized/evaluated):** 72/55/46 **Country:** Hungary **Age (mean in years):** 67.6 **Sex (male/female):** 29/26 (52.7% male) **Duration of disease (mean in years):** 6.8 **HY (mean):** 2.4 **UPDRS-M (mean):** NR **MMSE (mean):** ≥ 24 (inclusion criteria) **Physical capability:** TUG (s): 17.00 **Inclusion criteria:** PD patients; HY 2 to 3; mobility difficulty and postural instability based on a qualitative assessment of gait and postural stability, turns, rigidity, interjoint coordination, trunk posture, and equilibrium while participants walked forward, backwards, and sideways **Exclusion criteria:** Brain abnormalities based on a diagnostic MRI, MMSE < 24, a BDI score > 40, severe cardiac disease, uncontrolled diabetes, a history of stroke, traumatic brain injury, seizure disorder, past or current deep brain stimulation, or current participation in a self-directed or formal group exercise program
Interventions	**Length of intervention:** 3 weeks/2 years **Intervention 1:** Exercise group (sensorimotor and visuomotor agility training, X-box virtual reality exergame) [multi-domain training]; 60 minutes; 5x/week; 3 weeks **Intervention 2:** Exercise and maintenance group (same exercises as intervention 1 with longer duration) [multi-domain training]; 60 minutes; 3x/week; 2 years **Intervention 3:** Control group [passive control group]

Tollar 2019 *(Continued)*

	Primary setting: Group
	Supervision by (if provided): Therapists
Outcomes	MDS-UPDRS-M, MDS-UPDRS-II; Schwab and England ADL; EQ-5D; PDQ-39; BDI; TUG; postural stability by the magnitude of sway measured on a force platform
	Follow-up (maximum time after end of intervention): 24 months
Notes	**Funding sources:** Somogy Megyei Kaposi Mór Teaching Hospital
	Conflicts of interest: None

Toole 2000

Study characteristics	
Methods	Randomized controlled trial
	Single center
	A priori consideration of test power: No
Participants	**Number of participants (recruited/randomized/evaluated):** 11/11/7
	Country: USA
	Age (mean in years): 71.7
	Sex (male/female): 4/3 (57.1% male)
	Duration of disease (mean in years): NR
	HY (range): 1 to 3
	UPDRS-M (mean): NR
	MMSE (mean): NR
	Physical capability: NR
	Inclusion criteria:
	Parkinsonism, stage 1 to 4 (later stage 4 was eliminated for group-stage consistency; so only stages 1 to 3 were included)
	Exclusion criteria:
	Medical problems (radiation treatment for melanoma, depression, and eye surgery)
Interventions	**Length of intervention:** 10 weeks
	Intervention 1: Treatment group (resistance and balance exercises) [multi-domain training]; 60 minutes; 3x/week
	Intervention 2: Control group [passive control group]
	Primary setting: Group
	Supervision by (if provided): NR

Toole 2000 *(Continued)*

Outcomes	Computerized dynamic posturography; Biodex (peak torque, ankle inversion, knee extension, knee flexion) **Follow-up (maximum time after end of intervention):** 0 (post-intervention)
Notes	**Funding sources:** This project was supported, in part, by a grant to Tonya Toole, PhD and Charles G. Maitland, MD from the Neuroscience Center of the Tallahassee Memorial Regional Medical Center, Tallahassee, FL. **Conflicts of interest:** NR

Van Puymbroeck 2018

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** No
Participants	**Number of participants (recruited/randomized/evaluated):** 111/30/27 **Country:** USA **Age (mean in years):** 67.7 **Sex (male/female):** 17/10 (63% male) **Duration of disease (mean in years):** NR **MHY (range):** 1.5 to 3 **UPDRS-M (mean):** 28.27; 31.58 **Short MMSE (mean):** ≥ 4 (inclusion criteria) **Physical capability:** Functional Gait Assessment: 14.93; 15.83 **Inclusion criteria:** Diagnosis of PD; 1.5 to 3 on the MHY Scale of Parkinson's Disease Progression; endorse a fear of falling; be able to stand and walk 10 meters with or without an assistive device; be ≥ 18 years old; be able to speak English; score ≥ 4 out of 6 on the short MMSE; and be able and willing to attend twice weekly sessions for 8 weeks **Exclusion criteria:** Self-reported life expectancy < 12 months; identified an inability to attend sessions due to transportation issues; were currently receiving physical therapy or enrolled in an intervention study; or were unable or refused to provide informed consent
Interventions	**Length of intervention:** 8 weeks **Intervention 1:** Yoga [mind-body training]; duration not reported; 2x/week **Intervention 2:** Wait-list control [passive control group] **Primary setting:** Group **Supervision by (if provided):** Certified yoga therapist

Van Puymbroeck 2018 *(Continued)*

Outcomes	Functional Gait Assessment; FOG-Q; Mini-BESTest; MHY; MDS-UPDRS-M **Severity of motor signs assessed during:** NR **Follow-up (maximum time after end of intervention):** 0 (post-intervention)
Notes	**Funding sources:** College of Health, Education, and Human Development at Clemson University **Conflicts of interest:** None

Vergara-Diaz 2018

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** Yes
Participants	**Number of participants (recruited/randomized/evaluated):** 98/32/27 **Country:** USA **Age (mean in years):** 63.8 **Sex (male/female):** 16/16 (50% male) **Duration of disease (mean in years):** 2.9 **HY (range):** 2 to 2.5 **UPDRS-M (mean):** 23.5 **MMSE (mean):** NR **Physical capability:** TUG: 9.69; 9.72 **Inclusion criteria:** Diagnosed with idiopathic PD (< 10 years) and had limited disease progression (MHY stages 1 to 2.5); 40 to 75 years of age; and willing to undergo baseline and follow-up testing while off PD-related medication for 12 hours **Exclusion criteria:** Diagnosis of atypical parkinsonism; history of major neurological or psychiatric disease, orthopedic impairment, or other disease that could likely contribute to a gait disturbance; any severe, chronic condition or acute medical event for which participation in exercise programs was contraindicated; history of deep brain stimulation or other brain surgery; or significant tai chi experience (> 6 months training in past 2 years).
Interventions	**Length of intervention:** 6 months **Intervention 1:** Tai chi [mind-body training]; 60 minutes; 2x/week + 1x/week at home **Intervention 2:** Control group [passive control group] **Primary setting:** Group **Supervision by (if provided):** Instructors

Vergara-Diaz 2018 *(Continued)*

Outcomes	UPDRS; PDQ-39; TUG; TMT; ABC; feasibility (recruitment rate, adherence, and compliance); change in dual-task gait stride-time variability **Severity of motor signs assessed during:** off-medication state **Follow-up (maximum time after end of intervention):** 0 (post-intervention)
Notes	**Funding sources:** Harvard University Faculty of Medicine **Conflicts of interest:** PMW is the founder and sole owner of the Tree of Life Tai Chi Center. PMW's interests were reviewed and managed by the Brigham and Women's Hospital and Partner's HealthCare in accordance with their conflict of interest policies. The other authors have no conflicts of interest to declare.

Vivas 2011

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** No
Participants	**Number of participants (recruited/randomized/evaluated):** 15/12/11 **Country:** Spain **Age (mean in years):** 67.0 **Sex (male/female):** 7/5 (58.3% male) **Duration of disease (mean in years):** 4.2; 7.8 **HY (mean):** 2.7; 2.4 **UPDRS-M (mean):** NR **MMSE (mean):** 27.8; 27.5 **Physical capability:** NR **Inclusion criteria:** Idiopathic PD; ability to follow a stable medication schedule; to be in PD stages 2 or 3 according to the HY Scale while in the off-medication state; and lack of dementia (MMSE ≥ 24) **Exclusion criteria:** Unable to walk independently or had undergone surgical treatment for PD
Interventions	**Length of intervention:** 4 weeks **Intervention 1:** Water-based therapy (trunk mobility exercises, postural stability, transferring oneself and changing body position) [aqua-based training]; 45 minutes; 2x/week **Intervention 2:** Land-based therapy (trunk mobility exercises, postural stability, transferring oneself and changing body position) [multi-domain training]; 45 minutes; 2x/week **Primary setting:** Individual

Vivas 2011 *(Continued)*

	Supervision by (if provided): Physiotherapist
Outcomes	UPDRS (total); TUG; BBS; FRT; Gait analysis **Follow-up (maximum time after end of intervention):** 17 days
Notes	**Funding sources:** Programme Alban, the European Union Programme of High Level Scholarships for Latin America, Consellería de Educación, and Conselleria de Industria Xunta de Galicia **Conflicts of interest:** None

Volpe 2013

Study characteristics	
Methods	Randomized controlled trial Single-center **A priori consideration of test power:** No
Participants	**Number of participants (recruited/randomized/evaluated):** NR/24/NR **Country:** Italy **Age (mean in years):** 61.6; 65.0 **Sex (male/female):** 13/11 (54.2% male) **Duration of disease (mean in years):** 9.0; 8.9 **HY (mean):** 2.2; 2.2 **UPDRS-M (mean):** 24.58; 23.92 **MMSE (mean):** 26.5; 26.3 **Physical capability:** NR **Inclusion criteria:** Idiopathic Parkinson's disease as diagnosed by a medical practitioner and were rated level 0 to 2.5 on the MHY scale; mild to moderately severe PD for safety reasons as people at stage 3 or more on the HY scale have a high risk of falls **Exclusion criteria:** Did not speak Italian; had comorbidities that prevented dancing, mobility, or safe exercise; deep brain stimulation surgery; unable to travel to the dancing or physiotherapy venues
Interventions	**Length of intervention:** 6 months **Intervention 1:** Irish set dancing group [dance]; 90 minutes (dance class); 60 minutes (at home); 1x/week (dance class); 2x/week (at home) **Intervention 2:** Standard physiotherapy [multi-domain training]; 90 minutes (physiotherapy); 60 minutes (at home); 1x/week (physiotherapy); 1x/week (at home) **Primary setting:** Group and individual **Supervision by (if provided):** Dancing teachers

Volpe 2013 *(Continued)*

Outcomes	UPDRS-M, BBS, FOG-Q, PDQ-39, TUG **Severity of motor signs assessed during:** NR **Follow-up (maximum time after end of intervention):** 3 weeks
Notes	**Funding sources:** NR **Conflicts of interest:** None

Volpe 2014

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** Yes
Participants	**Number of participants (recruited/randomized/evaluated):** 40/34/34 **Country:** Italy **Age (mean in years):** 68; 66 **Sex (male/female):** NR **Duration of disease (mean in years):** 7.5; 7.6 **HY (mean):** 2.82; 2.65 **UPDRS-M (mean):** 41.9; 39.2 **MMSE (mean):** ≥ 25 (inclusion criteria) **Physical capability:** TUG (s): 13.1; 12.8 **Inclusion criteria:** Diagnosis of 'clinically probable' idiopathic Parkinson's disease; HY stage 2.5 and 3; ability to walk without any assistance; at least two falls in the last year; MMSE ≥ 25; no relevant comorbidity or vestibular/visual dysfunctions, limiting locomotion or balance; stable dopaminergic therapy in the last four weeks **Exclusion criteria:** History of deep brain stimulation surgery and other conditions limiting hydrotherapy (for example, cardiopulmonary disease)
Interventions	**Length of intervention:** 2 months **Intervention 1:** Hydrotherapy [aqua-based training]; 60 minutes; 5x/week **Intervention 2:** Land-based rehabilitation (balance exercises) [gait/balance/functional training]; 60 minutes; 5x/week **Primary setting:** NR **Supervision by (if provided):** NR

Volpe 2014 *(Continued)*

Outcomes	Centre of pressure sway area; in the antero-posterior and medio-lateral directions with open/closed eyes; UPDRS-II; UPDRS-M; BBS; TUG; ABC; falls; FES; PDQ-39 **Severity of motor signs assessed during:** on-medication state **Follow-up (maximum time after end of intervention):** 1 week
Notes	**Funding sources:** None **Conflicts of interest:** None

Volpe 2017a

Study characteristics	
Methods	Randomized controlled trial Multicenter **A priori consideration of test power:** No
Participants	**Number of participants (recruited/randomized/evaluated):** 41/30/24 **Country:** Italy **Age (mean in years):** 70.6; 70.0 **Sex (male/female):** 19/11 (63.3% male) **Duration of disease (mean in years):** 9.4; 9.0 **HY (mean):** 2.6; 2.7 **UPDRS-M (mean):** 41.1; 45.2 **MMSE (mean):** 26.5; 26.6 **Physical capability:** TUG (s): 12.9; 14.8 **Inclusion criteria:** Diagnosis of idiopathic Parkinson's disease (according to the United Kingdom Parkinson's Disease Society Brain Bank criteria); HY stage ≤ 3; MMSE > 2; flexion (in the sagittal plane) of the thoraco-lumbar spine with an almost complete resolution in the supine position, and/or lateral flexion (in the coronal plane) that could be almost completely alleviated by passive mobilization or supine positioning, ability to attend physiotherapy **Exclusion criteria:** Fixed postural deformities (ankylosing spondylitis, vertebral fractures, idiopathic or degenerative scoliosis), in the presence of major depression (diagnosed by means of Diagnostic and Statistical Manual of Mental Disorders criteria), if they were implanted for deep brain stimulation, in case of severe comorbidities (cardiac, pulmonary or orthopedic diseases) or urinary incontinence
Interventions	**Length of intervention:** 8 weeks **Intervention 1:** Water-based physiotherapy [aqua-based training]; 60 minutes; 5x/week **Intervention 2:** Non-water-based physiotherapy [multi-domain training]; 60 minutes; 5x/week **Primary setting:** NR

Volpe 2017a *(Continued)*

	Supervision by (if provided): Physiotherapists
Outcomes	Body Analysis Kapture; shoulder symmetry; pelvic symmetry; UPDRS-M; BBS; ABC; TUG; FES; PDQ-39; Likert pain scale **Severity of motor signs assessed during:** on-medication state **Follow-up (maximum time after end of intervention):** 8 weeks
Notes	**Funding sources:** None **Conflicts of interest:** None

Volpe 2017b

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** No
Participants	**Number of participants (recruited/randomized/evaluated):** 40/22/22 **Country:** Italy **Age (mean in years):** 69.1; 78.4 **Sex (male/female):** 13/9 (59.1% male) **Duration of disease (mean in years):** NR **HY (mean):** 2.5; 2.4 **UPDRS-M (mean):** 25.6; 26.5 **MMSE (mean):** NR **Physical capability:** 6-MIN-W (m): 315.8; 310.7 **Inclusion criteria:** Participants were eligible for inclusion if they consented to participation, had PD diagnosed according to the current criteria; HY stage 3 on levodopa, and no history of falls in the past **Exclusion criteria:** Presence of important freezing of gait affecting gait analysis recording, dyskinesias and peripheral neuropathy, presence of co-morbidities preventing mobility (orthopedic diseases) or safe exercise (including major medical conditions such as malignancies), history of deep brain stimulation surgery or other conditions affecting stability (e.g. poor visual acuity or vestibular dysfunction), HY ≥4 on levodopa, and inability to travel to the physiotherapy venues
Interventions	**Length of intervention:** 3 weeks **Intervention 1:** Hydrotherapy ("PDS2-UW") [aqua-based training]; 40 minutes; 7x/week **Intervention 2:** Land-based walking ("PDS1-LBW") [gait/balance/functional training]; 40 minutes; 7x/week **Intervention 3:** Hydrotherapy ("PDS1-UW"); 40 minutes; 7x/week

Volpe 2017b *(Continued)*

	Intervention 4: Control group hydrotherapy ("CS1"); 40 minutes; 7x/week
	Intervention 5: Control group land-based walking ("CS2-LBW"); 40 minutes; 7x/week
	Primary setting: NR
	Supervision by (if provided): Physiotherapists with license of lifeguard
Outcomes	UPDRS-M; 6-MIN-W; TUG; BBS; PDQ-39
	Severity of motor signs assessed during: NR
	Follow-up (maximum time after end of intervention): 0 (post-intervention)
Notes	**Funding sources:** NR
	Conflicts of interest: NR

Wan 2021

Study characteristics	
Methods	Randomized controlled trial
	Single center
	A priori consideration of test power: No
Participants	**Number of participants (recruited/randomized/evaluated):** 52/52/40
	Country: China
	Age (mean in years): 64.95; 67.03
	Sex (male/female): 19/21 (47.5% male)
	Duration of disease (mean in years): 3.63; 3.25
	HY (range): 1 to 4
	UPDRS-M (mean): NR
	MMSE (mean): NR
	Physical capability: TUG: 11.47; 11.77
	Inclusion criteria:
	No obvious cognitive or mobility impairment, and no auxiliary equipment required for activities; aged 40 to 85 years; HY scale score 1 to 4; UPDRS-M: at least one limb score of tremor, stiffness, posture stability, or slow movement items ≥ 2 points; stable medication doses; and medical clearance to participate in the experiment
	Exclusion criteria:
	History of non-Parkinson's neurological impairments; currently participation in other behavioral or pharmacological studies or coach-guided exercise programs; mental status score of fewer than 24 points; physical weakness, impaired vision, or inability to understand the test content
Interventions	**Length of intervention:** 12 weeks
	Intervention 1: Health Qigong [mind-body training]; 60 minutes; 4x/week

Wan 2021 *(Continued)*

	Intervention 2: Control group [passive control group]
	Primary setting: Group
	Supervision by (if provided): Professional Health Qigong coach
Outcomes	Reaction time; one-legged blind balance test; TUG; normal speed-walking; fast speed-walking; sit and reach test; knee flexion; hip flexion; hip extension; shoulder joint
	Follow-up (maximum time after end of intervention): 0 (post-intervention)
Notes	**Funding sources:** Beijing Sport University International cooperation topics
	Conflicts of interest: Dr Zhirong Wan reports grants from Beijing Sport University, during the conduct of the study. Dr Xiaolei Liu reports grants from Beijing Sport University, during the conduct of the study. Professor Hui Yang reports grants from Beijing Sport University, during the conduct of the study. Miss Fang Li reports grants from Beijing Sport University, during the conduct of the study. Miss Lei Li reports grants from Beijing Sport University, during the conduct of the study. Professor Yulin Wang reports grants from Beijing Sport University, during the conduct of the study. Dr Hao Jiang reports grants from Beijing Sport University, during the conduct of the study. Prof. Dr. Jichen Du reports grants from Beijing Sport University, during the conduct of the study. The authors report no other conflicts of interest in this work.

Wang 2017

Study characteristics	
Methods	Randomized controlled trial
	Single center
	A priori consideration of test power: No
Participants	**Number of participants (recruited/randomized/evaluated):** NR/40/40
	Country: China
	Age (mean in years): 63.4; 64.45
	Sex (male/female): 26/14 (65% male)
	Duration of disease (mean in years): 3.8; 4.3
	HY (mean): 1.93; 2.00
	UPDRS-M (mean): 26.75; 29.95
	MMSE (mean): 27.85; 28.05
	Physical capability: 6-MIN-W (m): 178.35; 183.55
	Inclusion criteria:
	The diagnostic criteria were developed by the Parkinson's Disease and Movement Disorders Section of the Chinese Medical Association Neurological Society in 2006; HY grade 1 to 3; aged 55 to 75 years; disease duration ≥ 1 year; educational level of junior high school and above; MMSE score ≥ 24; no cognitive impairment; possess regular rehabilitation training and water exercise training conditions, i.e. stable vital signs, good blood pressure control, able to walk with support
	Exclusion criteria:

Wang 2017 *(Continued)*

	Non-primary Parkinson's disease, such as trauma, poisoning, and vascular disease as causes of Parkinson's syndrome; presence of contraindications to aquatic exercise training, such as cardiac and renal dysfunction, tumors, extreme physical disability, and bleeding tendencies; presence of other neurological diseases
Interventions	**Length of intervention:** 8 weeks **Intervention 1:** Aquatic exercise training [aqua-based training]; 50 minutes; 5x/week **Intervention 2:** Regular land-based rehabilitation training (walking, mat training, Bobath ball training, balance board training, land platform training) [gait/balance/functional training]; 50 minutes; 5x/week **Primary setting:** NR **Supervision by (if provided):** Rehabilitation therapist
Outcomes	UPDRS-M; BBS; TUG; 6-MIN-W, 10MWT **Severity of motor signs assessed during:** NR **Follow-up (maximum time after end of intervention):** 0 (post-intervention)
Notes	**Funding sources:** NR **Conflicts of interest:** NR **Language:** Chinese

Winward 2012

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** No
Participants	**Number of participants (recruited/randomized/evaluated):** NR/39/39 **Country:** UK **Age (mean in years):** 64.1 **Sex (male/female):** 31/8 (79.5% male) **Duration of disease (mean in years):** 5.79 **HY (range):** 0 to 4 **UPDRS-M (mean):** NR **MMSE (mean):** NR **Physical capability:** 2-MIN-W (m): 134.1 **Inclusion criteria:** PD diagnosis; ≥ 18 years; ability to use an exercise facility or gym; walk 10 meters; HY 0 to 4; participate for the duration of the study **Exclusion criteria:**

Winward 2012 *(Continued)*

	Unable to meet the study criteria; any contraindications to exercise
Interventions	**Length of intervention:** 12 weeks **Intervention 1:** Gym-based exercise group (aerobic, cardiovascular fitness, strength, flexibility) [multi-domain training]; 30 to 45 minutes; 5x/week **Intervention 2:** Wait-list control [passive control group] **Primary setting:** Group **Supervision by (if provided):** NR
Outcomes	PASE; Parkinson's Disease Questionnaire Summary Index; 2-MIN-W; Fatigue Severity Scale **Follow-up (maximum time after end of intervention):** 0 (post-intervention)
Notes	**Funding sources:** Long-term Neurological Conditions, Department of Health, UK; Thames Valley Primary Care Trust; National Institute for Health Research; Parkinson's Disease Society; and the University of Birmingham, UK **Conflicts of interest:** None

Wong-Yu 2015

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** Yes
Participants	**Number of participants (recruited/randomized/evaluated):** 144/84/80 **Country:** China **Age (mean in years):** 59.4; 62.6 **Sex (male/female):** 46/34 (57.5% male) **Duration of disease (mean in years):** 7.1; 5.6 **HY (mean):** 2.5; 2.4 **MDS-UPDRS-M (mean):** 26.9; 31.3 **MMSE (mean):** ≥ 25 (inclusion criteria) **Physical capability:** PASE score: 102.4; 97.7, gait speed(m/s): 1.19; 1.17 **Inclusion criteria:** Diagnosed with PD, aged 30 years or over, had no falls or only one fall in the past six months, were stable on anti-Parkinsonian medications and could walk independently for 30 meters with or without an assistive device **Exclusion criteria:** Neurological conditions other than PD, any history of neurosurgery, significant musculoskeletal or cardiopulmonary diseases, disorders that might affect balance or locomotion, communication or cogni-

Wong-Yu 2015 *(Continued)*

	tive deficits with MMSE < 24, or had joined any structured exercise programme in the previous three months
Interventions	**Length of intervention:** 8 weeks **Intervention 1:** Balance group [gait/balance/functional training]; 120 minutes; 1x/week + 3x/week at home **Intervention 2:** Control group (upper limb training) [active control group]; 120 minutes; 1x/week + 3x/week at home **Primary setting:** Group **Supervision by (if provided):** Physiotherapist and an assistant who had attended a trainers' program
Outcomes	BESTest; gait speed; TUG; dual-task TUG; ABC; fall-related outcomes **Follow-up (maximum time after end of intervention):** 12 months
Notes	**Funding sources:** Hong Kong Parkinson's Disease Foundation **Conflicts of interest:** None

Yang 2010

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** Yes
Participants	**Number of participants (recruited/randomized/evaluated):** 64/33/30 **Country:** Taiwan **Age (mean in years):** 68.07; 66.27 **Sex (male/female):** 16/14 (53.3% male) **Duration of disease (mean in years):** 4.77; 5.27 **HY (mean):** 2.23; 2.17 **UPDRS-M (mean):** NR **MMSE (mean):** NR **Physical capability:** Walking speed (cm/sec): 88.75; 79.81 **Inclusion criteria:** Idiopathic PD (as defined by the UK Brain Bank criteria) diagnosed by a neurologist; HY 1 to 3; ability to walk independently; stable medication usage; freedom from any other problems that might affect training; ability to understand instructions and follow commands **Exclusion criteria:** NR
Interventions	**Length of intervention:** 4 weeks

Yang 2010 *(Continued)*

	Intervention 1: Downhill walking [gait/balance/functional training]; 30 minutes; 3x/week **Intervention 2:** Conventional therapy (flexibility exercises, strengthening exercises, proprioceptive neuromuscular facilitation, coordinating training, balance training, overground walking training) [multi-domain training]; 30 minutes; 3x/week **Primary setting:** Individual **Supervision by (if provided):** Physical therapist
Outcomes	Gait parameters measured with the "GAITRite" system, including walking speed, cadence, stride length; thoracic kyphosis measured with an electronic goniometer; muscle strength evaluated using a hand-held dynamometer **Follow-up (maximum time after end of intervention):** 1 month
Notes	**Funding sources:** Mackay Memorial Hospital **Conflicts of interest:** None

Yen 2011

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** Yes
Participants	**Number of participants (recruited/randomized/evaluated):** 67/42/38 **Country:** Taiwan **Age (mean in years):** 70.4; 70.1; 71.6 **Sex (male/female):** 33/9 (78.6% male) **Duration of disease (mean in years):** 6.0; 6.1; 7.8 **HY (mean):** 2.6; 2.4; 2.6 **UPDRS-M (mean):** 15.1; 15.9; 16.8 **MMSE (mean):** 28.5; 28.5; 28.1 **Physical capability:** NR **Inclusion criteria:** Idiopathic PD, intact cognition (MMSE score > 24), HY 2 to 3, previous lack of participation in balance or gait training, and able to follow simple commands and having no uncontrolled chronic diseases **Exclusion criteria:** History of other neurological, cardiovascular, or orthopedic diseases affecting postural stability and on-off motor fluctuation and dyskinesia above grade 3 on the UPDRS
Interventions	**Length of intervention:** 6 weeks **Intervention 1:** Virtual reality balance training (VR balance board) [gait/balance/functional training]; 30 minutes; 2x/week

Yen 2011 *(Continued)*

	Intervention 2: Conventional balance training [gait/balance/functional training]; 30 minutes; 2x/week
	Intervention 3: Control [passive control group]
	Primary setting: Individual
	Supervision by (if provided): Physical therapist
Outcomes	Equilibrium scores, sensory ratios, and verbal reaction times
	Follow-up (maximum time after end of intervention): 4 weeks
Notes	**Funding sources:** National Taiwan University Hospital
	Conflicts of interest: NR

Youm 2020

Study characteristics	
Methods	Randomized controlled trial
	Single center
	A priori consideration of test power: Yes
Participants	**Number of participants (recruited/randomized/evaluated):** 23/23/17
	Country: Korea
	Age (mean in years): 68.0; 72.1
	Sex (male/female): 10/7 (58.8% male)
	Duration of disease (mean in years): 6.4; 8.0
	HY (mean): 2.40; 2.29
	UPDRS-M (mean): 40.35; 44.43
	MMSE (mean): 26.60; 27.60
	Physical capability: 30-second sit to stand test (repetitions): 15.3; 13.9
	Inclusion criteria:
	Diagnosis of idiopathic PD, a HY stage of 1 through 3, treatment with dopaminergic medications, and a MMSE score of greater than 24 points
	Exclusion criteria:
	History of orthopedic, neurosurgical, or neurological issues within the preceding six months
Interventions	**Length of intervention:** 12 weeks
	Intervention 1: Exercise group (progressive trunk resistance and stretching exercise program) [multi-domain training]; 60 to 90 minutes; 3x/week
	Intervention 2: Control group [passive control group]
	Primary setting: Group

Youm 2020 *(Continued)*

	Supervision by (if provided): not specified ("with guidance")
Outcomes	MMSE; UPDRS-total; UPDRS-M; HY; 30-second sit to to stand test; "2 min step"; 2.44 m TUG; arm curl; chair sit and reach test; back scratch; trunk mobility scale; First and Second Step Phase for Sit-to-Walk-Test (step time, step length, step speed, toe clearance height) **Severity of motor signs assessed during:** on-medication state **Follow-up (maximum time after end of intervention):** 0 (post-intervention)
Notes	**Funding sources:** Dong-A University research funds **Conflicts of interest:** None

Yuan 2020

Study characteristics	
Methods	Randomized controlled trial with cross-over after 6 weeks of intervention and 6 weeks wash-out Single center **A priori consideration of test power:** No
Participants	**Number of participants (recruited/randomized/evaluated):** NR/24/24 **Country:** Taiwan **Age (mean in years):** 67.8; 66.5 **Sex (male/female):** 11/13 (45.8% male) **Duration of disease (mean in years):** NR **HY (range):** 1 to 3 **UPDRS-M (mean):** NR **MMSE (mean):** 28.5; 26.0 **Physical capability:** Number of falls in the past year: 0; 4 **Inclusion criteria:** Aged 60 to 80 years; clinical diagnosis of idiopathic mild to moderate PD of HY stage 1 to 3; independent community-living ambulatory individuals; and cognitive level as assessed by the MMSE score > 23 **Exclusion criteria:** History of dementia, previous stroke, arthritis, vision impairment, diabetes, or uremia; previous engagement in any exergaming training program or commercial exergaming system within 6 months; and inability to walk without assistance or the presence of cardiovascular disease that impaired walking
Interventions	**Length of intervention:** 6 weeks **Intervention 1:** Interactive video-game-based training [gait/balance/functional training]; 30 minutes; 3x/week **Intervention 2:** Control group [passive control group] **Primary setting:** Individual

Yuan 2020 *(Continued)*

	Supervision by (if provided): Certified physical therapist
Outcomes	BBS; SF-36; Modified FES; Multi-Directional Reach Test, and Maximum Step Length test **Follow-up (maximum time after end of intervention):** 0 (post-intervention)
Notes	**Funding sources:** Ministry of Science and Technology and the Higher Education Sprout Project by the Ministry of Education in Taiwan **Conflicts of interest:** None

Zhang 2015

Study characteristics	
Methods	Randomized controlled trial Single center **A priori consideration of test power:** No
Participants	**Number of participants (recruited/randomized/evaluated):** 109/40/40 **Country:** China **Age (mean in years):** 66.0; 64.4 **Sex (male/female):** 24/16 (60% male) **Duration of disease (mean in years):** 6.8; 4.9 **HY (range):** 1 to 3 **UPDRS-M (mean):** 18.5; 15.2 **MMSE (mean):** 27.4; 26.4 **Physical capability:** Gait velocity (cm/s): 106.0; 119.9 **Inclusion criteria:** Idiopathic PD, HY 1 to 4, complete the 10-meter walking test and TUG with or without an assistive device; stable medication use; UPDRS-M ≥ 2; willing to be assigned to any of the two interventions **Exclusion criteria:** Participating in any other behavioral or pharmacologic study; MMSE < 24, MMSE < 17 for people who had not gone to school; MMSE < 20 for people who had informal literacy training or elementary education; other neurologic/musculoskeletal/cardiopulmonary/metabolic conditions that would impede full participation in the study
Interventions	**Length of intervention:** 12 weeks **Intervention 1:** Tai chi [mind-body training]; 60 minutes; 2x/week **Intervention 2:** Multimodal exercise training (core muscle training, crossing obstacle training, standing on ankle joint correcting board, cycle ergometer) [multi-domain training]; 60 minutes; 2x/week **Primary setting:** Group **Supervision by (if provided):** Rehabilitation trainer

Zhang 2015 *(Continued)*

Outcomes	BBS; UPDRS-M; TUG; stride length; gait velocity **Severity of motor signs assessed during:** on-medication state **Follow-up (maximum time after end of intervention):** 0 (post-intervention)
Notes	**Funding sources:** National Major Scientific and Technological Special Project for BSignificant New Drugs Development; National Natural Science Foundation of China; Shanghai Education Development Foundation and Shanghai Municipal Education Commission BShuguang Program and the Shanghai Science and Technology Commission **Conflicts of interest:** None

Zhu 2011

Study characteristics	
Methods	Randomized controlled trial Multicenter **A priori consideration of test power:** No
Participants	**Number of participants (recruited/randomized/evaluated):** NR/40/38 **Country:** China **Age (mean in years):** 63.35; 64.83 **Sex (male/female):** 23/17 (57.5% male) **Duration of disease (mean in years):** 2.72; 2.78 **HY (range):** 1 to 2 **UPDRS-M (mean):** 17.74; 17.79 **MMSE (mean):** NR **Physical capability:** NR **Inclusion criteria:** Primary Parkinson's disease; 40 to 85 years old; course of disease is less than 3 years, and the revised HY stage is 1 to 2; voluntary cooperation in treatment **Exclusion criteria:** Various secondary Parkinson's syndrome and Parkinson's superposition syndrome; concurrent schizophrenia or other severe psychosis; serious organic damage to heart, liver, kidney and other organs; accompanied by other serious central system diseases; mid-term interruption of treatment for reasons other than curative effect; forced termination of treatment due to adverse reactions; delayed follow-up visit or lost to follow-up, unable to judge the curative effect or incomplete data affecting the curative effect; do not follow the design scheme; the dosage of drugs taken during the treatment exceeds 10%; the total number of training sessions is less than 70%, or the time and intensity of each training session is less than 70% of the training requirements.
Interventions	**Length of intervention:** 4 weeks **Intervention 1:** Tai chi practice [mind-body training]; 30 to 45 minutes; 2x/day; 5x/week

Zhu 2011 *(Continued)*

	Intervention 2: Walk exercise [gait/balance/functional training]; at least 40 minutes; 2x/day; 5x/week
	Primary setting: NR
	Supervision by (if provided): Coach Hua Liang, a national Wuying level athlete & Dong Qing, a national Taijiquan first-level athlete; Li Jianxing and Li Ning provided home training for some participants
Outcomes	UPDRS-M; BBS
	Severity of motor signs assessed during: NR
	Follow-up (maximum time after end of intervention): 0 (post-intervention)
Notes	**Funding sources:** NR
	Conflicts of interest: NR
	Language: Chinese

We display the categories used for inclusion in the analysis in square brackets. Labels in square brackets are not displayed for arms that we did not include in the analysis.
ABC: Activities-specific Balance Confidence; **ADL:** activities of daily living; **BBS:** Berg Balance Scale; **BDI:** Beck Depression Inventory; **BESTest:** Balance Evaluation Systems Test; **CNS:** central nervous system; **CT:** computed tomography; **EQ-5D:** EuroQol 5 Dimensions; **FES:** Falls Efficacy Scale; **FES-I:** Falls Efficacy Scale International; **FTSTS**: Five-Times-Sit-To-Stand; **FoG:** freezing of gait; **FOG-Q:** Freezing of Gait Questionnaire; **FRT:** Functional Reach Test; **HY:** Hoehn and Yahr scale; **iPD:** idiopathic Parkinson's disease; **MDS:** Movement Disorder Society; **MDS-UPDRS-I:** Movement Disorder Society Unified Parkinson's Disease Rating Scale/Part 1 (mentation, behavior and mood); **MDS-UPDRS-II:** Movement Disorder Society Unified Parkinson's Disease Rating Scale/Part 2 (activities of daily living); **MDS-UPDRS-M:** Movement Disorder Society Unified Parkinson Disease Rating Scale/Motor Score; **MHY:** Modified Hoehn and Yahr scale; **min:** minute;**Mini-BESTest:** Mini-Balance Evaluation Systems Test; **MMSE:** Mini Mental State Examination; **MoCA:** Montreal Cognitive Assessment; **MRI:** magnetic resonance imaging; **N-FOG-Q:** New Freezing of Gait Questionnaire; **NR:** not reported; **QoL:** quality of life; **PASE:** Physical Activity Scale for the Elderly; **PDQ-8:** Parkinson's Disease Questionnaire 8; **PDQ-39:** Parkinson's Disease Questionnaire 39; **PDQ-L:** Parkinson's Disease Quality of Life Questionnaire; **ROM:** range of motion; **SF-8/SF-12:** Short-Form Health Survey - 8-item/12-item questionnaire; **SF-36:** Short-Form Health Survey - 36-item questionnaire; **2-MIN-W:** 2-minute walk test; **6-MIN-W:** 6-minute walk test; **10MWT:** 10-meter walk test; **TMT:** Trail Making Test; **TUG:** Timed up and go; **UPDRS-I:** Unified Parkinson's Disease Rating Scale/Part 1 (mentation, behavior and mood); **UPDRS-II:** Unified Parkinson's Disease Rating Scale/Part 2 (activities of daily living); **UPDRS-M:** Unified Parkinson's Disease Rating Scale/Motor Score

Characteristics of excluded studies *[ordered by study ID]*

Study	Reason for exclusion
Antunes Marques 2019	Similar interventions
Cancela 2020	Similar interventions
Capato 2020b	Similar interventions
Combs 2013	Similar interventions
Granziera 2021	Similar interventions
Hashimoto 2015	Not an RCT
Israel 2018	Not an RCT
Kalyani 2019	Not an RCT

Study	Reason for exclusion
Laupheimer 2011	No supervision (participants were provided with cycling system at home and training sessions were unsupervised)
Maciel 2020	Not an RCT
Melo 2018	Similar interventions
Moon 2020	Similar interventions
Munneke 2010	Cluster-RCT
NCT03637023	Terminated
NCT04291027	Terminated
Passos-Monteiro 2020	Similar interventions
Picelli 2012	Similar interventions
Rawson 2019	Not an RCT
Sage 2009	Not an RCT
Sahu 2018	Similar interventions
Segura 2020	Not an RCT
Serrao 2019	Similar interventions
Silva-Batista 2020	Similar interventions
Soke 2021	Similar interventions
Thaut 1996	No supervision
Van Wegen 2015	Similar interventions
Wang 2018	Similar interventions
Xiao 2016	Fewer than five supervised sessions (only four training sessions followed by unsupervised training at home)
Yousefi 2009	Not an RCT
Yu 1998	Not an RCT
Zhang 2018	Not an RCT
Zhu 2020	Similar interventions

RCT: randomized controlled trial

Characteristics of studies awaiting classification *[ordered by study ID]*

ACTRN12605000566639

Methods	Randomized controlled trial
Participants	Inclusion criteria: • Age: 18 to 80 years old • Gender: both • Diagnosis of Parkinson's disease confirmed using the United Kingdom Brain Bank Parkinson's disease criteria • Rated between Grade 1 and 4 on the Hoehn & Yahr staging of Parkinson's disease • Able to walk without physical assistance for at least 14 meters Sample size (planned): 28 Sample size (actual): NR
Interventions	Community-based progressive strength training vs. active control group
Outcomes	Muscle strength, maximum weight, footstep patterns, walking endurance, upper extremity function, measure of participation, adverse events
Notes	Study start: 2005 Study completion: NR Recruitment status: not yet recruiting

ACTRN12609000900213

Methods	Randomized controlled trial
Participants	Inclusion criteria: • Age: no limit • Gender: both • Diagnosis of Parkinson's disease Sample size (planned): 84 Sample size (actual): NR
Interventions	Water-based exercises vs. active control group
Outcomes	Severity of disease, gait quality & function (TUG), functional mobility & balance
Notes	Study start: 2007 Study completion: NR Recruitment status: recruiting

ACTRN12612001016820

Methods	Randomized controlled trial
Participants	Inclusion criteria: • Age: 18 to 75 years old • Diagnosed with idiopathic Parkinson's disease by a neurologist • Between Hoehn and Yahr stages 1 to 3

ACTRN12612001016820 *(Continued)*

	• Be medically safe to participate in an active exercise program, as assessed by participants' neurologist, GP or other medical practitioner Sample size (planned): 20 Sample size (actual): NR
Interventions	Weekly dance classes vs. usual care
Outcomes	Adherence, feasibility, functional mobility (TUG), gait speed, quality of life (PDQ-39), balance
Notes	Study start: 2012 Study completion: NR Recruitment status: not yet recruiting

ACTRN12618000923268p

Methods	Randomized controlled trial
Participants	Inclusion criteria • Community-living men and women • Independence to walk continuously for 6 minutes without walking aids and able to cover 300 m • Walk 8-meter test over or equal to 0.8 m per second velocity • Score between 1 and 2 on Hoehn and Yahr scale • Less than 4 risk factors determined by the Quick screen (copyright) • Score 6 or more in the Short Physical Performance Battery • Minimum age: 50 years • Maximum age: 75 years • Gender: males and females Sample size (planned): 30 Sample size (actual): NR
Interventions	Folk dance lessons plus education on physical activity vs. education on physical activity
Outcomes	Step time, balance, cognitive function, functional performance, mental health, neurological symptoms (UPDRS), HY, motivation for physical activity, satisfaction, adherence
Notes	Study start: 2019 Study completion: NR Recruitment status: not yet recruiting

Amara 2020

Methods	Randomized controlled trial
Participants	Inclusion criteria: • Inclusion required age ≥ 45 years • Clinical diagnosis of idiopathic PD • Hoehn and Yahr stages 2 to 3 • Stable medication regimen for at least 4 weeks prior to study entry without anticipation of medication change during the study

Amara 2020 *(Continued)*

	Sample size (planned): 75 Sample size (actual): 71
Interventions	Supervised exercise training vs. improved sleep hygiene vs. healthy control
Outcomes	TUG (according to trial record); polysonography (sleep architecture: including sleep efficiency, total sleep time, wake after sleep onset (amount of time spent awake after sleep onset); latency to sleep onset, time and percentage of each sleep stage, latency to first REM period, arousal index, periodic limb movement index, apnea hypopnea index, and REM sleep without atonia); MDS-UPDRS; Pittsburgh Sleep Quality Index (PSQI); Epworth Sleepiness Scale (ESS); Fatique Severity Scale (FSS); Psychomotor vigilance test (PVT)
Notes	Study start: 2015 Study completion: 2020 Recruitment status: completed

ChiCTR-INR-17011340

Methods	Randomized controlled trial
Participants	Inclusion criteria: • Diagnosis of idiopathic Parkinson's disease • Must speak either English or French sufficiently to fill out questionnaires and understand the instructions for dance classes Sample size (planned): 120 Sample size (actual): NR
Interventions	Square dance vs. usual care
Outcomes	UPDRS-M, HY, PDQ-39, TUG, Berg Balance Scale, modified Frozen Questionnaire
Notes	Study start: 2017 Study completion: 2017 Recruitment status: not yet recruiting

ChiCTR-IOR-16009065

Methods	Randomized controlled trial
Participants	Inclusion criteria: • A clinical diagnosis of Parkinson's disease, with a disease severity rating of stage 1 to 3 on the Hoehn and Yahr scale • Aged above 18 years old • Ability to stand unaided or walk with or without an assistive device Sample size (planned): 160 Sample size (actual): NR
Interventions	Yoga vs. usual care

ChiCTR-IOR-16009065 *(Continued)*

Outcomes	Psychological distress, heart rate, UPDRS II, TUG, well-being, PDQ-8
Notes	Study start: 2016 Study completion: NR Recruitment status: completed, no results posted

ChiCTR-IPR-17011875

Methods	Randomized controlled trial

Participants	Inclusion criteria:
	• Diagnosis of primary Parkinson's disease (meet the 2013 Criteria of Guidelines for the diagnosis of Parkinson's disease of European Neurological Union)
	  ○ Reduced capacity of movement
	  ○ Meets at least one of the following clinical manifestations, including muscle rigidity; resting tremor; posture instability
	  ○ Unilateral disease; resting tremor; progressive disorder; after the onset of persistent asymmetric involvement; levodopa treatment at first effective
	• Hoehn and Yahr grades 1 to 3, able to walk independently
	• No change to participant drug regime in the week prior to enrolment in the trial, medication during treatment unchanged
	• Auditory, visual, and cognitive ability is normal
	Sample size (planned): 90
	Sample size (actual): NR

Interventions	Baduajin aerobic exercises vs. balance function training vs. usual care
Outcomes	Gait, UPDRS, blood composition
Notes	Study start: 2017 Study completion: 2019 Recruitment status: not yet recruiting

ChiCTR-TRC-14004549

Methods	Randomized controlled trial
Participants	Inclusion criteria: • Adults diagnosed with idiopathic Parkinson's disease with a disease severity rating of stage 1 to 4 on the Hoehn and Yahr scale • Prescribed one or more anti-parkinsonian medications by a consultant neurologist or consultant physician with specialist knowledge of movement disorders • Not demented or significantly cognitively impaired Sample size (planned): 142 Sample size (actual): NR
Interventions	Tai chi vs. rehabilitation training + medication
Outcomes	Balance, gait, quality of life

ChiCTR-TRC-14004549 *(Continued)*

Notes	Study start: 2014 Study completion: 2017 Recruitment status: not yet recruiting

ChiCTR1800019534

Methods	Randomized controlled trial
Participants	Inclusion criteria: • Age: 50 to 80 years • No history of leg injuries or other diseases associated with balance impairments • Berg Balance Scale (BBS < 56) • MMSE > 22 • Individuals were referred if they were within 3 weeks of their stroke, could stand unassisted for 1 minute, and were in need of balance training according to the judgment of the senior physical therapist Sample size (planned): 80 Sample size (actual): NR
Interventions	Balance training vs. active control
Outcomes	Balance
Notes	Study start: 2018 Study completion: NR Recruitment status: not yet recruiting

CTRI/2017/08/009471

Methods	Randomized controlled trial
Participants	Inclusion criteria: • Age: from 18 to 70 years • Gender: both male and female • Patient group: diagnosis of PD according the UKPDS Brain Bank criteria by a movement disorder specialist (Hoehn Yahr stage 4 or less) • Healthy volunteers: non-practitioner of yoga • No known medical co-morbidities that will interfere with doing yoga or transcranial magnetic stimulation Sample size (planned): 245 Sample size (actual): NR
Interventions	Yoga vs. aerobic exercise
Outcomes	UPDRS, PDQ-39, motor & non-motor symptoms, fatigue
Notes	Study start: 2016 Study completion: 2019 Recruitment status: open to recruitment

de Oliveira 2017

Methods	Randomized controlled trial
Participants	Inclusion criteria: • Age: 60 to 90 years old • Community-dwelling individuals with idiopathic PD • All sedentary (not performing any physical activity superior to 3 METs [metabolic equivalent of task]) • HY stage: 1 to 3 Sample size (planned): 30 Sample size (actual): 24
Interventions	Individualized exercises vs. group exercises vs. monitoring
Outcomes	Wisconsin card sorting test; Raven colored matrices (both cognition), according to trial record; cognitive functions; functionality; quality of life
Notes	Study start: 2014 Study completion: 2017 Recruitment status: completed

DRKS00008732

Methods	Randomized controlled trial
Participants	Sample size (planned): 60 Sample size (actual): NR
Interventions	LSVT BIG therapy vs. intensive physiotherapy vs. regular physiotherapy
Outcomes	Non-motor function (NMS score), severity of motor signs (UPDRS-M), psychometric function (BDI-II, adverse events, Parkinson's Neuropsychometric Dementia Assessment- (PANDA), MMSE, quality of life (PDQ-39)
Notes	Study start: 2015 Study completion: NR Recruitment status: recruiting

Huang 2020

Methods	Randomized controlled trial
Participants	Inclusion criteria • Diagnosed with postural instability and gait disorder Parkinson's Disease Sample size (planned): NR Sample size (actual): 80

Huang 2020 *(Continued)*

Interventions	Drug-only vs. drug-combined virtual reality training vs. drug-combined audiovisual training vs. drug-combined repetitive transcranial magnetic stimulation
Outcomes	Rating scales (BBS, FOG-Q, TUG, MDS-UPDRS)
Notes	Study start: NR Study completion: NR Recruitment status: NR

IRCT2015040616830N4

Methods	Randomized controlled trial
Participants	Inclusion criteria: • Age: 55 to 65 years old • Parkinson's disease according to neurologist diagnosis • Level 1 to 3 according to Hoehn and Yahr scale • Having an acceptable level of cognitive function, i.e. score of more than 21 on the Mini Mental State Examination (MMSE) • Able to walk independently and without assistive device at least 10 meters • No other neurological diseases or any orthopedic problems Sample size (planned): 40 Sample size (actual): NR
Interventions	Sensory reweighting excercises vs. usual care
Outcomes	Postural control, functional balance, functional mobility
Notes	Study start: 2015 Study completion: NR Recruitment status: completed, no results posted

IRCT20160712288885N1

Methods	Randomized controlled trial
Participants	Inclusion criteria: • Age: from 50 to 70 years • Gender: both male and female • Diagnosis of Parkinson's disease at moderate levels (levels 2 and 3) • Passage of at least 3 years after the disease diagnosis • Lack of other neurological diseases or any acute and chronic physical or mental disorder • The ability to stand and walk independently Sample size (planned): 48 Sample size (actual): NR
Interventions	Pilates exercises vs. balance exercise vs. walking

IRCT20160712228885N1 *(Continued)*

Outcomes	Gait, functional balance, falling risk
Notes	Study start: 2016 Study completion: NR Recruitment status: completed, no results posted

IRCT20171030037099N1

Methods	Randomized controlled trial
Participants	Inclusion criteria: • No age limit • Gender: both • Moderate Parkinson's disease; lack of chronic cardiac disease • No regular physical activity or physiotherapy intervention during the study time • Not having open surgery in the past 6 months to one year Sample size (planned): 30 Sample size (actual): 30
Interventions	Balance exercises vs. usual care (medication)
Outcomes	Balance, muscle strength, walking time (TUG)
Notes	Study start: 2017 Study completion: NR Recruitment status: completed, no results posted

Kargarfard 2012

Methods	Randomized controlled trial
Participants	Inclusion criteria • Gender: only female • Parkinson's disease patients who had been referred to neurologists in Isfahan Sample size (planned): NR Sample size (actual): 20
Interventions	Aquatic exercise therapy vs. medications
Outcomes	BBS
Notes	Study start: NR Study completion: NR Recruitment status: NR

Khongprasert 2019

Methods	Randomized controlled trial
Participants	Inclusion criteria • Diagnosed with Parkinson's disease (mild to moderate severity) Sample size (planned): NR Sample size (actual): 22
Interventions	Thai traditional game-based exercise for gait and balance
Outcomes	BBS, balance platform, TUG, the GaitRite walkway
Notes	Study start: NR Study completion: NR Recruitment status: NR

Koli 2018

Methods	Randomized controlled trial
Participants	Inclusion criteria: • Age: 40 to 80 years old • H&Y stage 1.5 to 3 • Ability to follow simple commands • Capacity to walk independently Sample size (planned): 34 Sample size (actual): 25
Interventions	Indian classical dance therapy vs. physiotherapy
Outcomes	UPDRS-I, Activities-specific Balance Confidence Scale (ABC scale), PDQ-39
Notes	Study start: 2017 Study completion: 2018 Recruitment status: NR

Lee 2019

Methods	Randomized controlled trial
Participants	Inclusion criteria: • Participants with idiopathic PD Sample size (planned): NR Sample size (actual): 30
Interventions	Gaming vs. normal activity
Outcomes	BBS, Static posturography and Sensory Organization Test (SOT) of Computerized Dynamic Posturography (CDP)

Lee 2019 *(Continued)*

Notes	Study start: NR Study completion: NR Recruitment status: NR

Lee G 2018

Methods	Randomized controlled trial
Participants	Inclusion criteria: • Age: between 50 and 80 years • Stage 1 to 3 on the Hoehn and Yahr scale • No other neurological, or cognitive impairments • Not having received any exercise therapy within the 3 months prior to the study Sample size (planned): NR Sample size (actual): 50
Interventions	Wii balance-training vs. standard physiotherapy
Outcomes	"Verbal analogue scale", activities-specific balancing confidence scale (ABC), PDQ-39, fall index, Sensory Organization Test (SOT) of Computerized Dynamic Posturography (CDP)
Notes	Study start: NR Study completion: NR Recruitment status: NR

Mohammadpour 2018

Methods	Randomized controlled trial
Participants	Inclusion criteria: • Diagnosis of Parkinson's idsease • Lack of chronic cardiovascular diseases or cognitive disorders approved by a specialist physician Sample size (planned): NR Sample size (actual): 30
Interventions	Combined aerobic and resistance exercise program vs. no regular physical activity (only drugs)
Outcomes	PDQOL, UPDRS-M
Notes	Study start: NR Study completion: NR Recruitment status: NR

NCT00004760

Methods	Randomized controlled trial
Participants	Inclusion criteria:

NCT00004760 *(Continued)*

	• Age: 50 to 90 years • Stage 2 or 3 Parkinson's disease (Hoehn and Yahr scale) • Able to ambulate independently • Able to function independently in home • Moderate rigidity • No moderate or severe tremor • No unstable angina • No psychiatric or medical contraindication to exercise, e.g. dementia, hip fracture • No other neurologic disorder, e.g. stroke, multiple sclerosis • Resides within 30 miles of Duke University Sample size (planned): NR Sample size (actual): 80
Interventions	Axial exercise program vs. standard care
Outcomes	NR
Notes	Study start: 1995 Study completion: 1997 Recruitment status: completed, no results posted

NCT00029809

Methods	Randomized controlled trial

Participants	Inclusion Criteria:
	
	• Age: 40 to 85 years old
	• Ambulatory patients with Parkinson's Disease, defined as a clinical state in which at least two of these four cardinal features are present
	  ◦ slowness of movement
	  ◦ tremor at rest
	  ◦ muscular rigidity
	  ◦ gait disturbance or posture imbalance.
	• Not exercising regularly more than 2x per week
	
	Sample size (planned): 40
	Sample size (actual): NR

Interventions	Chinese exercise modalities vs. NR
Outcomes	Motor control, motor disability
Notes	Study start: NR Study completion: NR Recruitment status: completed, no results posted

NCT00167453

Methods	Randomized controlled trial
Participants	Inclusion criteria:

NCT00167453 *(Continued)*

	• Age: 40 to 80 years old • Clinical diagnosis of Parkinson's disease or Parkinson Syndrome • Stages 1 to 3 of disease progression Sample size (planned): 45 Sample size (actual): NR
Interventions	Exercise vs. education + exercise vs. no intervention
Outcomes	Self-efficacy, activity-specific balance (ABC), TUG, PDQ-8, social & physical activities, Schwab & England ADL scale, Northwestern University Disability scale
Notes	Study start: 2005 Study completion: 2007 Recruitment status: completed, no results posted

NCT00387218

Methods	Randomized controlled trial
Participants	Inclusion criteria: • Age: older than 30 years old • Community-dwelling, independently ambulatory adults with mild to moderate Parkinson's disease (Stages 2, 2.5, and 3 on the modified Hoehn and Yahr scale) • A diagnosis of PD made by their attending neurologist using criteria from the UK Brain Bank, e.g. at least two of the cardinal signs of PD (i.e., bradykinesia, resting tremor, rigidity, postural instability) • Without PD medication other known or suspected causes of parkinsonism • Must be on a stable regimen for at least one month prior to enrollment Sample size (planned): 170 Sample size (actual): NR
Interventions	Usual care vs. aerobic training vs. targeted flexibility vs. functional training
Outcomes	Balance, oxygen consumption, functional capacity, UPDRS, UPDRS-ADL, PDQ-39, spinal range of motion
Notes	Study start: 2002 Study completion: 2009 Recruitment status: unknown (was recruiting, but no verification since 2008)

NCT01014663

Methods	Randomized controlled trial
Participants	Inclusion criteria: • Diagnosis of Parkinson's disease • Currently not receiving physical therapy services • Medically stable with a physician release stating approval to enter an exercise program • Independently ambulatory in the home setting with or without the use of an assistive device Sample size (planned): NR

NCT01014663 *(Continued)*

	Sample size (actual): 31
Interventions	Non-contact boxing training vs. traditional therapeutic exercise
Outcomes	Mobility (TUG, Four-Square Step Test, 6-Minute Walk Test, Berg Balance Scale, Functional Reach Test)
Notes	Study start: 2009 Study completion: 2011 Recruitment status: completed, no results posted

NCT01076712

Methods	Randomized controlled trial
Participants	Inclusion criteria: • Age: 35 to 75 years old • Stable medication usage • Hoehn and Yahr stage 2 to 4 • At least 1 score of 2 or more for at least 1 limb of either the tremor, rigidity, or bradykinesia item of the Unified Parkinson's Disease Rating Scale (UPDRS) • Able to walk independently • No severe cognitive impairments (Mini Mental State Examination - Chinese Cantonese version) score greater than 24 Sample size (planned): 112 Sample size (actual): NR
Interventions	Physiotherapy vs. education classes
Outcomes	MDS-UPDRS-M, levodopa equivalent daily dosage, TUG, activities-specific balance confidence scale, PDQ-39, number of injurious falls
Notes	Study start: 2010 Study completion: 2012 Recruitment status: unknown (was recruiting, but no verification since 2010)

NCT01246700

Methods	Randomized controlled trial
Participants	Inclusion criteria: • Diagnosis of Parkinson's disease by a clinician/neurologist • Absence of mentation • Established medication schedule and dosage Sample size (planned): NR Sample size (actual): 76
Interventions	Sensory attention focused exercise (SAFEx) then no treatment vs. no treatment then SAFEx

NCT01246700 *(Continued)*

Outcomes	Disease severity (UPDRS), TUG, 30-second chair stand, grooved pegboard, step length, velocity, step to step length variability
Notes	Study start: 2008 Study completion: 2010 Recruitment status: unknown (was active, but no verification since 2010)

NCT01427062

Methods	Randomized controlled trial
Participants	Inclusion criteria: • Age: 45 years or older • Diagnosed as having Parkinson's disease • Stable on anti-parkinsonian medications for at least 6 weeks prior to entry into the study • Able to walk a 10-meter distance at least 3 times with or without walking aids independently • At stage 2 or 3 of the Hoehn and Yahr staging Sample size (planned): 52 Sample size (actual): NR
Interventions	Anticipatory & compensatory postural control training vs. strength-focused training
Outcomes	Reaction time of limits of stability test, one-leg-stance time, pull test, fall rate, movement velocity & end point excursion of limits of stability test, gait velocity, stride length, cadence
Notes	Study start: 2009 Study completion: 2012 Recruitment status: unknown (was recruiting, but no verification since 2011)

NCT01439022

Methods	Randomized controlled trial
Participants	Inclusion criteria: • Parkinson's disease diagnosed by neurological examination; idiopathic PD defined by the UK Parkinson's Disease Society Brain Bank Criteria • Able to walk ≥ 100m • Maintained a stable medical regime for 12 weeks prior to initiation of the study, and anticipated to maintain a stable regime for the course of study (as determined by the referring clinician) Sample size (planned): NR Sample size (actual): 105
Interventions	Exercise programme vs. handwriting programme
Outcomes	Change in 2 minute walk, TUG, nine-hole peg test, health status (SF-36), quality of life (EQ-5D), blood pressure, BMI, aerobic fitness, leg power, grip strength, disease status (UPDRS), non-motor symptoms, process evaluation, adherence
Notes	Study start: 2011 Study completion: 2014

NCT01439022 *(Continued)*

	Recruitment status: completed, no results posted

NCT01562496

Methods	Randomized controlled trial
Participants	Inclusion criteria: • Age: between 30 and 75 years • Diagnosis of idiopathic Parkinson's disease according to the UK Queen Square Brain Bank Criteria • Hoehn & Yahr disease stages 1 to 2 • Having insufficient physical activity according to the American College of Sports Medicine (ACSM) guideline for adults, 50 to 64 years old with a chronic condition • Untreated with anti-parkinsonian medication or receiving medication, for less than two years, medication-responsive without fluctuations Sample size (planned): NR Sample size (actual): 35
Interventions	Aerobic exercise vs. no intervention
Outcomes	Trails A & B track, UPDRS, cognitive function (MMSE, Scales for Outcomes in Parkinson's Disease (SCOPA)), kinetics (TUG, finger-tap test, pegboard test), quality of life (PDQ-39), maximal exercise, feasibility, neuroplasticity
Notes	Study start: 2012 Study completion: 2014 Recruitment status: completed, no results posted

NCT01757509

Methods	Randomized controlled trial
Participants	Inclusion criteria: • Age: over 18 years old • Diagnosis of idiopathic Parkinson's disease, stage 1 to 2.5 on the Hoehn and Yahr scale • Showing a clear benefit from anti-parkinson medication • Able to walk three meters with or without an assistive device • Not pregnant Sample size (planned): NR Sample size (actual): 24
Interventions	Set dancing intervention + usual care vs. usual care
Outcomes	Balance (Berg Balance Scale), UPDRS-M, quality of life (PDQ-39), functional exercise tolerance (6-minute walk test), caregiver burden (Zarit Care Giver Burden Interview (ZCBI))
Notes	Study start: 2012 Study completion: 2013 Recruitment status: completed, no results posted

NCT01835652

Methods	Randomized controlled trial
Participants	Inclusion criteria: • Age: 40 to 70 years old • Gender: both • Idiopathic Parkinson's disease according to UK Brain Bank criteria (modified to permit inclusion of participants with a family history) • Mild to moderate Parkinsonism (Hoehn & Yahr stages 1 to 3) Sample size (planned): NR Sample size (actual): 13
Interventions	Active aerobic exercise training vs. passive exercise (stretching, balance-based)
Outcomes	Positron emission tomography (PET), functional magnetic resonance imaging (fMRI), motor function (MDS-UPDRS-M, finger tapping, Purdue pegboard), cognitive function (Montreal Cognitive Assessment, Wisconsin Card-Sorting Task, Trail-Making B Test, computerized reaction time test), mood & apathy (Beck Depression inventory, Starkstein apathy scale)
Notes	Study start: 2013 Study completion: 2015 Recruitment status: completed, no results posted

NCT01960985

Methods	Randomized controlled trial
Participants	Inclusion criteria: • Age: 65 to 85 years old • Definitive idiopathic Parkinson's disease as diagnosed by a neurologist • Hoehn and Yahr Stage 1 to 3 • Able to ambulate without an assistive device • On stable doses of Parkinson's medications prior to study onset Sample size (planned): NR Sample size (actual): 42
Interventions	Motor training (external cues) vs. motor training vs. no treatment
Outcomes	UPDRS, balance (BBS), gait (dynamic gait index), retropulsion test, TUG, balance (BESTest)
Notes	Study start: 2006 Study completion: 2012 Recruitment status: completed, no results posted

NCT02017938

Methods	Randomized controlled trial

NCT02017938 *(Continued)*

Participants	Inclusion criteria: • Age: 20 years and older • Gender: both • Clinical diagnosis of Parkinson disease • Hoehn and Yahr ≤ 3 Sample size (planned): 90 Sample size (actual): NR
Interventions	Virtual reality anti-fatigue ergo cycling training vs. control (NR)
Outcomes	Muscle twitch force, muscle voluntary activity level, heart rate, heart rate variability, Borg's rate of perceived exertion
Notes	Study start: 2013 Study completion: 2016 Recruitment status: unknown (was recruiting, but no verification since 2013)

NCT02267785

Methods	Randomized controlled trial
Participants	Inclusion criteria: • Age: 30 to 85 years old • Confirmed diagnosis of idiopathic Parkinson's disease based on the United Kingdom Brain Bank criteria • Mild cognitive impairment (Level II criteria Movement Disorder Task Force) • Medically eligible for MRI imaging • Able to provide a written medical clearance from their primary physician to participate in exercise • Stable PD medications for 3 months Sample size (planned): NR Sample size (actual): 25
Interventions	Skill-based exercise vs. aerobic exercise vs. social contact
Outcomes	Context-dependent motor learning, dual task performance (during fMRI), verbal fluency, Tower of London test, Wisconsin Card Sorting test, quality of life (PDQ-39), motor symptoms (MDS-UPDRS, physical performance test, TUG), activity-specific balance (ABC), control beliefs, self-efficacy, cardiovascular fitness, BMI, mental health (geriatric depression/anxiety scales, daily activities, cognitive function
Notes	Study start: 2014 Study completion: 2019 Recruitment status: unknown (was active, but no verification since 2019)

NCT02419768

Methods	Randomized controlled trial
Participants	Inclusion criteria:

NCT02419768 *(Continued)*

	• Diagnosis idiopathic Parkinson according to the Brain Bank criteria of the United Kingdom Parkinson's Disease Society • Disease severity according to modified Hoehn & Yahr stages 1 to 4 • Absence of dementia Minimal Mini Mental State Examination score of 24 or higher • Stable drug usage in the last 4 weeks Sample size (planned): 50 Sample size (actual): NR
Interventions	Physical exercise vs. no intervention
Outcomes	Balance (BESTest), MDS-UPDRS-M, 6-minute walking test, 10-meter walking test, longe-range autocorrelations, instrumented gait analysis, Impact on Participation and Autonomy Questionnaire (IPAQ), activities based balance (ABC)
Notes	Study start: 2014 Study completion: 2016 (estimated) Recruitment status: unknown (was recruiting, but no verification since 2016)

NCT02476240

Methods	Randomized controlled trial
Participants	Inclusion criteria: • Diagnosed with idiopathic Parkinson's disease by a neurologist • Able to stand 2 minutes, unassisted • Able to walk 10 meters, unassisted • Able to understand English instructions Sample size (planned): NR Sample size (actual): 65
Interventions	Internally focused PD-SAFEx (sensory attention focused exercise) vs. externally focused PD-SAFEx vs. control group
Outcomes	UPDRS-M, single & dual task walking, anxiety (Parkinson anxiety scale), cognitive status (MoCA test), quality of life (PDQ-39), physical activity (Community Health Activities Model Program for Seniors questionnaire (CHAMPS))
Notes	Study start: 2015 Study completion: 2016 Recruitment status: completed, no results posted

NCT02476266

Methods	Randomized controlled trial
Participants	Inclusion criteria: • Diagnosed with idiopathic Parkinson's disease by a neurologist • Able to stand two minutes, unassisted • Able to understand English instructions • Signed Physical Activity Readiness Medical Examination (PARmed-X) by physician

NCT02476266 *(Continued)*

	Sample size (planned): NR Sample size (actual): 53
Interventions	Power training vs. strength training vs. no intervention
Outcomes	Muscle activity (Lean-and-Release perturbation technique), severity of motor signs (UPDRS-M), gait, balance, muscle strength, TUG, thirty-second sit to stand, quality of life (PDQ-39), physical activity (Community Health Activities Model Program for Seniors questionnaire (CHAMPS))
Notes	Study start: 2015 Study completion: 2016 Recruitment status: completed, no results posted

NCT02615548

Methods	Randomized controlled trial
Participants	Inclusion criteria: • Age: 45 to 80 years • Gender: both • Idiopathic Parkinson's disease • Hoehn & Yahr stages 1 to 3 • Willing and able to participate in 60 minutes of physical activity, 3x/week for 12 weeks, then 2x/week for 36 weeks Sample size (planned): NR Sample size (actual): 30
Interventions	Community exercise class vs. self-directed exercise acitivity
Outcomes	Gait (functional gait assessment FGA), physical endurance (6-Minute Walk Test), attitude towards intervention
Notes	Study start: 2016 Study completion: 2017 Recruitment status: submitted, not posted on ClinicalTrials.gov

NCT02656355

Methods	Randomized controlled trial
Participants	Inclusion criteria: • Age: 20 years and older • Gender: both • Clinical diagnosis of Parkinson disease Sample size (planned): 90 Sample size (actual): NR
Interventions	Weight shift training + anticipatory postural adjustment (APA) feedback vs. weight shift training vs. usual care

NCT02656355 *(Continued)*

Outcomes	Gait, balance
Notes	Study start: 2015 Study completion: 2017 Recruitment status: unknown (was recruiting, but no verification since 2016)

NCT02674724

Methods	Randomized controlled trial
Participants	Inclusion criteria: • Age: 50 to 75 years • Hoehn and Yahr stages 2 to 3 • Idiopathic Parkinson's disease diagnosed according to the United Kingdom Parkinson's Disease Society Brain Research Centre Criteria • Ability to walk independently without walking devices aid • Absence of orthopedic injuries or pain in joints that could interfere with training program • Stable medication regimen for PD treatment at recruitment stage • Mini Mental State Examination Scale (MMSE) ≥ to 27 for literate patients and schooling ≥ of 4 years of formal education • No cardiovascular instability, no pacemaker, decompensated metabolic disease, vestibular dysfunction, and stroke Sample size (planned): 63 Sample size (actual): NR
Interventions	Gym group vs. free weights vs. stretching
Outcomes	Postural sway, balance (BBS, Mini-BESTest, TUG, Dynamic Posturography), quality of life (PDQ-39)
Notes	Study start: 2016 Study completion: 2018 Recruitment status: completed, no results posted

NCT02745171

Methods	Randomized controlled trial
Participants	Inclusion criteria: • People diagnosed with idiopathic Parkinson's disease • Gender: both • People in stages 1 to 3 of modified version of the Hoehn and Yahr scale Sample size (planned): 20 Sample size (actual): NR
Interventions	Physical therapy vs. no intervention
Outcomes	Quality of life (PDQ-39)
Notes	Study start: 2016

NCT02745171 *(Continued)*

	Study completion: 2016 Recruitment status: unknown (was recruiting, but no verification since 2016)

NCT02816619

Methods	Randomized controlled trial
Participants	Inclusion criteria: • Age: from 18 to 80 • Gender: both • Clinical criteria for Parkinson's disease • Social security coverage • Ability to provide informed consent Sample size (planned): 50 Sample size (actual): NR
Interventions	Personalised physical activitiy program vs. free practice of physical activitiy
Outcomes	UPDRS-M, PDQ-39, ADL, activity, balancing abilities (stabilometry), muscular strength (isometric test), cardiorespiratory function, 6-MIN-W, body mass, dropout rates
Notes	Study start: 2016 Study completion: 2018 Recruitment status: unknown (was recruiting, but no verification since 2016)

NCT02999997

Methods	Randomized controlled trial
Participants	Sample size (planned): NR Sample size (actual): 51
Interventions	Exercise with Ronnie Gardiner Method vs. no exercise
Outcomes	TUG cognitive & manual, Mini-BESTest, Four Step Square Test, BBS, Chair Stand 30s, MoCA, auditory memory test, symbol digit modalities test, Victoria Stroop test, grooved pegboard, Trail Making Test, Rey complex figures, WHO Disability Assessment Schedule (WHODAS) 2.0, FOG-Q, PDQ-39, FES-I, actigraphy
Notes	Study start: 2017 Study completion: 2018 Recruitment status: completed, no results posted

NCT03212014

Methods	Randomized controlled trial
Participants	Inclusion criteria: • Age: 40 to 85 years old

NCT03212014 *(Continued)*

	• Parkinson's disease diagnosis, Hoehn-Yahr level 1 to 3 • Stable medicine intake for 2 weeks at least • Able to walk independently for 15 meters Sample size (planned): 75 Sample size (actual): NR
Interventions	LSVT-BIG vs. power Rehabilitation vs. traditional rehabilitation
Outcomes	Balance (Mini-BESTest), UPDRS, muscle power of lower extremity, quality of life (PDQ-39)
Notes	Study start: 2017 Study completion: 2017 Recruitment status: unknown (was recruiting, but no verification since 2017)

NCT03406728

Methods	Randomized controlled trial
Participants	Inclusion criteria: • Gender: both • Confirmed diagnosis of Parkinson's disease by a registered movement disorders specialist • Currently taking dopaminergic medication • Able to walk 15 m, unassisted • Able to stand for 2 minutes unassisted • Able to understand English Instructions Sample size (planned): 36 Sample size (actual): NR
Interventions	Parkinson's Disease Sensory Attention Focused Exercise (PDSAFEx) vs. usual daily activities vs. virtual reality intervention
Outcomes	UPDRS, sensory organisation (SOT), number of falls, TUG, balance (ABC), falls efficacy (FES), quality of life (PDQ-39)
Notes	Study start: 2018 Study completion: 2018 Recruitment status: unknown (was not recruiting, no verification since 2018)

NCT03443752

Methods	Randomized controlled trial
Participants	Inclusion criteria: • A clinical diagnosis of Parkinson's disease • Stable medication use • Ability to comprehend English, • Ability to stand without aid and walk with or without assisted aids Sample size (planned): 60

NCT03443752 *(Continued)*

	Sample size (actual): NR
Interventions	Shotokan karate vs. tai chi
Outcomes	UPDRS-II, PDQ-39, TUG, gait
Notes	Study start: 2018 Study completion: 2018 Recruitment status: unknown (was not recruiting, no verification since 2018)

NCT03568903

Methods	Randomized controlled trial
Participants	Inclusion criteria: • Age: 60 to 81 years old • Diagnosis of idiopathic Parkinson's disease • No other untreated medical conditions that might affect gait or postural stability • Able to walk without assistive device • Score of Mini Mental State Examination above 24 • No other neurological conditions in medical anamnesis Sample size (planned): 44 Sample size (actual): NR
Interventions	Comprehensive physical therapy vs. no intervention
Outcomes	Gait speed (TUG), body composition, Tinetti test, range of motion, handwriting, quality of life (PDQ-39), pain, patient satisfaction, activities of daily living
Notes	Study start: 2013 Study completion: 2017 Recruitment status: completed, no results posted

NCT03618901

Methods	Randomized controlled trial
Participants	Inclusion criteria: • Gender: both • Able to understand verbal instructions in English • Diagnosed with idiopathic Parkinson's disease by a neurologist Sample size (planned): 60 Sample size (actual): NR
Interventions	Rock steady boxing vs. PD SAFEx
Outcomes	Motor symptom improvements (UPDRS), quality of life (PDQ-39), balance (biodex balance system, Mini-BESTest, ABC), gait (TUG), strength, cognitive abilities (Scale of Outcomes of Parkinson Dis-

NCT03618901 *(Continued)*

	ease (SCOPA), Montreal Cognitive Assessment, MMSE), physical activity (Community Health Activities Model Program for Seniors questionnaire (CHAMPS))
Notes	Study start: 2018 Study completion: 2019 Recruitment status: unknown (was recruiting, but no verification since 2019)

NCT03689764

Methods	Randomized controlled trial
Participants	Sample size (planned): NR Sample size (actual): 24
Interventions	Interactive video-game exercise then no intervention vs. no intervention then interactive video-game exercise
Outcomes	Balance (BBS), SF-36, falls efficacy (MFES), multidirectional reach (MDRT), maximum step length
Notes	Study start: 2014 Study completion: 2019 Recruitment status: completed, no results posted

NCT04012086

Methods	Randomized controlled trial
Participants	Sample size (planned): NR Sample size (actual): 40
Interventions	Physical therapy vs. no physical therapy
Outcomes	Cognitive function (MoCA), motor performance (MDS-UPDRS-M)
Notes	Study start: 2015 Study completion: 2018 Recruitment status: completed, results not posted

Ogundele 2018

Methods	Randomized controlled trial
Participants	Inclusion criteria: people with Parkinson's disease Sample size (planned): NR Sample size (actual): 43
Interventions	Virtual reality gaming vs. activity-based gait and balance training
Outcomes	Gait analysis (assessing balance, step length, gait velocity, cadence), PDQ-39
Notes	Study start: NR

Ogundele 2018 *(Continued)*

	Study completion: NR Recruitment status: NR

RBR-34d7jm

Methods	Randomized controlled trial
Participants	Inclusion criteria: • Participants between stages 1 to 3 of the Hoehn & Yahr scale • Regular use of specific medication for Parkinson's disease Sample size (planned): 100 Sample size (actual): NR
Interventions	Dance & rhythmic activities vs. socializing activities
Outcomes	Cognitive function (executive function, memory, attention), gait (velocity, step length), postural control, disease severity (HY, UPDRS), global cognitive function (MMSE), visuospatial ability, quality of life (PDQ-39), anxiety, depression, stress, coordination of upper & lower limbs, functional balance (BBS), functional mobility (TUG), fear of falls
Notes	Study start: 2015 Study completion: NR Recruitment status: completed, results not posted

RBR-3vm7bf

Methods	Randomized controlled trial
Participants	Inclusion criteria: • Age: 50 to 72 years old • Idiopathic Parkinson's disease diagnosed by a neurologist physician according to the CBCL • Stage II and / or III, according to the Hoehn and Yahr scale • Individuals who do not present with dementia verified by the Addenbrooke's Cognitive Examination Revised (ACE-R) scale • Ability to wander and stand independently and safely. Sample size (planned): 30 Sample size (actual): NR
Interventions	Isokinetic training vs. standard exercise
Outcomes	Muscle performance, functional capacity, neurodegeneration
Notes	Study start: 206 Study completion: NR Recruitment status: completed, results not posted

RBR-3z39v3

Methods	Randomized controlled trial
Participants	Inclusion criteria: • Individuals with Parkinson's disease • Age: between 60 and 80 years old • Members of an extension project • Classified in stages I and II according to the Hoehn and Yahr Scale • Without cognitive alterations • Medical release for physical activity Sample size (planned): 30 Sample size (actual): NR
Interventions	Pilates vs. functional training
Outcomes	Gait performance determined by Kinematic gait analysis, American Alliance for Health, Physical Education and Recreation and Dance (AAHPERD score)
Notes	Study start: 2019 Study completion: NR Recruitment status: recruiting

RBR-4m3k2c

Methods	Randomized controlled trial
Participants	Inclusion criteria: • Age: over 60 years • Gender: both sexes • Diagnosed with major depression • Alzheimer's disease • Parkinson's disease Sample size (planned): 180 Sample size (actual): NR
Interventions	Physical training & exercise vs. no physical exercise
Outcomes	Depressive symptoms (geriatric depression scale), overall cognitive state performance (MMSE), UPDRS
Notes	Study start: 2014 Study completion: 2019 Recruitment status: recruiting

RBR-6rngmb

Methods	Randomized controlled trial
Participants	Inclusion criteria:

RBR-6rngmb *(Continued)*

	• Participants with clinical diagnosis of Parkinson's disease (International Classification of Diseases (ICD) 10: G20) • Both sexes • Age range between 50 and 75 years • Signature of the "TCLE" • Have performed a physiotherapeutic review that freed the individual for therapy Sample size (planned): 20 Sample size (actual): NR
Interventions	Game therapy through virtual reality vs. conventional physiotherapy
Outcomes	BBS, baropodometry
Notes	Study start: 2019 Study completion: NR Recruitment status: recruiting

RBR-7xfkpx

Methods	Randomized controlled trial
Participants	Inclusion criteria: • Diagnosis of Parkinson's disease obtained by a neurologist • Presenting with gait blocking symptom, with scores greater than or equal to 4 by the New Freezing of Gait Questionnaire scale • Stages 3 or 4 of the disease by the Hoehn and Yahr modified scale • Score equal to or greater than 23 in the MMSE • Not presenting neurological or physical dysfunctions Sample size (planned): 30 Sample size (actual): NR
Interventions	Postural pertubation training (moving platform) vs. strength training
Outcomes	Reactive postural response, dynamic & global balance, mobility (TUG), freezing, motor status (UP-DRS II, III), events of daily life, fear of falls, anxiety (HADS)
Notes	Study start: 2018 Study completion: 2019 Recruitment status: recruiting

Rosenfeldt 2021

Methods	Randomized controlled trial
Participants	Inclusion criteria • Clinical diagnosis of idiopathic PD • Age: between 30 and 75 years • Not currently engaged in formal exercise intervention or clinical study • Hoehn and Yahr stage 2 to 3 in an on-medication state

Rosenfeldt 2021 *(Continued)*

	Sample size (planned): NR Sample size (actual): 50
Interventions	Forced exercise on a stationary cycle that was controlled by a motor, to augment voluntary cycling rate by 35% vs. voluntary exercise on a stationary cycle without motor assistance
Outcomes	MDS-UPDRS-M, Trail Making Test, number of participants with increased motor cortex and thalamus connectivity (using functional magnetic resonance imaging)
Notes	Study start: 2012 Study completion: 2018 Recruitment status: completed

Shen 2014

Methods	Randomized controlled trial
Participants	Inclusion criteria: • Diagnosis of idiopathic PD according to the United Kingdom PD Society Brain Bank Criteria • Be stable on anti-Parkinsonian medications • Be able to walk independently for 10 m • Be able to follow instructions—that is, MMSE score > 23.19 • No other neurological conditions, uncompensated cardiovascular disease, visual disturbance, or recent musculoskeletal disorders in the back or lower limbs that would interfere with balance and locomotion Sample size (planned): NR Sample size (actual): 51
Interventions	Balance and gait training vs. active control
Outcomes	Self-perceived balance confidence level, measured by the validated Activities-Specific Balance Confidence (ABC) Scale; limit of stability (LOS) test, single-leg-stance (SLS) test
Notes	Study start: NR Study completion: NR Recruitment status: completed

Stozek 2017

Methods	Randomized controlled trial
Participants	Inclusion criteria: • PD patients • HY stage: 1.5 to 3.0 Sample size (planned): NR Sample size (actual): 30
Interventions	Dance vs. Nordic walking vs. passive control

Stozek 2017 *(Continued)*

Outcomes	UPDRS, Functional Reach Test, BBS, Retropulsion test (Pastor), TUG, 10-meter walk test, timed 360° turn, Physical Performance Test
Notes	Study start: NR Study completion: NR Recruitment status: NR

Swarnakar 2019

Methods	Randomized controlled trial
Participants	Inclusion criteria: • Individuals with newly diagnosed Parkinson's disease • Stable dose of PD medications • Hoehn and Yahr stage ≤ 2 Sample size (planned): NR Sample size (actual): 22
Interventions	Strengthening, stretching, aerobic, agility, trunk exercises vs. stretching exercise
Outcomes	UPDRS I-VI
Notes	Study start: NR Study completion: NR Recruitment status: NR

TCTR20180111003

Methods	Randomized controlled trial
Participants	Inclusion criteria: • Age: 50 to 85 years old • Gender: both • Diagnosed idiopathic Parkinson's Disease according to the United Kingdom Brain Bank Criteria with Hoehn and Yahr stages 1 to 3 • Stable on anti-PD medications • Could walk 10 m with or without any walking assist Sample size (planned): 40 Sample size (actual): NR
Interventions	Square stepping exercise group vs. trunk and upper limb training
Outcomes	Cortical excitability, balance (Mini-BESTest), cognition (MoCA, Trail Making Test, Digit Span Task), quality of life (PDQ-39)
Notes	Study start: 2018 Study completion: 2019 Recruitment status: recruiting

TCTR20180530004

Methods	Randomized controlled trial
Participants	Inclusion criteria: • Age: 20 to 85 years old • Gender: both • Clinical diagnosis of idiopathic Parkinson's disease by a neurologist • Hoehn and Yahr stage 1 to 3 • Independent walking • No cognitive impairment Sample size (planned): 60 Sample size (actual): NR
Interventions	Multicomponent exercise vs. dual-task training vs. control exercise
Outcomes	Quantitative electroencephalogram (EEG), neuropsychological tests, gait performance, disease severity and clinical characteristics (UPDRS), quality of life (PDQ-8)
Notes	Study start: 2018 Study completion: 2019 Recruitment status: not yet recruiting

Wróblewska 2019

Methods	Randomized controlled trial*
Participants	Inclusion criteria: • Outpatients with PD who suffered from freezing of gait episodes during the "on"-state • HY 2 to 3 • Stable pharmacotherapy • Sufficient general health condition for the training intervention • No previous experience with Nordic walking Sample size (planned): NR Sample size (actual): 40
Interventions	Nordic walking vs. no intervention
Outcomes	FOG-Q, TUG, provocative test for freezing and motor blocks
Notes	Study start: NR Study completion: NR Recruitment status: completed *Please note that it was unclear whether an appropriate method of randomization was applied.

ADL: activities of daily living; **BBS:** Berg Balance Scale; **BDI:** Beck Depression Inventory; **BMI:** body mass index**BESTest:** Balance Evaluation Systems Test; **EQ-5D:** EuroQoL 5 Dimensions; **FES:** Falls Efficacy Scale; **FOG-Q:** Freezing of Gait Questionnaire; **HADS:** Hospital Anxiety and Depression Scale; **HY:** Hoehn and Yahr scale; **LSVT BIG:** Lee Silverman Voice training BIG; **MDS-UPDRS-M:** Movement Disorder Society Unified Parkinson Disease Rating Scale/Motor Score; **MHY:** Modified Hoehn and Yahr scale; **Mini-BESTest:** Mini-Balance Evaluation

Systems Test; **MMSE:** Mini Mental State Examination; **MoCA:** Montreal Cognitive Assessment; **N-FOG-Q:** New Freezing of Gait Questionnaire; **PDQ-39:** Parkinson's Disease Questionnaire 39; **PDQ-8:** Parkinson's Disease Questionnaire 8; **PDQ-L:** Parkinson's disease quality of life; **SAFEx:** Sensory Attention Focused Exercise; **SF-36:** Short-Form Health Survey-36 item questionnaire; **6-MIN-W:** 6-minute walk test; **TUG:** Timed up and go; **UPDRS-M:** Unified Parkinson's Disease Rating Scale/Motor Score

Characteristics of ongoing studies *[ordered by study ID]*

ACTRN12617001057370

Study name	The effect of a physiotherapy exercise program with a self-management approach versus usual care on physical activity in people with mild-moderate Parkinson's disease: a randomised controlled trial
Methods	Randomized controlled trial
Participants	Inclusion criteria: • Diagnosis of idiopathic PD confirmed by a neurologist • Modified Hoehn and Yahr stage 1 to 3 • Living in the community • Able to attend assessment and treatment sessions • Montreal Cognitive Assessment Scale (MoCA) score of > 23/30 • Provide consent • Minimum age: 18 years • Maximum age: no limit • Gender: both males and females Sample size (planned): 92 Sample size (actual): 44
Interventions	Group exercise, chronic disease self-management, usual care vs. usual care
Outcomes	Physical activity, step length, gait speed and endurance, PDQ-39, outcome expectations, self-efficacy
Starting date	Study start: 2017 Study completion: 2021 (anticipated) Recruitment status: recruiting
Contact information	s.brauer@uq.edu.au
Notes	anzctr.org.au/ACTRN12617001057370.aspx

ACTRN12620001135909

Study name	A randomised trial of exercise therapy for Parkinson's disease
Methods	Randomized controlled trial
Participants	Inclusion criteria: • Parkinson's disease • Modified Hoehn & Yahr stage 3 or less • Age 30 to 75 years

ACTRN12620001135909 *(Continued)*

	• Sedentary lifestyle (low levels of aerobic physical activity, defined by the American College of Sports Medicine recommendation for older adults as any level below recommended weekly amount of aerobic exercise) • Receiving a stable dopaminergic medication dose Sample size (planned): 16 Sample size (actual): NR
Interventions	Strength training and aerobic exercises vs. stretching, flexibility or relaxation exercises
Outcomes	MDS-UPDRS, 6-meter walk test, 6-minute walk test, PDQ-39, reported falls
Starting date	Study start: 2020 Study completion: 2021 Recruitment status: recruiting
Contact information	m.morris@latrobe.edu.au
Notes	anzctr.org.au/Trial/Registration/TrialReview.aspx?ACTRN=12620001135909

Bevilacqua 2020

Study name	Rehabilitation of older people with Parkinson's disease: an innovative protocol for RCT study to evaluate the potential of robotic-based technologies
Methods	Randomized controlled trial
Participants	Inclusion criteria: • Age: 65 and older • Hoehn and Yahr scale: 1 to 3 • "FAC ≤ 2" • Ranking scale score ≤ 3 • Stability of drug treatment for at least 1 month • Geriatric Depression Scale 5-items: negative Sample size (planned): 195 Sample size (actual): NR
Interventions	Virtual reality games vs. robotic treadmill vs. traditional physical rehabilitation therapy
Outcomes	Tinetti performance-oriented mobility assessment (POMA), walking speed through instrumental Gait Analysis, Falls Efficacy Scale - International short form (FES-I Short form)
Starting date	Study start: 2019 Study completion: 2022 Recruitment status: recruiting
Contact information	r.bevilacqua@inrca.it
Notes	bmcneurol.biomedcentral.com/articles/10.1186/s12883-020-01759-4

ChiCTR1900022621

Study name	The effect of rehabilitation on physical function in patients with Parkinson's disease
Methods	Randomized controlled trial
Participants	Inclusion criteria: • Age: < 75 years • People diagnosed with Parkinson's Syndrome in accordance with the 2015 International Diagnostic Association (MDS) Diagnostic Criteria and the Chinese Parkinson's Disease Diagnostic Criteria Sample size (planned): 80 Sample size (actual): NR
Interventions	Rehabilitation vs. usual care
Outcomes	Motor function
Starting date	Study start: 2019 Study completion: 2021 Recruitment status: not yet recruiting
Contact information	zhu36121209@sina.com wywjl2009@hotmail.com
Notes	www.chictr.org.cn/showproj.aspx?proj=34905

ChiCTR2000029025

Study name	The effect of LSVT BIG treatment on motor and nonmontor symtoms [sic] in patients with Parkinson's disease
Methods	Randomized controlled trial
Participants	Inclusion criteria: • Age: 30 to 85 years old • Diagnosed with primary Parkinson's disease: Hoehn and Yahr stages 1 to 3 • Stable anti-parkinsonism medication at 1 month before study initiation and at the end of follow-up Sample size (planned): 30 Sample size (actual): NR
Interventions	LSVT BIG treatment vs. non-rehabilitation
Outcomes	UPDRS-M, PDQ-8, Non-Motor Symptoms Scale (NMSS), TUG, Box and Block-Test (BBT), BDI-II,
Starting date	Study start: 2020 Study completion: NR

ChiCTR2000029025 *(Continued)*

	Recruitment status: recruiting
Contact information	taoenxiang@163.com
Notes	www.chictr.org.cn/showproj.aspx?proj=44830

ChiCTR2000029135

Study name	Effects of innovative tai chi on motor symptoms in patients with mild to moderate Parkinson's disease
Methods	Randomized controlled trial
Participants	Inclusion criteria: • Age: 40 to 70 years • Primary Parkinson's disease diagnostic standards that meet the 2016 Chinese PD Diagnostic Standards • Meet the improved Hoehn and Yahr clinical grading standard grades 1 to 2.5 • Those who take the base dose of medopa have a stable effect Sample size (planned): 40 Sample size (actual): NR
Interventions	Innovative tai chi exercise vs. stretching training
Outcomes	UPDRS-M, BBS, TUG, functional reach test, PDQ-39, height, weight, pressure, heart rate, stability limit
Starting date	Study start: 2020 Study completion: NR Recruitment status: data analysis completed
Contact information	wangru0612@163.com
Notes	www.chictr.org.cn/showproj.aspx?proj=48394

ChiCTR2000036306

Study name	A prospective cohort study of exercise rehabilitation in the treatment of Parkinson's disease and its mechanism
Methods	Randomized controlled trial
Participants	Inclusion criteria: • People with primary Parkinson's disease who meet the clinical diagnostic criteria of MDS • People with early Parkinson's disease with HY stage 1 to 2.5 • Aged 50 to 70 years old • Primary school grade 6 and above with educational attainment • Sedentary lifestyle, no regular or regular exercise history in the past 2 years

ChiCTR2000036306 *(Continued)*

	• The drug treatment regimen remains stable for at least 3 months, and the treatment regimen remains unchanged during the follow-up period • Can walk or live independently • MMSE score is greater than or equal to 24 Sample size (planned): 90 Sample size (actual): NR
Interventions	Tai chi training vs. brisk walking training vs. no intervention
Outcomes	UPDRS, TUG, BBS, Parkinson's Disease Cognitive Rating Scale (PD-CRS), plasma metabonomics, brain magnetic resonance imaging
Starting date	Study start: 2020 Study completion: 2023 Recruitment status: recruiting
Contact information	huangpei699@126.com
Notes	www.chictr.org.cn/showproj.aspx?proj=58856

ChiCTR2000037178

Study name	A prospective clinical study of innovative Wuqinxi exercise intervention in delaying the occurrence of freezing of gait in Parkinson's disease
Methods	Randomized controlled trial
Participants	Inclusion criteria: • People who were diagnosed with PD according to the 2015 international MDS PD criteria • No history of FOG (N-FOG-Q score = 0) • PD patients at high risk of developing FOG (the risk value was accounted according to our established predicting model for FOG) • Having received a stable anti PD medication therapy for at least 2 months • Aged ranging from 45 to 85 years old. Sample size (planned): 100 Sample size (actual): NR
Interventions	Innovative Wuqinxi vs. low intensity stretching exercise
Outcomes	Incidence of freezing of gait, MDS-UPDRS-M, Frontal Assessment Battery (FAB), Clinical Global Impression Scale (CGI-Skala), PDQ-39, Bold signal of activated brain areas, Apathy scale score, Hamilton Anxiety Rating Scale (HAM-A), Hamilton Depression Scale
Starting date	Study start: 2020 Study completion: NR Recruitment status: recruiting
Contact information	ganjing67@126.com

ChiCTR2000037178 *(Continued)*

Notes	www.chictr.org.cn/showproj.aspx?proj=60001

ChiCTR2000037305

Study name	A randomized controlled study of multifactorial interventions to prevent early cognitive decline in elderly people
Methods	Randomized controlled trial
Participants	Inclusion criteria: • Age: 60 years old or older • One or more of the following diseases: family history of dementia, diabetes, hypertension, hyperlipidemia, ischemic heart disease, atrial fibrillation, smoking, drinking, obesity, weight loss, after 65-year-old history of Parkinson's disease, cerebrovascular disease, depression, chronic kidney disease (CKD), low level of education, the lack of physical and mental activity and low social support, etc. • Existing mild cognitive impairment (namely MMSE score: illiteracy 18 to 27) Sample size (planned): 290 Sample size (actual): NR
Interventions	Comprehensive intervention vs. health education
Outcomes	MMSE, Mini Nutritional Assessment, Cooper Healthy Lifestyle Questionnaire, Pittsburgh sleep quality index, atherosclerotic cardiovascular disease (ASCVD) 10-year risk forecasting model, Patient Health Questionnaire-9, 6-MIN-W
Starting date	Study start: 2020 Study completion: NR Recruitment status: recruiting
Contact information	mawenlin@tongji.edu.com
Notes	www.chictr.org.cn/showprojen.aspx?proj=60460

ChiCTR2000037384

Study name	A clinical study of innovative Wuqinxi exercise therapy delaying the occurrence of motor complications of Parkinson's disease
Methods	Randomized controlled trial
Participants	Inclusion criteria: • Age: 40 to 75 years old • People who has been clinically diagnosed with Parkinson's disease according to the 2015 international MDS PD criteria • People at HY grades 1 and 2 • Have been treated with stable anti-Parkinson medications • Could walk independently

ChiCTR2000037384 *(Continued)*

	Sample size (planned): 60 Sample size (actual): NR
Interventions	Innovative "Wuqinxi" exercise therapy in combination with routine anti-PD medication treatment vs. routine exercise in combination with routine anti-PD medication treatment
Outcomes	The time point of motor complication (wearing-off phenomenon), MDS-UPDRS-M, Non-Motor Symptoms Questionnaire (PD-NMSQ30), gait parameters, activated brain areas and network, PDQ-8, Clinical Global Impressions Scale (CGI)
Starting date	Study start: 2020 Study completion: NR Recruitment status: recruiting
Contact information	liuzhenguo@xinhuamed.com.cn
Notes	www.chictr.org.cn/showproj.aspx?proj=60280

CTRI/2018/05/014241

Study name	A clinical trial to study the effect of exercises in early stage Parkinson's disease
Methods	Randomized controlled trial
Participants	Inclusion criteria: • Age: From 18 to 99 years • Gender: both male and female • Newly diagnosed Parkinson's disease, Hoehn and Yahr stage 1 or 2 • On stable pharmacological regimes during the study and for 6 months before entry into the study Sample size (planned): 30 Sample size (actual): 40
Interventions	Active strengthening exercises vs. passive strengthening exercises
Outcomes	UPDRS I, II, III, VI, quality of life (PDQ-39)
Starting date	Study start: 2018 Study completion: 2019 Recruitment status: completed, no results posted
Contact information	wadhwadr@gmail.com
Notes	www.ctri.nic.in/Clinicaltrials/pmaindet2.php?trialid=23331

CTRI/2019/06/019618

Study name	Benefits of yoga on daily activities and quality of life for individuals with Parkinson's disease

CTRI/2019/06/019618 *(Continued)*

Methods	Randomized controlled trial
Participants	Inclusion criteria: • Hoehn and Yahr scale: 1 to 3 • Able to follow simple commands • Pull test < 3 Sample size (planned): 34 Sample size (actual): NR
Interventions	Yoga vs. standard physical therapy
Outcomes	UPDRS, Adenbrook Cognitive Examination - Revised, BESTest, PDQ-39, BDI
Starting date	Study start: 2019 Study completion: 2022 Recruitment status: not yet recruiting
Contact information	karthikbabu78@gmail.com
Notes	trialsearch.who.int/?TrialID=CTRI/2019/06/019618

CTRI/2020/06/025794

Study name	Consequence of Pilates on imbalance, movability and core stability in patients with Parkinson disease
Methods	Randomized controlled trial
Participants	Inclusion criteria: • Age: 50 to 80 years old • People with Parkinson's disease • Balance instability • Core instability • Decreased mobility • Exertion Sample size (planned): 17 Sample size (actual): NR
Interventions	Pilates vs. simple walking
Outcomes	Mini-BESTest Scale, Lindop Parkinson Rating Scale
Starting date	Study start: 2020 Study completion: NR Recruitment status: not yet recruiting

CTRI/2020/06/025794 *(Continued)*

Contact information	jaspreet_malik16@yahoo.co.in
Notes	www.ctri.nic.in/Clinicaltrials/pmaindet2.php?trialid=37645

DRKS00018841

Study name	Therapeutischer Einfluss von Laufbandtherapie vs. Physiotherapie ohne Laufband auf das Dual-Task-Verhalten während des Gehens bei Parkinsonpatienten
Methods	Randomized controlled trial
Participants	Inclusion criteria: • Age: 20 to 80 years old • Idiopathic Parkinson's disease • Hoehn and Yahr Stages 1 to 3 • Free walking on a treadmill for a period of 25 minutes • Must be cognitively able to perform the required tasks Sample size (planned): 100 Sample size (actual): 100
Interventions	Treadmill therapy vs. physiotherapy
Outcomes	Gait analysis, MDS-UPDRS-M, BBS
Starting date	Study start: 2019 Study completion: 2021 Recruitment status: completed
Contact information	W.Jost at parkinson-klinik.de
Notes	www.drks.de/drks_web/navigate.do?navigationId=trial.HTML&TRIAL_ID=DRKS00018841

Gooßes 2020

Study name	Feasibility of music-assisted treadmill training in Parkinson's disease patients with and without deep brain stimulation: insights from an ongoing pilot randomized controlled trial
Methods	Randomized controlled trial
Participants	Inclusion criteria: • Clinical diagnosis of idiopathic PD (according to UK Brain Bank Criteria) and confirmed by a neurologist • Non-demented (score ≥ 17 in the MoCA) • No clinically relevant depression (score ≤ 10 on the Geriatric Depression Scale—GDS), or other concurrent neurologic or psychiatric illness • No orthopedic or cardiac contraindication to performing the training Sample size (planned): NR

Gooßes 2020 *(Continued)*

	Sample size (actual): 32
Interventions	Music-assisted treadmill training (MATT) vs. ergometer training
Outcomes	Adverse events (e.g. abortions of single training sessions, cardiovascular incidences, falls or almost falls during/after MATT; extreme fatigue that caused the cancellation of other training sessions after the MATT session or ergometer training); participants' subjective training perception, including mood, motivation, exhaustion, and fun (four-point Likert scale, e.g. "very happy," "rather happy," "rather unhappy," and "very unhappy"; "not exhausted at all," "hardly exhausted," "little exhausted," and "very exhausted")
Starting date	Study start: 2019 Study completion: NR Recruitment status: NR
Contact information	elke.kalbe@uk-koeln.de
Notes	www.frontiersin.org/articles/10.3389/fneur.2020.00790/full#h3

Hackney 2020

Study name	Rationale and design of the PAIRED Trial: partnered dance aerobic exercise as a neuroprotective, motor, and cognitive intervention in Parkinson's disease
Methods	Randomized controlled trial
Participants	Inclusion criteria: • Age: 40 years and older • Diagnosis of Parkinson's disease • Hoehn and Yahr stage 1 to 3 • ≥1 on UPDRS-IV item 4.3 • PD diagnosis based on established criteria and determined by a board-certified neurologist with training in movement disorders • At least 3 of the cardinal signs (rigidity, bradykinesia, tremor, postural instability) • Show clear symptomatic benefit from antiparkinsonian medications Sample size (planned): 102 Sample size (actual): NR
Interventions	Partnered dance aerobic exercise vs. walking aerobic exercise
Outcomes	BDI II, the Composite Physical Function index, Physical Activity Scale for the Elderly, PDQ-39, SF-12, five-item Satisfaction with Life Scale, Multidimensional Scale of Perceived Social Support (MSPSS), MDS-UPDRS parts I–IV, spatial function (reverse Corsi blocks), Brooks spatial memory, Benton's judgment of line orientation, executive function (Trail Making Test, Tower of London), 6-MIN-W, spatiotemporal parameters (6-meter computerized GAITRite walkway), Mini-BESTest, dynamic gait index, TUG, four-square step test, VO_2 max and initial fitness level (Young Men's Christian Association's [YMCA] submaximal test), Neuromelanin-sensitive MRI (NM-MRI), $T2^*$-weighted blood-oxygen-level-dependent (BOLD), Magnetization Prepared Rapid Gradient-Echo (MPRAGE)
Starting date	Study start: NR Study completion: NR

Hackney 2020 *(Continued)*

	Recruitment status: NR
Contact information	mehackn@emory.edu
Notes	www.frontiersin.org/articles/10.3389/fneur.2020.00943/full#h13

Li 2021

Study name	Improvement of freezing of gait in patients with Parkinson's disease by music exercise therapy: a study protocol for a randomized controlled trial
Methods	Randomized controlled trial
Participants	Inclusion criteria: • Complying with the diagnostic criteria • Aged 40 to 85 years • The participant's vital signs are stable, conscious and can cooperate well with the evaluation-level treatment • Slow onset • Static tremor, stiffness and motor decline in at least two of the three items • Levodopa treatment is effective, and symptoms fluctuate and motor disorders occur after many years of application Sample size (planned): 60 Sample size (actual): NR
Interventions	Stretch training combined with music and exercise therapy vs. routine rehabilitation therapy
Outcomes	Parkinson Comprehensive Score Scale, 6-MIN-W, ADL
Starting date	Study start: 2019 Study completion: 2021 Recruitment status: not yet recruiting
Contact information	xyfyli@163.com
Notes	www.chictr.org.cn/showproj.aspx?proj=43563

Lima 2020

Study name	Effects of a power strength training using elastic resistance exercises on the motor and non-motor symptoms in patients with Parkinson's disease H&Y 1–3: study protocol for a randomised controlled trial (PARK-BAND Study)
Methods	Randomized controlled trial
Participants	Inclusion criteria: • Diagnosis of Parkinson's disease according to the UK PD Brain Bank Diagnostic Criteria • Stages 1 to 3 according to the modified Hoehn and Yarh scale

Lima 2020 *(Continued)*

	• Stable anti-parkinsonian medication regime for at least 4 weeks before the intervention • Independent in basic daily living activities according to Schwab and England score greater or equal to 80% • Age of 40 years or more Sample size (planned): 50 Sample size (actual): NR
Interventions	Power training with elastic bands and resistance tubes vs. health education
Outcomes	UPDRS, Short Physical Performance Battery (SPPB), PDQ-39, Pittsburgh Sleep Quality Index (IQSP), Epworth Sleepiness Scale (ESE), Parkinson's Disease Sleep Rating Scale (PDSS), REM sleep disorders screening questionnaire - Brazilian version (QRDCSR-BR), sleep latency, total sleep time, frequency of awakening, sit and stand test five times (TSL5x), 4-meter walk test, Fall Effectiveness Scale - International (FES-I), assessing knee extensor and flexor strength, number of falls, new freezing of gait questionnaire (N-FOG-Q)
Starting date	Study start: 2020 Study completion: 2022 Recruitment status: not yet recruiting
Contact information	
Notes	ensaiosclinicos.gov.br/rg/RBR-5w2sqt

Mayoral-Moreno 2021

Study name	Falls prevention and quality of life improvement by square stepping exercise in people with Parkinson's disease: project report
Methods	Randomized controlled trial
Participants	Inclusion criteria: • ≥18 years old • Diagnosed with Parkinson's disease, in stages 1 to 3, according to HY scale • No pathology that contraindicates the physical exercise program • The Physical Activity Fitness Questionnaire (PAR-Q) will be administered to find out if they are living with diseases that prevent physical load • Not be suffering from moderate and severe cognitive impairment, determined by Mini Mental State Examination scores Sample size (planned): 60 Sample size (actual): NR
Interventions	Square Stepping Exercise training program vs. usual care
Outcomes	Applicability (percentage of participants who are able to perform the set exercise), safety (documentation of difficulties/injuries), balance (L-Test, TUG), number of falls, fear of falling (FES-I), physical condition (2-minute walking test), lower extremity strength (stand up and sit on a chair for 30 s), speed (Brisk Walking Test), Functional Reach Test, Short Physical Performance Battery (SPPB), International Fitness Scale (International Fitness Scale-IFIS), Brief International Cognitive

Mayoral-Moreno 2021 *(Continued)*	
	Assessment (BICAMS), PDQ-8, BDI-II, Perceived Functional Social Support (Duke-UNC), Anticipatory Cognitions Questionnaire (ACQ)
Starting date	Study start: NR Study completion: NR Recruitment status: NR
Contact information	mmayoralm@unex.es
Notes	www.mdpi.com/2075-4426/11/5/361

NCT02457832	
Study name	Motor training in PD
Methods	Randomized controlled trial
Participants	Inclusion Criteria: • Age: 40 to 70 years • Able to walk with or without an assistive device 10 feet • Best corrected/aided acuity better than 20/70 in the better eye • Absence of dementia or vascular cognitive impairment • Absence of primary memory deficits Samples size (planned): 99 Sample size (actual): NR
Interventions	Internally guided exercise vs. externally guided exercise vs. behavioural control vs. normal control
Outcomes	Percent signal change, connectivity strength
Starting date	Study start: 2014 Study completion: 2023 Recruitment status: active, not recruiting
Contact information	Madeleine E. Hackney, Atlanta VA Medical and Rehab Center, Decatur
Notes	clinicaltrials.gov/ct2/show/record/NCT02457832

NCT03244813	
Study name	Evaluation of the impact of a personalized program of adapted physical activates [sic] in patients with Parkinson disease (ACTIPARK)
Methods	Randomized controlled trial
Participants	Inclusion criteria: • Age: 40 to 80 years old • The participant has experienced symptoms of Parkinson's disease for at least 5 years and is in a stable state (no medical event or change of treatment in at least 1 month)

NCT03244813 *(Continued)*

	• The functional impact and duration of fluctuations is ≥ 3 (MDS UPDRS) • The participant can walk autonomously, including using a technical aid Sample size (planned): NR Sample size (actual) :19
Interventions	Adapted physical activity vs. usual care
Outcomes	Weekly activity, quality of life (PDQ-39), risk of fall (TUG, Tinneti Falls Efficacy Scale, 0 to 10 scale), endurance (6-minute walk test), activity of care giver, burden of care giver, grip strength (pinch test), patient dependence (activities of daily living), dementia
Starting date	Study start: 2018 Study completion: 2019 Recruitment status: completed, no results posted
Contact information	
Notes	clinicaltrials.gov/ct2/show/record/NCT03244813

NCT03343574

Study name	Cardiovascular effects of exercise in patients with Parkinson's disease
Methods	Randomized controlled trial
Participants	Inclusion criteria: • Age: 40 to 90 years old • Gender: both • Clinical diagnosis of Parkinson's Disease • Between stages 2 and 4 of Hoehn and Yahr classification of Parkinson's disease Sample size (planned): 300 Sample size (actual): NR
Interventions	Abdominal strengthening exercise vs. usual care
Outcomes	Blood pressure, heart rate, composite autonomic severity score, Middle Cerebral Artery flow velocity, oxy-/deoxy-haemoglobin ratio, Composite Autonomic Symptom Scale (COMPASS), orthostatic hypotension, dizziness
Starting date	Study start: 2017 Study completion: 2020 Recruitment status: active, not recruiting
Contact information	Mandar Jog, Western University, London
Notes	clinicaltrials.gov/ct2/show/record/NCT03343574

NCT03560089

Study name	Serious games rehabilitation programme to treat gait and balance disorders in PD patients (PARKGAME-II)
Methods	Randomized controlled trial
Participants	Inclusion criteria: • Age: 18 to 75 years old • Gender: both • Parkinson's disease • Gait and balance disorders resistant to dopaminergic medication Sample size (planned): 50 Sample size (actual): NR
Interventions	Serious game vs. placebo serious game
Outcomes	TUG, step length, step velocity, MDS-UPDRS, gait, PD-QoL, cognitive function (Montreal Cognitive Assessment)
Starting date	Study start: 2018 Study completion: 2021 Recruitment status: recruiting
Contact information	marielaure.welter@icm-institute.org
Notes	clinicaltrials.gov/ct2/show/record/NCT03560089

NCT03563807

Study name	Golf instruction versus tai chi for people with Parkinson's disease
Methods	Randomized controlled trial
Participants	Inclusion criteria: • Age: > 18 • Gender: both male and female • A diagnosis of Parkinson's disease by a movement disorders specialist, HY stage 2 to 3 in the "on" state treated with Parkinson's disease medications • Participants must be capable of providing informed consent and complying with trial procedures including transportation to and from classes • Participants who are engaged in physical therapy or other exercise programs must be at a stable regimen for 60 days prior to the start of the study and must be willing to maintain their current regimen for the duration of the study Sample size (planned): 35 Sample size (actual): NR
Interventions	Golf vs. tai chi
Outcomes	Tolerability, safety, balance (Mini-BESTest), activity-specific balance confidence

NCT03563807 *(Continued)*

Starting date	Study start: 2018 Study completion: 2020 Recruitment status: completed, no results posted
Contact information	
Notes	clinicaltrials.gov/ct2/show/record/NCT03563807

NCT03582371

Study name	Aqua stand-up paddle balance effect in Parkinson's disease (AquaSUP PARK)
Methods	Randomized controlled trial
Participants	Inclusion criteria: • Age: 18 to 80 years old • Idiopathic Parkinson's disease according to the criteria of the UK Parkinson's Disease Society Brain Bank Clinical Diagnostic • Presence of balance disorder: Hoehn and Yahr stage 2.5 to 4 • Motor level stable, without change of treatment in last 6 weeks • Participants affiliated to a social security scheme or beneficiary of an equivalent scheme Sample size (planned): 96 Sample size (actual): NR
Interventions	Stand-up paddle rehabilitation vs. physiotherapy rehabilitation
Outcomes	Balance (BBS), MDS-UPDRS-M, cognitive function, TUG, functional capacity, 2-minute walking test, PDQ-39, mental health (Beck Depression Inventory)
Starting date	Study start: 2018 Study completion: 2022 Recruitment status: recruiting
Contact information	FLABEAU Olivier, Centre Hospitalier de la côte Basque
Notes	clinicaltrials.gov/ct2/show/record/NCT03582371

NCT03711955

Study name	Comparing the effects of instability resistance training versus aerobic training on cognitive and motor improvements found in Parkinson's disease participants
Methods	Randomized controlled trial
Participants	Inclusion criteria: • Age: 50 to 80 years old • Idiopathic Parkinson's disease

NCT03711955 *(Continued)*

	• On stable medication (dopaminergic medication) • Hoehn and Yahr stage between 2 and 3 • No other neurological disorder • No significant arthritis, cardiovascular disease, and cognitive impairment by Mini Mental State Examination (score < 23) Sample size (planned): 30 Sample size (actual): NR
Interventions	Aerobic training vs. instability training
Outcomes	Executive function (MoCA), gait variability (TUG), motor/non-motor symptoms (UPDRS)
Starting date	Study start: 2019 Study completion: 2020 Recruitment status: recruiting
Contact information	Alisha Mistry, Movement Disorder Research and Rehabilitation Center
Notes	clinicaltrials.gov/ct2/show/record/NCT03711955

NCT03751371

Study name	Robotic walking device to improve mobility in Parkinson's disease
Methods	Randomized controlled trial
Participants	Inclusion criteria: • Diagnosis of idiopathic Parkinson's disease • Age: from 50 to 80 years • Able to ambulate without assistance (Hoehn and Yahr stages 1 to 3) • On stable doses of Parkinson's medications for at least 4 weeks prior to the study Sample size (planned): 46 Sample size (actual): NR
Interventions	Training with Honda Walking Assist (HWA) device vs. usual care
Outcomes	Gait velocity, 6-minute walk test, stride length, double support time, swing time, perceived ease of walking, self-efficacy, number of steps, time spent walking, number of falls, adverse events, freezing of gait
Starting date	Study start: 2019 Study completion: 2021 (estimated)
Contact information	Anne Kloos, Ohio State University
Notes	clinicaltrials.gov/ct2/show/record/NCT03751371

NCT03833349

Study name	The impact of three distinct exercise types on fatigue, anxiety, and depression in Parkinson's disease (PDExercise)
Methods	Randomized controlled trial
Participants	Inclusion criteria: • People diagnosed with idiopathic Parkinson's disease • Age: 18 to 75 years • Hoehn and Yahr stage less than or equal to 3 • Mini Mental State Exam (MMSE) score of over 23 at screening • If participants are taking any medications for depression, fatigue, or anxiety, regimen must be stable for 8 weeks prior to baseline visit • Participants willing and able to give informed consent Sample size (planned): 24 Sample size (actual): NR
Interventions	Spinning class vs. yoga class vs. dance class
Outcomes	Fatigue (FSS), anxiety (Zung's self-reported anxiety scale), depressive symptoms (Beck Depression Inventory II)
Starting date	Study start: 2019 Study completion: 2019 Recruitment status: completed, no results posted
Contact information	Mary Feldman
Notes	clinicaltrials.gov/ct2/show/study/NCT03833349

NCT03860649

Study name	Effects of different physical therapies and dance in people with Parkinson's disease
Methods	Randomized controlled trial
Participants	Inclusion criteria: • Age: over 40 years • Gender: both sexes • Clinical diagnosis of idiopathic Parkinson's disease, staging between 1 and 4 in Hoehn and Yahr scale Sample size (planned): NR Sample size (actual): 100
Interventions	Nordic walking vs. jogging vs. dance vs. Pilates training
Outcomes	TUG, Locomotor Rehabilitation Index (LRI), walking speed (self-selected, optimal), quality of life (PDQ-39), cognitive function (MoCA, MMSE, GDS), FOG-Q, UPDRS

NCT03860649 *(Continued)*

Starting date	Study start: 2018 Study completion: 2022 Recruitment status: active, not recruiting
Contact information	Leonardo A. Peyré-Tartaruga, Federal University of Rio Grande do Sul
Notes	clinicaltrials.gov/ct2/show/record/NCT03860649

NCT03882879

Study name	Kick out Parkinson's Disease 2
Methods	Randomized controlled trial
Participants	Inclusion criteria: • Age: 30 to 90 years old • Gender: both • Diagnosed with Parkinson's disease by a treating healthcare provider Sample size (planned): NR Sample size (actual): 52
Interventions	Karate classes vs. usual exercise routine then karate classes
Outcomes	Mobility (TUG), well-being (Patient Global Impression of Change Scale), depression and anxiety, quality of life (PDQ-39), cognitive abilities, "Instrumented" TUG (i-TUG), "Instrumented-WALK (i-WALK)", "Instrumented-SWAY (i-SWAY)"
Starting date	Study start: 2019 Study completion: 2020 Recruitment status: completed
Contact information	Jori Fleisher, Rush University Medical Center
Notes	clinicaltrials.gov/ct2/show/record/NCT03882879

NCT03960931

Study name	Interest of hydrophysiotherapy care in Parkinson disease's motor and non-motor symptoms (THERMAPARK)
Methods	Randomized controlled trial
Participants	Inclusion criteria: • Age: 18 to 75 years old • Suffering from Parkinson's disease (stage 2 or 3 of Hoehn and Yahr) • Motor fluctuation lower than 25% of awaked time • Dyskinesia lower than 25% of awake time (according to MDS-UPDRS scale)

NCT03960931 *(Continued)*

	• Stable pharmacological treatment during the 30 days before study • Already benefiting from physiotherapy Sample size (planned): 126 Sample size (actual): NR
Interventions	Aquatic rehabilitation vs. land-based physical activities vs. conventional rehabilitation
Outcomes	PDQ-39, anxiety (PAS), pain (visual analogue scale 0 to 10), TUG, walking distance and velocity, step height/length/width
Starting date	Study start: 2019 Study completion: 2021 Recruitment status: not yet recruiting
Contact information	
Notes	clinicaltrials.gov/ct2/show/record/NCT03960931

NCT03972969

Study name	Highly challenging balance program to reduce fall rate in PD
Methods	Randomized controlled trial
Participants	Inclusion criteria: • Age: 40 to 89 years old • Physician diagnosis of idiopathic Parkinson's disease • At least 2 of the 3 cardinal signs of PD (resting tremor, rigidity, bradykinesia) • Response to dopaminergic medication Sample size (planned): 162 Sample size (actual): NR
Interventions	Facility-based exercise vs. remote exercise vs. health education
Outcomes	Falls
Starting date	Study start: 2019 Study completion: 2023 Recruitment status: recruiting
Contact information	David.Sparrow@va.gov
Notes	clinicaltrials.gov/ct2/show/record/NCT03972969

NCT03974529

Study name	Intensive running exercise improves Parkinson's motor and non-motor symptoms
Methods	Randomized controlled trial
Participants	Inclusion criteria: • Age: 40 to 60 years old • Participants with idiopathic Parkinson's disease • Participants who are able to walk independently without walking aids for a distance of 30 meters Sample size (planned): 30 Sample size (actual): NR
Interventions	Intensive running vs. physiotherapy
Outcomes	UPDRS, PDQ-39, endurance, gait, Mini-BESTest, mood
Starting date	Study start: 2018 Study completion: 2020 Recruitment status: recruiting
Contact information	Danny TM Chan, Chinese University of Hong Kong
Notes	clinicaltrials.gov/ct2/show/record/NCT03974529

NCT03983785

Study name	The effect of Pilates and elastic taping on balance and postural control in early Parkinson's disease
Methods	Randomized controlled trial
Participants	Inclusion criteria: • Diagnosis of idiopathic Parkinson's disease • Mini Mental Test Score ≥ 24 • Modified Hoehn and Yahr Score ≤ 2 • Ability to stand 1 minute independently • Ability to walk 10 meters Sample size (planned): 31 Sample size (actual): NR
Interventions	Pilates vs. elastic taping vs. no intervention
Outcomes	Balance, postural control
Starting date	Study start: 2017 Study completion: 2020 Recruitment status: completed, no results posted

NCT03983785 *(Continued)*

Contact information	Evrim Goz, Dokuz Eylul University
Notes	clinicaltrials.gov/ct2/show/record/NCT03983785

NCT04000360

Study name	Pragmatic cyclical lower extremity exercise trial for Parkinson's disease
Methods	Randomized controlled trial
Participants	Inclusion criteria: • Adults with a diagnosis of idiopathic Parkinson's disease by a physician or physician extender • Hoehn and Yahr stage 1 to 3 • Demonstrate the ability to safely mount and dismount the Peloton stationary cycle Sample size (planned): 250 Sample size (actual): NR
Interventions	High-intensity aerobic exercise vs. usual care
Outcomes	MDS-UPDRS-M, nine-hole peg test, processing speed
Starting date	Study start: 2019 Study completion: 2024 Recruitment status: recruiting
Contact information	jansena@ccf.org
Notes	clinicaltrials.gov/ct2/show/record/NCT04000360

NCT04046276

Study name	Intensity of aerobic training and neuroprotection in Parkinson's disease (AEROPROTECT)
Methods	Randomized controlled trial
Participants	Inclusion criteria: • Age: > 18 years old • Diagnosis of Parkinson's disease according to the UKPDSBB criteria • Previous MRI available, to further help distinguish idiopathic PD from atypical parkinsonism Hoehn and Yahr stage 1 to 3 in 'off' state Sample size (planned): 69 Sample size (actual): NR
Interventions	Conventional therapy vs. medium-intensity aerobic exercise vs. high-intensity aerobic exercise

NCT04046276 *(Continued)*

Outcomes	MDS-UPDRS-M, mobility (2-minute walking test, 20-meter up and go test, Global Mobility Task (GMT)), upper limb performance, aerobic capacity, MoCA, digit span task, trail making test
Starting date	Study start: 2019 Study completion: 2021 Recruitment status: not yet recruiting
Contact information	jean-michel.gracies@aphp.fr
Notes	clinicaltrials.gov/ct2/show/record/NCT04046276

NCT04063605

Study name	The effect of clinical Pilates training on balance and postural control of people with Parkinson's disease
Methods	Randomized controlled trial
Participants	Inclusion criteria: • Age: 45 to 70 years old • Stage 2 to 3 of Modified Hoehn and Yahr Scale • 26 or > 26 points on the Mini Mental test • Having had Parkinson's disease at least 2 years Sample size (planned): 38 Sample size (actual): 40
Interventions	Clinical Pilates vs. classic physiotherapy
Outcomes	One-leg stance test, tandem stance test, Functional reach test, Sit-to-stand test, TUG, BBS
Starting date	Study start: 2019 Study completion: 2022 Recruitment status: completed
Contact information	Beliz Belgen Kaygisiz, European University of Lefke
Notes	clinicaltrials.gov/ct2/show/record/NCT04063605

NCT04122690

Study name	Partnered dance aerobic exercise as a neuroprotective, motor and cognitive intervention in Parkinson's disease (PDAE in PD)
Methods	Randomized controlled trial
Participants	Inclusion criteria: • Age: older than 40 years

NCT04122690 *(Continued)*

	• Montreal Cognitive Assessment (MoCA) score > 17 • Able to walk with or without an assistive device at least 10 feet • Best corrected/aided acuity better than 20/70 in the better eye • Willingness to be randomized to either group • HY stages 1 to 3 • Report 'off' times (reporting > 0 on item 4.3 of the UPDRS-IV) Sample size (planned): 150 Sample size (actual): NR
Interventions	Partnered dance aerobic exercise vs. walking aerobic exercise
Outcomes	MDS-UPDRS-M, visuospatial working memory (Corsi blocks), endurance (6-minute walk test), change in iron accumulation, cardiovascular output, spatial cognition, change in loss of neuromelanin, executive function, orientation, gait, attention, spatial imagery, Mini-BESTest, 4 square step test, dynamic gait index, PDQ-39, self-reported daily activities, satisfaction, Multidimensional Scale of Perceived Social Support (MSPSS)
Starting date	Study start: 2020 Study completion: 2024 Recruitment status: recruiting
Contact information	mehackn@emory.edu
Notes	clinicaltrials.gov/ct2/show/record/NCT04122690

NCT04135924

Study name	Influence of trainning [sic] in Parkinson's disease
Methods	Randomized controlled trial
Participants	Inclusion criteria: • Age: 55 to 75 years old • No cognitive impairment • Mini Mental State Examination with scores above 23 • Clinical diagnosis of Parkinson's disease in grade 2 to 3 on the modified Hoehn and Yahr scale Sample size (planned): 40 Sample size (actual): NR
Interventions	Nordic walking plus respiratory training vs. Nordic walking vs. respiratory training
Outcomes	Measurement of lipid peroxidation, respiratory function
Starting date	Study start: 2019 Study completion: 2020 Recruitment status: recruiting
Contact information	Rodrigo Santiago Barbosa Rocha, Universidade Metodista de Piracicaba

NCT04135924 *(Continued)*

Notes	clinicaltrials.gov/ct2/show/record/NCT04135924

NCT04194762

Study name	PARK-FIT. Treadmill vs cycling in Parkinson's disease. Definition of the most effective model in gait reeducation
Methods	Randomized controlled trial
Participants	Inclusion criteria: • Participant is diagnosed with idiopathic Parkinson's disease according to criteria from the United Kingdom Parkinson's Disease Society Brain Bank (UKPDSBB) • HY less than or equal to 2 • Stable drug treatment in the six weeks prior to the start of training and during the study Sample size (planned): 48 Sample size (actual): 48
Interventions	Treadmill training vs. cycling
Outcomes	Step length, MDS-UPDRS-M, PDQ-39
Starting date	Study start: 2019 Study completion: 2020 Recruitment status: recruiting
Contact information	sabela.novo@salud.madrid.org
Notes	clinicaltrials.gov/ct2/show/record/NCT04194762

NCT04215900

Study name	High-Speed yoga and executive function
Methods	Randomized controlled trial
Participants	Inclusion criteria: • Men and women between 50 and 85 years of age • Diagnosis of Parkinson's Disease (Hoehn and Yahr scale 1 to 3) • Ability to ambulate with or without an assistive device for at least 50 feet • Ability to get up and down from the floor with minimal assistance • No medical contraindication to participation in an exercise program including unstable or active untreated major medical illness • A score of 23 or above on the Montreal Cognitive Assessment • Not currently participating in yoga more than one time per week Sample size (planned): 90 Sample size (actual): NR

NCT04215900 *(Continued)*

Interventions	High-Speed multi-directional yoga vs. wait-list control
Outcomes	MoCA, executive function (Wisconsin Card Sort task, Inhibition of Cognitive Inference, Visual Spatial Ability and Task-switching), Stroop color word test, 6-MIN-W, body weight, fat-free mass, Mini-BESTest, TUG, PDQ-39, Reactive Balance Distance and Time, Modified Fall Efficacy Scale, UPDRS-M
Starting date	Study start: 2020 Study completion: 2021 Recruitment status: suspended
Contact information	Joseph Signorile, University of Miami
Notes	clinicaltrials.gov/ct2/show/record/NCT04215900

NCT04379778

Study name	Aerobic exercise and brain health in Parkinson's
Methods	Randomized controlled trial
Participants	Inclusion criteria: • Age: ≥ 40 years • Idiopathic Parkinson's disease diagnosis (within the previous five years) • Participants in symptomatic therapy / not in therapy • Participants who are not already taking medication are not expected to need medication within 6 months of inclusion (in case of drug startup, this is noted) • Hoehn and Yahr ≤ 3 • Ability to transport oneself to and from exercise and testing Sample size (planned): 70 Sample size (actual): NR
Interventions	Aerobic exercise vs. standard care
Outcomes	Effective transverse relaxation rate; quantitative susceptibility mapping (QSM MRI); Diffusional Kurtosis Imaging (DKI MRI); neuromelanin MRI change; volumetry MRI; blood markers; levodopa equivalents; MDS-UPDRS; VO_2max test; TUG; 6-MIN-W; Mini BESTest; Montreal Cognitive Assessment (MoCA); PDQ-39; BDI-II; Non-Motor Symptoms Questionnaire (NMSQ)
Starting date	Study start: 2020 Study completion: 2023 Recruitment status: recruiting
Contact information	mach@ph.au.dk
Notes	clinicaltrials.gov/ct2/show/record/NCT04379778

NCT04558879

Study name	Exercise and sleep in Parkinson's disease
Methods	Randomized controlled trial
Participants	Inclusion criteria: • Age: 45 to 80 years old • Mild to moderate idiopathic Parkinson's disease (Modified Hoehn and Yahr Scale stages 1 to 3) • On a stable dosage of medication during the previous month • Having poor sleep quality defined as a score > 18 in the PDSS-2 (scores above this cut-off value define clinically relevant sleep disorders) Sample size (planned): 60 Sample size (actual): NR
Interventions	Cardiovascular training vs. resistance training
Outcomes	Actigraphy/Sleep efficiency (SE = total sleep time/time spent in bed); Parkinson's Disease Sleep Scale version 2 (PDSS-2); polysomnography combined with electroencephalogram; MDS-UPDRS-M; Scale for Outcomes in Parkinson's Disease-Cognition; Parkinson's Disease Fatigue Scale; Scale for Outcomes in Parkinson's Disease-Psychosocial; Parkinson's Disease Quality of Life Scale; visuomotor tracking task
Starting date	Study start: 2020 Study completion: 2023 Recruitment status: not yet recruiting
Contact information	marc.roigpull@mcgill.ca
Notes	clinicaltrials.gov/ct2/show/record/NCT04558879

NCT04613141

Study name	The WalkingTall study: comparing WalkingTall with Parkinson's disease (WalkingTall-PD) with mobility-plus to reduce falls and improve mobility (WalkingTall-PD)
Methods	Randomized controlled trial
Participants	Inclusion criteria: • Age: 40 years and older • Diagnosed with idiopathic Parkinson's disease (according to UK PD Society Brain Bank Criteria) • Mild to severe (Hoehn and Yahr stage 1 to 4 idiopathic Parkinson's disease) • Ability to walk 18 meters with or without an aid • At least one fall in the past 6 months, or at least 2 falls in the past 12 months, or severe mobility impairment such as freezing of gait, or history of near falls • Being stable on anti-Parkinsonian medications for > 1 month Sample size (planned): 122 Sample size (actual): 60
Interventions	WalkingTall-PD vs. body weight exercise program

NCT04613141 *(Continued)*

Outcomes	Standard deviation of step times, assessed by a wearable device (McRoberts); rate of falling; levodopa equivalency daily dosage; Mini-BEST test; Physical Activity Enjoyment Scale Questionnaire; System Usability Scale Questionnaire; Attitudes to Fall-Related Intervention Scale Questionnaire; exercise self-efficacy; EuroQoL-5 dimensions (EQ-5D); Short Physical Performance Battery; Movement Disorders Society - Unified Parkinson's Disease Rating Scale; FOG-Q; ADL; exercise adherence; simple stepping ability; Stroop stepping test
Starting date	Study start: 2020 Study completion: 2022 Recruitment status: enrolling by invitation
Contact information	Matthew A Brodie, University of New South Wales
Notes	clinicaltrials.gov/ct2/show/record/NCT04613141

NCT04644367

Study name	Effects of a biomechanical-based tai chi program on gait and posture in people with Parkinson's disease
Methods	Randomized controlled trial
Participants	Inclusion criteria: • Age: 50 to 75 years • Diagnosed with Parkinson's disease and demonstrate a disease severity ranging from 1 to 3 on the Hoehn and Yahr (HY) scale • Have no fluctuations in motor symptoms as reported by the motor section of the Unified Parkinson's Disease Rating Scale (UPDRS-III) • Have stable medication use • Can stand and walk independently Sample size (planned): 40 Sample size (actual): NR
Interventions	Tai chi group vs. regular physical activity
Outcomes	Walking speed, walking cadence, walking step length, Center of Mass-Center of Pressure (COM-COP), Montreal Cognitive Assessment (MoCA), single-leg stance test, TUG, Wisconsin Card Sorting Test (WCST), Trail Making Test Part B (TMT-B), Stroop Test
Starting date	Study start: 2020 Study completion: 2022 Recruitment status: recruiting
Contact information	nlaw098@uottawa.ca
Notes	clinicaltrials.gov/ct2/show/record/NCT04644367

NCT04665869

Study name	Long-term effects of combined balance and brisk walking in Parkinson's disease
Methods	Randomized controlled trial
Participants	Inclusion criteria: • Age: 30 to 80 years old • Parkinson's disease diagnosed by neurologist with Hoehn and Yahr stage 2 or 3 • Having a 30-meter walking ability Sample size (planned): 92 Sample size (actual): 44
Interventions	Combined balance and brisk walking training vs. flexibility and strengthening exercise
Outcomes	MDS-UPDRS-M, MDS-UPDRS-I, Mini-BESTest, 6-MIN-W, TUG, Dual-task timed-up-and-go (DTUG), Five-times-sit-to-stand (FTSTS), Non-Motor Symptoms Scale for Parkinson's Disease (NMSS), gait analysis, Activities-specific Balance Confidence (ABC) Scale, PDQ-39, Pittsburgh Sleep Quality Index (PSQI), fall rate
Starting date	Study start: 2021 Study completion: 2022 Recruitment status: recruiting
Contact information	margaret.mak@polyu.edu.hk
Notes	clinicaltrials.gov/ct2/show/record/NCT04665869

NCT04699617

Study name	The feasibility and efficacy of an immersive virtual reality software in Parkinson's disease patients
Methods	Randomized controlled trial
Participants	Inclusion criteria: • People diagnosed with Parkinson's disease according to MDS criteria • Hoehn and Yahr stages between 1 and 3 • Ability to perform the Timed Up and Go (TUG) test in normal pace and without assistance, in less than 11.5 seconds in ON state • Stable medication for the past 1 month • Ability to communicate with the investigator, to understand and comply with the requirements of the study Sample size (planned): 30 Sample size (actual): NR
Interventions	Active training with the Dolphin 2.0 vs. delayed-start
Outcomes	TUG, MDS-UPDRS, Mini-BESTest, Scales for Outcomes in Parkinson's Disease-COGnition (SCOPA-COG), PDQ-39, Clinical Global Improvement, System Usability Scale, Simulator Sickness Ques-

NCT04699617 *(Continued)*

	tionnaire, number of steps/day, BMI, Schwab and England scale, patients' satisfaction and perceived exertion (7-point Likert scale)
Starting date	Study start: 2020 Study completion: 2022 Recruitment status: recruiting
Contact information	joaquimjferreira@gmail.com
Notes	clinicaltrials.gov/ct2/show/study/NCT04699617

NCT04863118

Study name	Acute effects of strength training and high intensity training on functional and biochemical measurements of individuals with Parkinson's disease in different environments and depths
Methods	Randomized controlled trial

Participants	Inclusion criteria:
	• Intervention group:
	  ◦ Diagnosed with Parkinson's disease for at least 6 months
	  ◦ Age: 50 to 70 years
	  ◦ Classified on the Hoehn and Yahr scale from 1 to 3
	  ◦ Rigid-akinetic and/or tremor-dominant type
	  ◦ Individuals who have preserved their cognitive skills, assessed by means of the MMSE and who have a cut-off score of 23/24
	• Control group:
	  ◦ Age: 50 to 70 years
	  ◦ Individuals who have preserved their cognitive skills (with the same cut-off score as the intervention group in the MMSE)
	  ◦ Walk independently
	Sample size (planned): 60
	Sample size (actual): NR

Interventions	Strength training protocol performed in shallow water and on dry land vs. high-intensity training protocol performed in shallow and deep water
Outcomes	Postural stability (stabilometry), strength (isokinetic dynamometry), spatiotemporal gait variables (kinematic analysis), BBS, TUG, biochemical analysis of the serum brain-derived neurotrophic factor level (venous blood collection)
Starting date	Study start: 2021 Study completion: 2022 Recruitment status: not yet recruiting
Contact information	cep@ufcspa.edu.br
Notes	clinicaltrials.gov/ct2/show/record/NCT04863118

NCT04872153

Study name	Exergames in in-patient rehabilitation
Methods	Randomized controlled trial
Participants	Inclusion criteria: • People with prescription for rehabilitation • Age: ≥ 50 years old • Able to score ≥ 20 on the Mini Mental State Examination (MMSE) • Able to provide signed informed consent • Physically able to stand for at least 3 minutes without external support (self-report) Sample size (planned): 120 Sample size (actual): NR
Interventions	Cognitive-motor training in form of exergames and standard rehabilitation treatment plan vs. standard rehabilitation treatment plan
Outcomes	System Usability Scale (SUS); NASA Task Load Index (NASA-TLX); adverse Events; attrition rate; adherence rate; Reaction Time Test (6-RTT); Trail Making Test (TMT); Color-Word Interference Test; the Go/No-Go Test; TUG; Short Physical Performance Battery (SPPB); Single and Dual Walking Task (10-meter distance)
Starting date	Study start: 2021 Study completion: 2021 Recruitment status: recruiting
Contact information	eleftheria.giannouli@ethz.ch
Notes	clinicaltrials.gov/ct2/show/record/NCT04872153

NCT04878679

Study name	Effect of WB-EMS on Parkinson's disease
Methods	Randomized controlled trial
Participants	Inclusion criteria: • Age: from 50 to 80 years old • Clinical diagnosis of Parkinson's disease from 1 to 3 of Hoehn and Yahr Scale • No participation in other physical activity program Sample size (planned): 36 Sample size (actual): NR
Interventions	Strength training vs. cardiovascular training vs. no physical activity

NCT04878679 *(Continued)*

Outcomes	30-second arm curl test; 30-second sit-to-stand test; Soda Pop Test; 8 Feet up and Go Test; 6-MIN-W; Hand Grip Test; Chair Sit and Reach Test; Tinetti Balance and Gait Evaluation Test; Stroop Test; Rey Auditory Verbal Learning Test; Trail Making Test Change; Blood Draw
Starting date	Study start: 2021 Study completion: 2021 Recruitment status: enrolling by invitation
Contact information	Alessandra di Cagno, Università degli studi di Roma Foro Italico
Notes	clinicaltrials.gov/ct2/show/record/NCT04878679

RBR-26kn3b

Study name	Comparison between training of upper limb respiratory and peripheral resistance on the respiratory function of patients with Parkinson's disease: a randomized clinical trial
Methods	Randomized controlled trial
Participants	Inclusion criteria: • Being on regular medication for Parkinson's disease • Being on the medication "on" period • Age: 50 to 80 years • Present stage 2, 2.5 or 3 according to the modified Hoehn and Yahr classification Sample size (planned): 42 Sample size (actual): NR
Interventions	Aerobic training and resistance training of the inspiratory musculature vs. aerobic training and upper limb resistance training
Outcomes	Forced expiratory volume in one second (FEV_1, by spirometry), forced vital capacity (FVC), FEV_1 / FVC ratio, maximum inspiratory pressure (Pimax), maximum expiratory pressure (Pemax), peak expiratory flow (PEF), chest expansion at axillary, xiphoid and umbilical level, 6-MIN-W, Stand-up test
Starting date	Study start: 2019 Study completion: NR Recruitment status: recruiting
Contact information	danieldf@ufba.br
Notes	ensaiosclinicos.gov.br/rg/RBR-26kn3b

RBR-277fqv

Study name	Effects of physical training with exergames on the respiratory function and on the balance of individuals with Parkinson's disease

RBR-277fqv *(Continued)*

Methods	Randomized controlled trial
Participants	Inclusion criteria: • Age: 50 to 80 years old • People with moderate stages of Parkinson's disease • Both genders • Autonomy to perform the exercises • Identified through the Mini Mental State Examination Sample size (planned): 34 Sample size (actual): NR
Interventions	Video-game-based physical training vs. functional training vs. no physical training
Outcomes	Respiratory capacity (spirometer, manovacuometer, 6-minute walk test), balance (BBS, TUG, baropodometry), quality of life (PDQL), perceived state of depression (Beck Depression Inventory)
Starting date	Study start: 2017 Study completion: NR Recruitment status: completed
Contact information	akelinefisioterapeuta@gmail.com
Notes	ensaiosclinicos.gov.br/rg/RBR-277fqv/

RBR-5r5dhf

Study name	Effectiveness of virtual and augmented reality versus neurofunctional physiotherapy in the treatment of motors and non motors [sic] symptoms in patients with Parkinson's disease
Methods	Randomized controlled trial
Participants	Inclusion criteria: • Age: over 50 years • Medical diagnosis of Parkinson's disease according to the criteria of the London Brain Bank • Mini Mental Score that does not characterize cognitive deficit • Hoehn and Yahr between 1.5 to 3.0 Sample size (planned): 40 Sample size (actual): NR
Interventions	Virtual reality-based rehabilitation vs. augmented reality-based rehabilitation vs. neurofunctional physiotherapy
Outcomes	Postural control, executive function, "COP" amplitude, velocity & area, conclusion time of trail making test
Starting date	Study start: 2018 Study completion: NR Recruitment status: recruiting

RBR-5r5dhf *(Continued)*

Contact information	h.andressa.goa@hormail.com
Notes	ensaiosclinicos.gov.br/rg/RBR-5r5dhf/

RBR-5yjyr7

Study name	Parkinson's disease and physiotherapy: analysis of the impact of intervention programs with terrestrial and aquatic physical activities - FisioPark
Methods	Randomized controlled trial
Participants	Inclusion criteria: • Age: 60 years or older • Diagnosis of idiopathic Parkinson's disease • Between stages 2 to 4 of the Hoehn and Yahr scale • Present medical certificate clearing to practice physical activity • Present medical certificate clearing to practice aquatic physical activity • "Present independent march" [understood to mean having the ability to walk independently] • Present visual, auditory, and cognitive skills to follow verbal instructions during evaluations and interventions Sample size (planned): 70 Sample size (actual): NR
Interventions	Exercises of simple terrestrial task vs. dual terrestrial task exercises vs. simple aquatic task exercises vs. dual aquatic task exercises vs. usual activities
Outcomes	MoCA, MMSE, Trail Making test parts A and B, Stroop Task test, UPDRS-M, UPDRS-II, PDQ-39, TUG, Five Times-sit to-stand test, Dynamic Gait Index scale score, Gait Speed test, Functional Reach Test, BBS, FES, FOG-Q, Aquatic Functional Assessment Scale
Starting date	Study start: 2019 Study completion: 2021 Recruitment status: not yet recruiting
Contact information	zanardiufpr@gmail.com
Notes	ensaiosclinicos.gov.br/rg/RBR-5yjyr7

RBR-74683n

Study name	Efficacy of aerobic training in immunological and neurotrophic parameters and in clinical measures in subjects with Parkinson's disease: a randomized clinical trial
Methods	Randomized controlled trial
Participants	Inclusion criteria: • Clinical diagnosis of idiopathic Parkinson's disease according to the criteria of clinical diagnosis of the United Kingdom Parkinson's Disease Society Brain Bank

RBR-74683n *(Continued)*

	• Age: above 40 years • To be in stage 1,5 to 3 of Hoehn and Yahr • Be in use of levadopa and clinically stable • Being able to wander independently or with the use of auxiliary devices • Have medical release for performing aerobic training Sample size (planned): 40 Sample size (actual): NR
Interventions	Aerobic training vs. stretching exercise and functional training of activities of daily living
Outcomes	Serum concentration of inflammatory mediators and neurotrophic factors, leukocyte analysis, lactate level, hematological parameters, brain-derived neurotrophic factor (BDNF) polymorphism, MoCA, Fatigue Severity Scale (FHS), BDI, Mini-BESTest, TUG, 10-meter test (T10m), five-sit-up test (TLS), co-operability test for exercise test, questionnaire for daily life activities for patients with Parkinson's disease, PDQ-39
Starting date	Study start: 2019 Study completion:NR Recruitment status: not yet recruiting
Contact information	aline.ggomes@hotmail.com
Notes	ensaiosclinicos.gov.br/rg/RBR-74683n

RBR-8s5v5f

Study name	Comparison between the effects of neuromuscular training and video game rehabilitation in the treatment of Parkinson's disease patients
Methods	Randomized controlled trial
Participants	Inclusion criteria: • Age: between 40 and 80 years • Presents with Parkinson's disease in stage 1 to 3 according to the modified Hoehn and Yahr classification • Signs the Free and Informed Consent Form and the Authorization of Images and Testimonials Sample size (planned): 22 Sample size (actual): NR
Interventions	Video game rehabilitation vs. neuromuscular training
Outcomes	Respiratory muscle strength, lung compliance, maximal inspiratory and expiratory pressures (evaluated by manovacuometry), forced vital capacity (FVC), TUG, pulmonary function and performance
Starting date	Study start: 2019 Study completion: NR Recruitment status: recruitment completed

RBR-8s5v5f *(Continued)*

Contact information	fleury.neto@ufba.br
Notes	ensaiosclinicos.gov.br/rg/RBR-8s5v5f

RBR-9v7gj4

Study name	The impact of adapted functional training and the solo Pilates method on motor and non-motor symptoms of individuals with Parkinson's disease
Methods	Randomized controlled trial
Participants	Inclusion criteria: • A clinical diagnosis of Parkinson's disease following the UKPDSBB criteria • Both sexes • Age: 50 years or over • With stable doses at least two weeks • No change in medication • Without any functional training for at least three months Sample size (planned): 45 Sample size (actual): NR
Interventions	Adapted functional training vs. routine activities
Outcomes	Mini-BESTest, cardiorespiratory fitness verified by ergospirometry, BDI, mood (Brunel Mood Scale [BRUMS]), the Sheppard Inventory, TUG, muscle strength of lower limbs (Biodex System 4 PRO isokinetic dynamometer), handgrip strength (hydraulic dynamometer), range of motion of shoulders, “Sit and reach” test
Starting date	Study start: 2020 Study completion: NR Recruitment status: not yet recruiting
Contact information	jessica.moratelli@hotmail.com
Notes	ensaiosclinicos.gov.br/rg/RBR-9v7gj4

TCTR20201009001

Study name	Effects of mindful walking meditation on gait, balance and disease severity in patients with Parkinson disease
Methods	Randomized controlled trial
Participants	Inclusion criteria: • Age: 40 to 85 years • Clinical diagnosis of Parkinson's disease, with a disease severity rating of stage 1 to 3 on the Hoehn and Yahr scale • Stable medication use

TCTR20201009001 *(Continued)*

	• Able to stand unaided and walk without an assistive device Sample size (planned): 32 Sample size (actual): NR
Interventions	Mindful walking meditation vs. usual care group
Outcomes	TUG, 10 meter walk test, Sit to stand test, MOCA test, UPDRS, World Health Organization Quality of Life (WHOQOL-BREF), PDQ-39, Hamilton Rating Scale for Depression, Patient Health Questionnaire (PHQ-9), Hospital anxiety and depression score (HADS), complications, compliance
Starting date	Study start: 2020 Study completion: NR Recruitment status: completed
Contact information	academic_brh@hotmail.com
Notes	www.thaiclinicaltrials.org/show/TCTR20201009001

ADL: activities of daily living; **BBS:** Berg Balance Scale; **BDI:** Beck Depression Inventory; **BMI:** body mass index**BESTest:** Balance Evaluation Systems Test; **EQ-5D:** EuroQoL 5 Dimensions; **FES:** Falls Efficacy Scale; **FOG-Q:** Freezing of Gait Questionnaire; **HADS:** Hospital Anxiety and Depression Scale; **HY:** Hoehn and Yahr scale; **LSVT BIG:** Lee Silverman Voice training BIG; **MDS:** Movement Disorder Society; **MDS-UPDRS-M:** Movement Disorder Society Unified Parkinson Disease Rating Scale/Motor Score; **MHY:** Modified Hoehn and Yahr scale; **Mini-BESTest:** Mini-Balance Evaluation Systems Test; **MMSE:** Mini Mental State Examination; **MoCA:** Montreal Cognitive Assessment; **MRI:** magnetic resonance imaging; **N-FOG-Q:** New Freezing of Gait Questionnaire; **PDQ-39:** Parkinson's Disease Questionnaire 39; **PDQ-8:** Parkinson's Disease Questionnaire 8; **PDQOL:** Parkinson's disease quality of life; **SAFEx:** Sensory Attention Focused Exercise; **SF-36:** Short-Form Health Survey-36 item questionnaire; **6-MIN-W:** 6-minute walk test; **TUG:** Timed up and go; **UKPDSBB:** UK Parkinson's Disease Society Brain Bank diagnostic criteria; **UPDRS-M:** Unified Parkinson's Disease Rating Scale/Motor Score

ADDITIONAL TABLES

Table 1. Results of network meta-analysis for severity of motor signs

Heterogeneity/Inconsistency: Q_{total} = 163.38, df = 68, P < 0.001, Q_{within} = 87.87, df = 40, P < 0.001; $Q_{between}$ = 75.51, df = 28, P < 0.001; I^2 = 58.4%, Tau^2 = 0.1501

Dance	.	.	-0.29 [-1.11, 0.54]	.	-0.06 [-1.06, 0.94]	.	.	-1.41 [-2.92, 0.09]	-0.70 [-1.18, -0.22]	.
-0.19 [-0.74, 0.36]	**Aqua-based training**	-0.33 [-0.93, 0.28]	0.18 [-0.34, 0.70]	.	.	.	.	.	-0.62 [-1.53, 0.30]	.
-0.22 [-0.69, 0.25]	-0.03 [-0.43, 0.37]	**Gait/balance/functional training**	-0.15 [-0.57, 0.27]	-0.07 [-0.61, 0.47]	1.53 [0.48, 2.58]	.	.	-0.45 [-0.96, 0.07]	-0.94 [-1.52, -0.36]	.
-0.24 [-0.67, 0.18]	-0.06 [-0.44, 0.32]	-0.03 [-0.30, 0.25]	**Multi-domain training**	0.16 [-0.58, 0.91]	-0.07 [-0.71, 0.56]	0.07 [-0.42, 0.56]	-0.29 [-1.34, 0.77]	-0.11 [-0.67, 0.44]	-0.63 [-1.02, -0.23]	.
-0.25 [-0.77, 0.27]	-0.06 [-0.55, 0.43]	-0.03 [-0.40, 0.34]	-0.00 [-0.37, 0.36]	**Strength/resistance training**	0.17 [-0.49, 0.83]	0.83 [-0.54, 2.20]	.	-0.24 [-1.07, 0.60]	-1.25 [-2.06, -0.44]	-0.60 [-1.43, 0.24]
-0.28 [-0.73, 0.17]	-0.09 [-0.55, 0.37]	-0.06 [-0.42, 0.29]	-0.04 [-0.35, 0.27]	-0.03 [-0.43, 0.36]	**Mind-body training**	0.19 [-0.94, 1.32]	.	.	-0.43 [-0.77, -0.09]	-0.41 [-1.06, 0.24]
-0.28 [-0.77, 0.20]	-0.10 [-0.57, 0.38]	-0.07 [-0.44, 0.31]	-0.04 [-0.36, 0.28]	-0.04 [-0.46, 0.39]	-0.00 [-0.37, 0.36]	**Endurance training**	0.26 [-0.73, 1.25]	-0.30 [-1.01, 0.41]	-0.21 [-0.67, 0.26]	-1.02 [-1.75, -0.29]
-0.35 [-1.13, 0.42]	-0.17 [-0.93, 0.60]	-0.14 [-0.85, 0.58]	-0.11 [-0.79, 0.57]	-0.11 [-0.85, 0.64]	-0.07 [-0.79, 0.64]	-0.07 [-0.76, 0.62]	**LSVT BIG**	.	-0.31 [-1.30, 0.67]	.
-0.59 [-1.11, -0.08]	-0.41 [-0.90, 0.09]	-0.38 [-0.75, -0.01]	-0.35 [-0.71, 0.01]	-0.35 [-0.79, 0.10]	-0.32 [-0.75, 0.12]	-0.31 [-0.73, 0.10]	-0.24 [-0.99, 0.51]	**Active control group**	.	.
-0.77 [-1.16, -0.37]	-0.58 [-0.99, -0.17]	-0.55 [-0.85, -0.25]	-0.52 [-0.77, -0.27]	-0.52 [-0.89, -0.15]	-0.49 [-0.76, -0.21]	-0.48 [-0.80, -0.17]	-0.41 [-1.10, 0.27]	-0.17 [-0.56, 0.22]	**Passive control group**	.

Table 1. Results of network meta-analysis for severity of motor signs *(Continued)*

-0.92 [-1.55, -0.29]	-0.73 [-1.36, -0.11]	-0.70 [-1.25, -0.16]	-0.68 [-1.20, -0.16]	-0.67 [-1.22, -0.13]	-0.64 [-1.14, -0.14]	-0.64 [-1.14, -0.13]	-0.57 [-1.39, 0.25]	-0.33 [-0.92, 0.26]	-0.15 [-0.67, 0.36]	**Flexibility training**

Treatment effects are expressed as standardized mean differences with 95% confidence intervals. Treatments are ordered by P-score (descending). Upper triangle: direct estimates. Lower triangle: network estimates.
Number of studies: 71. Number of treatments: 11. Number of pairwise comparisons: 85. Number of designs: 31

Table 2. Results of network meta-analysis for quality of life

Heterogeneity/Inconsistency: Q_{total} = 125.02, df = 50, P < 0.001, Q_{within} = 71.91, df = 26, P < 0.001; $Q_{between}$ = 53.11, df = 24, P < 0.001; I^2 = 60.0%, Tau^2 = 0.1210

Aqua-based training	.	.	.	.	-0.94 [-1.58, -0.30]	-0.15 [-0.86, 0.57]	.	.	.	-0.57 [-1.74, 0.59]	.
-0.32 [-0.88, 0.23]	**Endurance training**	-0.42 [-1.50, 0.67]	-0.05 [-0.97, 0.88]	.	-0.15 [-0.67, 0.38]	-0.09 [-0.75, 0.56]	.	.	.	-0.65 [-1.24, -0.05]	.
-0.35 [-0.91, 0.21]	-0.03 [-0.47, 0.42]	**Mind-body training**	.	-0.50 [-1.11, 0.11]	.	-0.43 [-1.19, 0.33]	0.15 [-0.85, 1.14]	.	-0.72 [-1.49, 0.04]	-0.44 [-0.89, 0.02]	.
-0.45 [-1.21, 0.32]	-0.12 [-0.78, 0.54]	-0.10 [-0.80, 0.61]	**Gaming**	.	-0.35 [-1.27, 0.56]	0.15 [-0.82, 1.13]	.	.	.	.	.
-0.49 [-1.03, 0.06]	-0.16 [-0.62, 0.29]	-0.14 [-0.54, 0.26]	-0.04 [-0.74, 0.66]	**Strength/ resistance training**	-0.06 [-0.57, 0.44]	0.18 [-0.71, 1.06]	.	.	-0.28 [-1.04, 0.49]	-0.90 [-1.50, -0.30]	0.03 [-0.74, 0.80]
-0.53 [-0.99, -0.07]	-0.21 [-0.57, 0.16]	-0.18 [-0.56, 0.20]	-0.08 [-0.72, 0.56]	-0.04 [-0.39, 0.30]	**Gait/balance/functional training**	-0.06 [-0.52, 0.40]	.	.	.	-0.35 [-0.71, 0.00]	-0.67 [-1.20, -0.14]
-0.55 [-1.02, -0.09]	-0.23 [-0.60, 0.14]	-0.20 [-0.56, 0.16]	-0.11 [-0.74, 0.53]	-0.07 [-0.42, 0.29]	-0.02 [-0.29, 0.24]	**Multi-domain training**	0.60 [-0.46, 1.67]	-0.42 [-1.43, 0.58]	.	-0.24 [-0.57, 0.09]	-0.44 [-0.92, 0.05]

Table 2. Results of network meta-analysis for quality of life *(Continued)*

-0.61 [-1.22, 0.00]	-0.29 [-0.82, 0.24]	-0.26 [-0.74, 0.22]	-0.17 [-0.92, 0.58]	-0.13 [-0.64, 0.38]	-0.08 [-0.54, 0.37]	-0.06 [-0.50, 0.38]	**Dance**	.	.	-0.08 [-0.59, 0.42]	0.46 [-0.91, 1.83]
-0.97 [-2.08, 0.13]	-0.65 [-1.72, 0.42]	-0.62 [-1.69, 0.44]	-0.53 [-1.72, 0.66]	-0.49 [-1.55, 0.58]	-0.44 [-1.48, 0.59]	-0.42 [-1.43, 0.58]	-0.36 [-1.46, 0.73]	**LSVT BIG**	.	.	.
-0.92 [-1.76, -0.08]	-0.59 [-1.37, 0.18]	-0.57 [-1.26, 0.13]	-0.47 [-1.42, 0.47]	-0.43 [-1.12, 0.26]	-0.39 [-1.12, 0.34]	-0.36 [-1.09, 0.36]	-0.30 [-1.11, 0.50]	0.06 [-1.18, 1.30]	**Flexibility training**	.	.
-0.85 [-1.32, -0.37]	-0.52 [-0.89, -0.16]	-0.50 [-0.83, -0.17]	-0.40 [-1.05, 0.25]	-0.36 [-0.70, -0.02]	-0.32 [-0.57, -0.07]	-0.30 [-0.53, -0.06]	-0.23 [-0.64, 0.17]	0.13 [-0.91, 1.16]	0.07 [-0.65, 0.79]	**Passive control group**	.
-0.90 [-1.47, -0.33]	-0.58 [-1.07, -0.08]	-0.55 [-1.03, -0.07]	-0.45 [-1.17, 0.26]	-0.41 [-0.87, 0.04]	-0.37 [-0.76, 0.02]	-0.35 [-0.72, 0.03]	-0.29 [-0.82, 0.24]	0.07 [-1.00, 1.15]	0.02 [-0.77, 0.80]	-0.05 [-0.46, 0.35]	**Active control group**

Treatment effects are expressed as standardized mean differences with 95% confidence intervals. Treatments are ordered by P-score (descending). Upper triangle: direct estimates. Lower triangle: network estimates.
Number of studies: 55. Number of treatments: 12. Number of pairwise comparisons: 67. Number of designs: 29

Table 3. Results of network meta-analysis for freezing of gait

Heterogeneity/Inconsistency: Q_{total} = 22.36, df = 13, P = 0.050, Q_{within} = 14.83, df = 9, P = 0.096; $Q_{between}$ = 7.53, df = 4, P = 0.110; I^2 = 41.9%, Tau^2 = 0.0632

Strength/resistance training	.	.	.	-1.16 [-2.25, -0.08]	-0.10 [-0.70, 0.50]	.	.
0.06 [-1.13, 1.25]	**Aqua-based training**	.	.	.	-0.45 [-1.52, 0.61]	.	.
-0.15 [-0.78, 0.49]	-0.21 [-1.33, 0.92]	**Dance**	.	.	-0.19 [-0.58, 0.20]	-0.49 [-1.23, 0.24]	.
-0.08 [-1.13, 0.97]	-0.14 [-1.54, 1.25]	0.06 [-0.92, 1.04]	**Mind-body training**	.	-0.31 [-1.22, 0.60]	.	.

Table 3. Results of network meta-analysis for freezing of gait *(Continued)*

-0.20 [-0.77, 0.37]	-0.26 [-1.36, 0.85]	-0.05 [-0.50, 0.40]	-0.11 [-1.07, 0.84]	**Gait/balance/functional training**	-0.28 [-0.60, 0.04]	-0.50 [-1.45, 0.45]	-0.42 [-1.02, 0.18]
-0.39 [-0.92, 0.13]	-0.45 [-1.52, 0.61]	-0.25 [-0.61, 0.12]	-0.31 [-1.22, 0.60]	-0.20 [-0.49, 0.10]	**Passive control group**	0.33 [-0.61, 1.28]	.
-0.44 [-1.14, 0.26]	-0.50 [-1.67, 0.67]	-0.29 [-0.80, 0.22]	-0.36 [-1.38, 0.67]	-0.24 [-0.73, 0.25]	-0.05 [-0.53, 0.43]	**Multi-domain training**	-0.41 [-1.21, 0.39]
-0.70 [-1.45, 0.05]	-0.76 [-1.96, 0.44]	-0.55 [-1.18, 0.08]	-0.62 [-1.68, 0.45]	-0.50 [-1.02, 0.01]	-0.31 [-0.87, 0.25]	-0.26 [-0.83, 0.31]	**Active control group**

Treatment effects are expressed as standardized mean differences with 95% confidence intervals. Treatments are ordered by P-score (descending). Upper triangle: direct estimates. Lower triangle: network estimates.
Number of studies: 20. Number of treatments: 8. Number of pairwise comparisons: 20. Number of designs: 11

Table 4. Results of network meta-analysis for functional mobility and balance

Heterogeneity/Inconsistency: Q_{total} = 204.30, df = 48, P < 0.001, Q_{within} = 108.31, df = 27, P < 0.001; $Q_{between}$ = 95.99, df = 21, P < 0.001; I^2 = 76.5%, Tau^2 = 0.3436

Aqua-based training	.	.	.	.	-0.69 [-1.48, 0.10]	.	-0.92 [-1.71, -0.13]	.	.	.	-0.70 [-2.11, 0.70]
-0.39 [-1.70, 0.92]	**LSVT BIG**	.	.	-0.50 [-1.81, 0.82]	.	.	.	.	.	.	-0.72 [-2.03, 0.60]
-0.52 [-1.19, 0.15]	-0.13 [-1.36, 1.10]	**Mind-body training**	0.00 [-1.32, 1.32]	.	-0.49 [-1.83, 0.85]	-0.26 [-1.17, 0.64]	0.41 [-0.47, 1.30]	.	.	-0.78 [-1.68, 0.13]	-0.96 [-1.45, -0.48]
-0.56 [-1.34, 0.23]	-0.16 [-1.46, 1.13]	-0.03 [-0.67, 0.60]	**Dance**	.	.	.	-1.62 [-3.17, -0.07]	.	-1.15 [-2.86, 0.55]	.	-0.46 [-1.08, 0.17]
-0.61 [-1.42, 0.21]	-0.21 [-1.39, 0.97]	-0.08 [-0.77, 0.60]	-0.05 [-0.84, 0.75]	**Endurance training**	.	.	-1.33 [-2.78, 0.12]	.	-0.03 [-1.28, 1.22]	-1.00 [-2.55, 0.55]	-0.53 [-1.35, 0.28]

Table 4. Results of network meta-analysis for functional mobility and balance *(Continued)*

-0.63 [-1.19, -0.06]	-0.23 [-1.47, 1.00]	-0.10 [-0.61, 0.40]	-0.07 [-0.72, 0.58]	-0.02 [-0.70, 0.66]	**Gait/balance/functional training**	-0.13 [-1.03, 0.76]	-0.51 [-1.12, 0.10]	.	-0.49 [-1.12, 0.13]	.	-0.26 [-1.00, 0.47]
-0.71 [-1.40, -0.01]	-0.31 [-1.56, 0.94]	-0.18 [-0.71, 0.34]	-0.15 [-0.83, 0.54]	-0.10 [-0.82, 0.61]	-0.08 [-0.60, 0.44]	**Strength/resistance training**	0.17 [-1.14, 1.49]	.	-0.05 [-1.25, 1.15]	-0.25 [-1.44, 0.95]	-0.92 [-1.55, -0.30]
-0.77 [-1.33, -0.20]	-0.37 [-1.61, 0.86]	-0.24 [-0.74, 0.25]	-0.21 [-0.85, 0.43]	-0.16 [-0.84, 0.51]	-0.14 [-0.56, 0.28]	-0.06 [-0.60, 0.48]	**Multi-domain training**	-0.13 [-1.50, 1.25]	.	.	-1.61 [-2.44, -0.78]
-0.90 [-2.38, 0.59]	-0.50 [-2.35, 1.35]	-0.37 [-1.83, 1.09]	-0.34 [-1.86, 1.18]	-0.29 [-1.82, 1.24]	-0.27 [-1.71, 1.17]	-0.19 [-1.67, 1.29]	-0.13 [-1.50, 1.25]	**Gaming**	.	.	.
-1.07 [-1.83, -0.32]	-0.68 [-1.97, 0.61]	-0.55 [-1.22, 0.13]	-0.51 [-1.27, 0.24]	-0.47 [-1.21, 0.28]	-0.45 [-0.99, 0.10]	-0.36 [-1.03, 0.30]	-0.30 [-0.94, 0.33]	-0.18 [-1.69, 1.34]	**Active control group**	.	.
-1.33 [-2.29, -0.37]	-0.94 [-2.32, 0.45]	-0.81 [-1.58, -0.04]	-0.77 [-1.71, 0.17]	-0.72 [-1.61, 0.17]	-0.70 [-1.55, 0.15]	-0.62 [-1.44, 0.20]	-0.56 [-1.41, 0.29]	-0.43 [-2.05, 1.18]	-0.26 [-1.20, 0.69]	**Flexibility training**	.
-1.40 [-2.01, -0.79]	-1.01 [-2.18, 0.17]	-0.88 [-1.27, -0.48]	-0.84 [-1.39, -0.30]	-0.79 [-1.40, -0.18]	-0.77 [-1.20, -0.35]	-0.69 [-1.15, -0.23]	-0.63 [-1.07, -0.20]	-0.50 [-1.94, 0.94]	-0.33 [-0.94, 0.29]	-0.07 [-0.87, 0.73]	**Passive control group**

Treatment effects are expressed as standardized mean differences with 95% confidence intervals. Treatments are ordered by P-score (descending). Upper triangle: direct estimates. Lower triangle: network estimates.
Number of studies: 54. Number of treatments: 12. Number of pairwise comparisons: 64. Number of designs: 27

Table 5. Comparison of direct and indirect evidence (in closed loops) for severity of motor signs

Comparison	Number of studies	Network estimate	Direct estimate	Indirect estimate	Test for disagreement
Aqua-based training vs gait/balance/functional training	3	-0.03 [-0.43, 0.37]	-0.33 [-0.93, 0.28]	0.20 [-0.33, 0.73]	0.1962
Aqua-based training vs multi-domain training	4	-0.06 [-0.44, 0.32]	0.18 [-0.34, 0.70]	-0.33 [-0.88, 0.23]	0.1972
Aqua-based training vs passive control group	2	-0.58 [-0.99, -0.17]	-0.62 [-1.53, 0.30]	-0.57 [-1.03, -0.11]	0.9315
Dance vs active control group	1	-0.59 [-1.11, -0.08]	-1.41 [-2.92, 0.09]	-0.48 [-1.03, 0.07]	0.2545
Dance vs mind-body training	1	-0.28 [-0.73, 0.17]	-0.06 [-1.06, 0.94]	-0.34 [-0.85, 0.17]	0.6252
Dance vs multi-domain training	2	-0.24 [-0.67, 0.18]	-0.29 [-1.11, 0.54]	-0.23 [-0.73, 0.27]	0.9036
Dance vs passive control group	5	-0.77 [-1.16, -0.37]	-0.70 [-1.18, -0.22]	-0.91 [-1.61, -0.20]	0.6338
Endurance training vs active control group	2	-0.31 [-0.73, 0.10]	-0.30 [-1.01, 0.41]	-0.32 [-0.83, 0.19]	0.9677
Endurance training vs flexibility training	2	-0.64 [-1.14, -0.13]	-1.02 [-1.75, -0.29]	-0.29 [-0.99, 0.41]	0.1587
Endurance training vs LSVT BIG	1	-0.07 [-0.76, 0.62]	0.26 [-0.73, 1.25]	-0.39 [-1.37, 0.58]	0.3546
Endurance training vs mind-body training	1	0.00 [-0.36, 0.37]	-0.19 [-1.32, 0.94]	0.03 [-0.36, 0.41]	0.7246
Endurance training vs multi-domain training	5	0.04 [-0.28, 0.36]	-0.07 [-0.56, 0.42]	0.12 [-0.30, 0.54]	0.5652
Endurance training vs passive control group	5	-0.48 [-0.80, -0.17]	-0.21 [-0.67, 0.26]	-0.72 [-1.15, -0.29]	0.1117
Endurance training vs strength/resistance	1	0.04 [-0.39, 0.46]	-0.83 [-2.20, 0.54]	0.13 [-0.32, 0.57]	0.1929
Flexibility training vs mind-body training	2	0.64 [0.14, 1.14]	0.41 [-0.24, 1.06]	0.97 [0.19, 1.75]	0.2806
Flexibility training vs strength/resistance training	1	0.67 [0.13, 1.22]	0.60 [-0.24, 1.43]	0.73 [0.01, 1.45]	0.8158
Gait/balance/functional vs active control group	3	-0.38 [-0.75, -0.01]	-0.45 [-0.96, 0.07]	-0.31 [-0.83, 0.22]	0.7170
Gait/balance/functional vs mind-body training	1	-0.06 [-0.42, 0.29]	1.53 [0.48, 2.58]	-0.27 [-0.64, 0.11]	0.0015
Gait/balance/functional training vs multi-domain training	6	-0.03 [-0.30, 0.25]	-0.15 [-0.57, 0.27]	0.06 [-0.30, 0.42]	0.4590

Table 5. Comparison of direct and indirect evidence (in closed loops) for severity of motor signs *(Continued)*

Gait/balance/functional vs passive control group	3	-0.55 [-0.85, -0.25]	-0.94 [-1.52, -0.36]	-0.40 [-0.76, -0.05]	0.1250
Gait/balance/functional training vs strength/resistance training	3	-0.03 [-0.40, 0.34]	-0.07 [-0.61, 0.47]	0.00 [-0.50, 0.51]	0.8562
LSVT BIG vs multi-domain training	1	0.11 [-0.57, 0.79]	0.29 [-0.77, 1.34]	-0.02 [-0.90, 0.87]	0.6690
LSVT BIG vs passive control training	1	-0.41 [-1.10, 0.27]	-0.31 [-1.30, 0.67]	-0.51 [-1.45, 0.44]	0.7813
Mind-body training vs multi-domain training	2	0.04 [-0.27, 0.35]	0.07 [-0.56, 0.71]	0.02 [-0.33, 0.38]	0.8996
Mind-body training vs passive control group	10	-0.49 [-0.76, -0.21]	-0.43 [-0.77, -0.09]	-0.59 [-1.05, -0.13]	0.5918
Mind-body training vs strength/resistance training	2	0.03 [-0.36, 0.43]	-0.17 [-0.83, 0.49]	0.14 [-0.35, 0.63]	0.4556
Multi-domain training vs active control group	3	-0.35 [-0.71, 0.01]	-0.11 [-0.67, 0.44]	-0.52 [-0.99, -0.05]	0.2784
Multi-domain training vs passive control group	7	-0.52 [-0.77, -0.27]	-0.63 [-1.02, -0.23]	-0.45 [-0.77, -0.13]	0.5040
Multi-domain training vs strength/resistance training	2	-0.00 [-0.37, 0.36]	0.16 [-0.58, 0.91]	-0.06 [-0.47, 0.36]	0.6148
Strength/resistance vs active control group	1	-0.35 [-0.79, 0.10]	-0.24 [-1.07, 0.60]	-0.39 [-0.92, 0.13]	0.7568
Strength/resistance vs passive control group	2	-0.52 [-0.89, -0.15]	-1.25 [-2.06, -0.44]	-0.32 [-0.74, 0.10]	0.0455

Estimates are expressed as standardized mean differences with 95% confidence intervals.
Results of tests for disagreements between direct and indirect estimates are reported as P values.
Only comparisons for which both direct and indirect evidence were available are shown.

Table 6. Comparison of direct and indirect evidence (in closed loops) for quality of life

Comparison	Number of studies	Network estimate	Direct estimate	Indirect estimate	Test for disagreement
Aqua-based training vs gait/balance/functional training	3	-0.53 [-0.99, -0.07]	-0.94 [-1.58, -0.30]	-0.10 [-0.76, 0.56]	0.0746
Aqua-based training vs multi-domain training	2	-0.55 [-1.02, -0.09]	-0.15 [-0.86, 0.57]	-0.85 [-1.46, -0.24]	0.1448
Aqua-based training vs passive control group	1	-0.85 [-1.32, -0.37]	-0.57 [-1.74, 0.59]	-0.90 [-1.43, -0.38]	0.6159
Dance vs active control group	1	-0.29 [-0.82, 0.24]	0.46 [-0.91, 1.83]	-0.42 [-1.00, 0.16]	0.2468
Dance vs mind-body training	1	0.26 [-0.22, 0.74]	-0.15 [-1.14, 0.85]	0.39 [-0.16, 0.93]	0.3601

Table 6. Comparison of direct and indirect evidence (in closed loops) for quality of life *(Continued)*

Dance vs multi-domain training	1	0.06 [-0.38, 0.50]	-0.60 [-1.67, 0.46]	0.20 [-0.28, 0.68]	0.1788
Dance vs passive control group	4	-0.23 [-0.64, 0.17]	-0.08 [-0.59, 0.42]	-0.52 [-1.20, 0.17]	0.3186
Endurance training vs gait/balance/functional training	4	-0.21 [-0.57, 0.16]	-0.15 [-0.67, 0.38]	-0.27 [-0.78, 0.25]	0.7469
Endurance training vs Gaming	1	-0.12 [-0.78, 0.54]	-0.05 [-0.97, 0.88]	-0.21 [-1.16, 0.75]	0.8124
Endurance training vs mind-body training	1	-0.03 [-0.47, 0.42]	-0.42 [-1.50, 0.67]	0.05 [-0.44, 0.54]	0.4400
Endurance training vs multi-domain training	2	-0.23 [-0.60, 0.14]	-0.09 [-0.75, 0.56]	-0.29 [-0.73, 0.15]	0.6273
Endurance training vs passive control group	3	-0.52 [-0.89, -0.16]	-0.65 [-1.24, -0.05]	-0.45 [-0.91, 0.01]	0.6097
Flexibility training vs mind-body training	1	0.57 [-0.13, 1.26]	0.72 [-0.04, 1.49]	-0.12 [-1.74, 1.50]	0.3546
Flexibility training vs strength/resistance training	1	0.43 [-0.26, 1.12]	0.28 [-0.49, 1.04]	1.13 [-0.50, 2.77]	0.3546
Gait/balance/functional vs active control group	3	-0.37 [-0.76, 0.02]	-0.67 [-1.20, -0.14]	-0.01 [-0.59, 0.57]	0.0971
Gait/balance/functional training vs gaming	1	0.08 [-0.56, 0.72]	0.35 [-0.56, 1.27]	-0.17 [-1.07, 0.72]	0.4199
Gait/balance/functional training vs multi-domain training	4	-0.02 [-0.29, 0.24]	-0.06 [-0.52, 0.40]	-0.00 [-0.32, 0.32]	0.8303
Gait/balance/functional training vs passive control group	5	-0.32 [-0.57, -0.07]	-0.35 [-0.71, 0.00]	-0.28 [-0.64, 0.08]	0.7796
Gait/balance/functional training vs strength/resistance	3	0.04 [-0.30, 0.39]	0.06 [-0.44, 0.57]	0.03 [-0.45, 0.50]	0.9135
Gaming vs multi-domain training	1	-0.11 [-0.74, 0.53]	0.15 [-0.82, 1.13]	-0.30 [-1.14, 0.54]	0.4875
Mind-body training vs multi-domain training	1	-0.20 [-0.56, 0.16]	-0.43 [-1.19, 0.33]	-0.14 [-0.55, 0.27]	0.5055
Mind-body training vs passive control group	5	-0.50 [-0.83, -0.17]	-0.44 [-0.89, 0.02]	-0.57 [-1.05, -0.08]	0.6978
Mind-body training vs strength/resistance training	2	-0.14 [-0.54, 0.26]	-0.50 [-1.11, 0.11]	0.14 [-0.39, 0.66]	0.1239
Multi-domain training vs active control group	3	-0.35 [-0.72, 0.03]	-0.44 [-0.92, 0.05]	-0.21 [-0.81, 0.38]	0.5625
Multi-domain training vs passive control group	7	-0.30 [-0.53, -0.06]	-0.24 [-0.57, 0.09]	-0.36 [-0.70, -0.01]	0.6206

Table 6. Comparison of direct and indirect evidence (in closed loops) for quality of life *(Continued)*

Multi-domain training vs strength/ resistance training	1	0.07 [-0.29, 0.42]	-0.18 [-1.06, 0.71]	0.11 [-0.28, 0.50]	0.5567
Strength/resistance training vs active control group	1	-0.41 [-0.87, 0.04]	0.03 [-0.74, 0.80]	-0.65 [-1.21, -0.09]	0.1589
Strength/resistance vs passive control group	3	-0.36 [-0.70, -0.02]	-0.90 [-1.50, -0.30]	-0.10 [-0.52, 0.32]	0.0309

Estimates are expressed as standardized mean differences with 95% confidence intervals.
Results of tests for disagreements between direct and indirect estimates are reported as P values.
Only comparisons for which both direct and indirect evidence were available are shown.

Table 7. Comparison of direct and indirect evidence (in closed loops) for freezing of gait

Comparison	Number of studies	Network estimate	Direct estimate	Indirect estimate	Test for disagreement
Dance vs multi-domain training	2	-0.29 [-0.80, 0.22]	-0.49 [-1.23, 0.24]	-0.10 [-0.81, 0.60]	0.4537
Dance vs passive control group	4	-0.25 [-0.61, 0.12]	-0.19 [-0.58, 0.20]	-0.58 [-1.52, 0.36]	0.4537
Gait/balance/functional training vs active control group	1	-0.50 [-1.02, 0.01]	-0.42 [-1.02, 0.18]	-0.72 [-1.70, 0.25]	0.6058
Gait/balance/functional training vs multi-domain training	1	-0.24 [-0.73, 0.25]	-0.50 [-1.45, 0.45]	-0.15 [-0.72, 0.42]	0.5438
Gait/balance/functional training vs passive control group	5	-0.20 [-0.49, 0.10]	-0.28 [-0.60, 0.04]	0.23 [-0.51, 0.97]	0.2190
Gait/balance/functional training vs strength/resistance training	1	0.20 [-0.37, 0.77]	1.16 [0.08, 2.25]	-0.17 [-0.84, 0.50]	0.0395
Multi-domain training vs active control group	1	-0.26 [-0.83, 0.31]	-0.41 [-1.21, 0.39]	-0.10 [-0.93, 0.72]	0.6058
Multi-domain training vs passive control group	1	0.05 [-0.43, 0.53]	-0.33 [-1.28, 0.61]	0.18 [-0.38, 0.74]	0.3608
Strength/resistance training vs passive control group	2	-0.39 [-0.92, 0.13]	-0.10 [-0.70, 0.50]	-1.44 [-2.56, -0.31]	0.0395

Estimates are expressed as standardized mean differences with 95% confidence intervals.
Results of tests for disagreements between direct and indirect estimates are reported as P values.
Only comparisons for which both direct and indirect evidence were available are shown.

Table 8. Comparison of direct and indirect evidence (in closed loops) for functional mobility and balance

Comparison	Number of studies	Network estimate	Direct estimate	Indirect estimate	Test for disagreement
Aqua-based training vs gait/balance/functional training	3	-0.63 [-1.19, -0.06]	-0.69 [-1.48, 0.10]	-0.56 [-1.36, 0.24]	0.8223

Table 8. Comparison of direct and indirect evidence (in closed loops) for functional mobility and balance *(Continued)*

Aqua-based training vs multi-domain training	3	-0.77 [-1.33, -0.20]	-0.92 [-1.71, -0.13]	-0.61 [-1.41, 0.20]	0.5840
Aqua-based training vs passive control group	1	-1.40 [-2.01, -0.79]	-0.70 [-2.11, 0.70]	-1.56 [-2.24, -0.88]	0.2831
Dance vs active control group	1	-0.51 [-1.27, 0.24]	-1.15 [-2.86, 0.55]	-0.36 [-1.20, 0.49]	0.4114
Dance vs mind-body training	1	0.03 [-0.60; 0.67]	-0.00 [-1.32; 1.32]	0.05 [-0.68, 0.77]	0.9528
Dance vs multi-domain training	1	-0.21 [-0.85, 0.43]	-1.62 [-3.17, -0.07]	0.09 [-0.62, 0.79]	0.0495
Dance vs passive control group	5	-0.84 [-1.39, -0.30]	-0.46 [-1.08, 0.17]	-2.03 [-3.13, -0.92]	0.0153
Endurance training vs active control group	1	-0.47 [-1.21, 0.28]	-0.03 [-1.28, 1.22]	-0.70 [-1.62, 0.22]	0.3991
Endurance training vs flexibility training	1	-0.72 [-1.61, 0.17]	-1.00 [-2.55, 0.55]	-0.59 [-1.68, 0.50]	0.6736
Endurance training vs LSVT BIG	1	0.21 [-0.97, 1.39]	0.50 [-0.82, 1.81]	-0.97 [-3.64, 1.71]	0.3357
Endurance training vs multi-domain training	1	-0.16 [-0.84, 0.51]	-1.33 [-2.78, 0.12]	0.16 [-0.60, 0.92]	0.0748
Endurance training vs passive control group	3	-0.79 [-1.40, -0.18]	-0.53 [-1.35, 0.28]	-1.13 [-2.05, -0.20]	0.3451
Flexibility training vs mind-body training	2	0.81 [0.04, 1.58]	0.78 [-0.13, 1.68]	0.88 [-0.56, 2.33]	0.9007
Flexibility training vs strength/resistance training	1	0.62 [-0.20, 1.44]	0.25 [-0.95, 1.44]	0.96 [-0.17, 2.09]	0.3971
Gait/balance/functional training vs active control group	4	-0.45 [-0.99, 0.10]	-0.49 [-1.12, 0.13]	-0.30 [-1.40, 0.81]	0.7618
Gait/balance/functional training vs mind-body training	1	0.10 [-0.40, 0.61]	0.49 [-0.85, 1.83]	0.04 [-0.51, 0.58]	0.5411
Gait/balance/functional training vs multi-domain training	5	-0.14 [-0.56, 0.28]	-0.51 [-1.12, 0.10]	0.20 [-0.39, 0.79]	0.0995
Gait/balance/functional training vs passive control group	3	-0.77 [-1.20, -0.35]	-0.26 [-1.00, 0.47]	-1.04 [-1.57, -0.51]	0.0935
Gait/balance/functional training vs strength/resistance training	2	-0.08 [-0.60, 0.44]	-0.13 [-1.03, 0.76]	-0.06 [-0.69, 0.58]	0.8946
LSVT BIG vs passive control group	1	-1.01 [-2.18, 0.17]	-0.72 [-2.03, 0.60]	-2.17 [-4.83, 0.48]	0.3357
Mind-body training vs multi-domain training	2	-0.24 [-0.74, 0.25]	0.41 [-0.47, 1.30]	-0.54 [-1.13, 0.06]	0.0809

Table 8. Comparison of direct and indirect evidence (in closed loops) for functional mobility and balance *(Continued)*

Mind-body training vs passive control group	8	-0.88 [-1.27, -0.48]	-0.96 [-1.45, -0.48]	-0.70 [-1.39, -0.02]	0.0809
Mind-body training vs strength/resistance training	2	-0.18 [-0.71, 0.34]	-0.26 [-1.17, 0.64]	-0.15 [-0.79, 0.50]	0.5406
Multi-domain training vs passive control group	3	-0.63 [-1.07, -0.20]	-1.61 [-2.44, -0.78]	-0.27 [-0.78, 0.24]	0.0071
Multi-domain training vs strength/resistance training	1	0.06 [-0.48, 0.60]	-0.17 [-1.49, 1.14]	0.11 [-0.48, 0.70]	0.7037
Strength/resistance training vs active control group	1	-0.36 [-1.03, 0.30]	-0.05 [-1.25, 1.15]	-0.50 [-1.30, 0.30]	0.5383
Strength/resistance training vs passive control group	5	-0.69 [-1.15, -0.23]	-0.92 [-1.55, -0.30]	-0.42 [-1.10; 0.25]	0.2884

Estimates are expressed as standardized mean differences with 95% confidence intervals.
Results of tests for disagreements between direct and indirect estimates are reported as P values.
Only comparisons for which both direct and indirect evidence were available are shown.

APPENDICES

Appendix 1. Categorization of interventions and control groups

Physical exercise categorized using an adaptation of the ProFaNE taxonomy (Lamb 2011)

Type of physical exercise	Description	Examples of interventions included in this review
Aqua-based training	Interventions that are delivered in an aquatic setting	Aquatic ai chi, aquatic exercise training, Halliwick aquatic exercises, water-based physiotherapy
Dance	Dance interventions or interventions that comprise components typically involved in dancing	Dance therapy, Ronnie Gardiner rhythm and music method, tango, waltz/foxtrot
Endurance training	Interventions that primarily address participants' endurance	Aerobic training, brisk walking, high-cadence cycling, Nordic walking, speed treadmill training
Flexibility training	Interventions that primarily address participants' flexibility	Flexibility exercises, stretching
Gait/balance/functional training	Interventions that involve gait training (i.e. training that involves correction of walking technique and changes of pace, level and direction), and/or balance training (i.e. training that involves the efficient transfer of body weight or challenges aspects of the balance systems) or balance retraining activities and/or functional training (i.e. training that utilises functional activities as the training stimulus)	Functional mobility training, Hi-Balance training, treadmill training

(Continued)

Gaming	Interventions that involve structured, physical exercises delivered via video-games and/or virtual reality applications, and may not be categorized using any of the other exercise categories	Exergaming, Nintendo Wii training
LSVT BIG	Interventions that deliver the 'Lee Silverman Voice Training BIG' program	LSVT BIG
Mind-body training	Interventions that primarily address the mind and body	Tai chi, qigong, yoga
Multi-domain training	Interventions that involve a balanced combination of components associated with multiple exercise categories	Multidisciplinary intensive rehabilitation treatment, multimodal exercise training, physiotherapy, rehabilitation exercises
Strength/resistance training	Interventions that involve all types of weight training (i.e. training that involves contracting the muscles against a resistance to overload and bring about a training effect in the muscular system)	Muscle power training, progressive resistance exercise

Control groups

Type of control group	Description	Examples of interventions included in this review
Active control group	Structured, supervised, non-physical interventions	Education program, mental/leisure program, speech and communication training
Passive control group	No intervention, unstructured interventions without supervision (including general physical activity), or usual care	Conventional care, educational brochure, home walking, medication only, wait-list control

Appendix 2. CENTRAL search strategy

Cochrane Central Register of Controlled Trials (via CRSonline)

#	Searches
1	MESH DESCRIPTOR Parkinson Disease EXPLODE ALL TREES
2	parkinson*
3	#1 or #2
4	MESH DESCRIPTOR Software EXPLODE ALL TREES
5	software:TI,AB,KY
6	(game or gaming or play* or simulation* or program* or techni* or video):TI,AB,KY
7	MESH DESCRIPTOR Virtual Reality Exposure Therapy EXPLODE ALL TREES

(Continued)

8	(user-computer interface or interactive or virtual* or vr or augmented or exergam* or kinect or nintendo wii or microsoft xbox):TI,AB,KY
9	#4 OR #5 OR #6 OR #7 OR #8
10	biofeedback:TI,AB,KY
11	MESH DESCRIPTOR movement EXPLODE ALL TREES
12	movement:TI,AB,KY
13	MESH DESCRIPTOR Physical Therapy Modalities EXPLODE ALL TREES
14	MESH DESCRIPTOR Physical Fitness EXPLODE ALL TREES
15	fitness:TI,AB,KY
16	MESH DESCRIPTOR Muscle Strength EXPLODE ALL TREES
17	(strength or muscle or locomot*):TI,AB,KY
18	MESH DESCRIPTOR Muscle Strength EXPLODE ALL TREES
19	((weight* next body*) or (weight* near2 training*) or motor activity):TI,AB,KY
20	#10 OR #11 OR #12 OR #13 OR #14 OR #15 OR #16 OR #17 OR #18 OR #19
21	MESH DESCRIPTOR Exercise EXPLODE ALL TREES
22	(exercise* or activit* or sport* or train* or intervention* or condition*):TI,AB,KY
23	MESH DESCRIPTOR Physical Endurance EXPLODE ALL TREES
24	endurance:TI,AB,KY
25	MESH DESCRIPTOR Gait EXPLODE ALL TREES
26	(gait* or postural balance):TI,AB,KY
27	MESH DESCRIPTOR Dancing EXPLODE ALL TREES
28	(danc* or tango):TI,AB,KY
29	MESH DESCRIPTOR Martial Arts EXPLODE ALL TREES
30	(martial art* or aerobic or boxing or shadowboxing or treadmill* or karate):TI,AB,KY
31	MESH DESCRIPTOR Walking EXPLODE ALL TREES
32	walking:TI,AB,KY
33	MESH DESCRIPTOR Bicycling EXPLODE ALL TREES
34	(bicycle* or cycl*):TI,AB,KY

(Continued)

35	#21 OR #22 OR #23 OR #24 OR #25 OR #26 OR #27 OR #28 OR #29 OR #30 OR #31 OR #32 OR #33 OR #34
36	MESH DESCRIPTOR Medicine, Chinese Traditional EXPLODE ALL TREES
37	(traditional chinese exercise):TI,AB,KY
38	#36 OR #37
39	MESH DESCRIPTOR Mind-Body Therapies EXPLODE ALL TREES
40	((mind near1 body)):TI,AB,KY
41	MESH DESCRIPTOR Tai Ji EXPLODE ALL TREES
42	((chi near1 tai) or (tai near1 ji*)):TI,AB,KY
43	(taiji* or taichi* or t'ai chi or wuqinxi or baduanjin or yijiejing):TI,AB,KY
44	MESH DESCRIPTOR Qigong EXPLODE ALL TREES
45	(qi-gong* or qigong* or (qi* near2 (gong* or kung* or chung* or gung*)) or (chi* near2 (gong* or kung* or chung* or gung*))):TI,AB,KY
46	(yoga or asana or pranayama or dhyana or pilates):TI,AB,KY
47	#39 OR #40 OR #41 OR #42 OR #43 OR #44 OR #45 OR #46
48	MESH DESCRIPTOR Rehabilitation EXPLODE ALL TREES
49	(rehab* or telerehab*):TI,AB,KY
50	MESH DESCRIPTOR Therapeutics EXPLODE ALL TREES
51	therap* or physical* or physiotherapy or exercise therapy
52	MESH DESCRIPTOR Exercise Test EXPLODE ALL TREES
53	(exercise test or strengthening program* or progressive resistance training or cardiorespiratory):TI,AB,KY
54	MESH DESCRIPTOR Cardiovascular System EXPLODE ALL TREES
55	(cardiovascular or aqua* or hydrotherapy or lsvt-big or lsvtbig or ("Lee Silverman Voice Treatment" and big) or periodicity or socio environmental):TI,AB,KY
56	(whole body near1 vibration*):TI,AB,KY
57	#48 OR #49 OR #50 OR #51 OR #52 OR #53 OR #54 OR #55 OR #56
58	#9 OR #20 OR #35 OR #38 OR #47 OR #57
59	#3 AND #58

Appendix 3. MEDLINE search strategy

Medline (via OvidSP)

#	Searches
1	exp PARKINSON DISEASE/
2	parkinson*.tw,kf.
3	or/1-2
4	exp SOFTWARE/
5	software.mp.
6	game.mp.
7	gaming.mp.
8	play*.mp.
9	simulation*.mp.
10	program*.mp.
11	techni*.mp.
12	video.mp.
13	VIRTUAL REALITY EXPOSURE THERAPY/
14	user-computer interface.mp.
15	interactive.mp.
16	virtual*.mp.
17	vr.mp.
18	augmented.mp.
19	exergam*.mp.
20	kinect.mp.
21	nintendo wii.mp.
22	microsoft xbox.mp.
23	or/4-22
24	biofeedback.mp.
25	exp MOVEMENT/

(Continued)

26	movement.mp.
27	exp PHYSICAL THERAPY MODALITIES/
28	exp PHYSICAL FITNESS/
29	fitness.mp.
30	exp MUSCLE STRENGTH/
31	strength.mp.
32	muscle.mp.
33	locomot*.mp.
34	exp BODY WEIGHT/
35	(weight* adj1 body*).mp.
36	(weight* adj2 training*).mp.
37	motor activity.mp.
38	or/24-37
39	exp EXERCISE/
40	exercise*.mp.
41	activit*.mp.
42	sport*.mp.
43	train*.mp.
44	intervention*.mp.
45	condition*.mp.
46	exp PHYSICAL ENDURANCE/
47	endurance.mp.
48	exp GAIT/
49	gait*.mp.
50	postural balance.mp.
51	exp DANCING/
52	danc*.mp.
53	tango.mp.

(Continued)

54	exp MARTIAL ARTS/
55	martial art*.mp.
56	aerobic.mp.
57	(boxing or shadowboxing).mp.
58	treadmill*.mp.
59	karate.mp.
60	exp WALKING/
61	walking.mp.
62	BICYCLING/
63	bicycle*.mp.
64	or/39-63
65	MEDICINE, CHINESE TRADITIONAL/
66	traditional chinese exercise.mp.
67	or/65-66
68	exp MIND-BODY THERAPIES/
69	(mind adj1 body).mp.
70	Tai ji/
71	((chi adj1 tai) or (tai adj1 ji*) or taiji* or taichi* or t'ai chi).mp.
72	(wuqinxi or baduanjin or yijiejing).mp.
73	QIGONG/
74	(qi-gong* or qigong*).mp.
75	((qi* adj2 (gong* or kung* or chung* or gung*)) or (chi* adj2 (gong* or kung* or chung* or gung*))).mp.
76	yoga.mp.
77	(asana or pranayama or dhyana).mp.
78	pilates.mp.
79	or/68-78
80	exp REHABILITATION/
81	rehab*.mp.

(Continued)

82	exp THERAPEUTICS/
83	therap*.mp.
84	physical*.mp.
85	physiotherapy.mp.
86	exercise therapy.mp.
87	exp EXERCISE TEST/
88	exercise test.mp.
89	strengthening program*.mp.
90	progressive resistance training.mp.
91	cardiorespiratory.mp.
92	exp CARDIOVASCULAR SYSTEM/
93	cardiovascular.mp.
94	aqua*.mp.
95	hydrotherapy.mp.
96	(lsvt-big or lsvtbig).mp.
97	("Lee Silverman Voice Treatment" and big).mp.
98	periodicity.mp.
99	socio environmental.mp.
100	(whole body adj1 vibration*).mp.
101	or/80-100
102	23 or 38 or 64 or 67 or 79 or 101
103	randomized controlled trial.pt.
104	controlled clinical trial.pt.
105	randomi?ed.ab.
106	placebo.ab.
107	clinical trials as topic.sh.
108	randomly.ab.
109	trial.ti.

(Continued)

110	or/103-109
111	exp animals/ not humans/
112	110 not 111
113	3 and 102 and 112

key: exp # /: explode # MeSH subject heading, tw: text word. kf: keyword heading word mp: multiple purpose, ti: title, ab: abstract, pt: publication type, *: truncation, ?: wildcard, adj#: adjacent within # number of words
searchline #103-#112 Cochrane RCT-Filter, sensitivity- and precision-maximizing version

Appendix 4. Embase search strategy

Embase (via Ovid)

#	Searches
1	PARKINSON DISEASE/
2	parkinson*.tw.
3	or/1-2
4	exp SOFTWARE/
5	software.tw.
6	game.tw.
7	gaming.tw.
8	play*.tw.
9	simulation*.tw.
10	program*.tw.
11	techni*.tw.
12	video.tw.
13	VIRTUAL REALITY EXPOSURE THERAPY/
14	user-computer interface.tw.
15	interactive.tw.
16	virtual*.tw.
17	vr.tw.
18	augmented.tw.

(Continued)

19	exergam*.tw.
20	kinect.tw.
21	nintendo wii.tw.
22	microsoft xbox.tw.
23	or/4-22
24	biofeedback.tw.
25	exp "MOVEMENT (PHYSIOLOGY)"/
26	movement.tw.
27	exp PHYSIOTHERAPY/
28	exp FITNESS/
29	fitness.tw.
30	MUSCLE STRENGTH/
31	strength.tw.
32	muscle.tw.
33	locomot*.tw.
34	exp BODY WEIGHT/
35	(weight* adj1 body*).tw.
36	(weight* adj2 training*).tw.
37	motor activity.tw.
38	or/24-37
39	exp EXERCISE/
40	exercise*.tw.
41	activit*.tw.
42	sport*.tw.
43	train*.tw.
44	intervention*.tw.
45	condition*.tw.
46	ENDURANCE/

(Continued)

47	endurance.tw.
48	exp GAIT/
49	gait*.tw.
50	postural balance.tw.
51	exp DANCING/
52	danc*.tw.
53	tango.tw.
54	exp MARTIAL ART/
55	martial art*.tw.
56	aerobic.tw.
57	(boxing or shadowboxing).tw.
58	treadmill*.tw.
59	karate.tw.
60	exp WALKING/
61	walking.tw.
62	CYCLING/
63	(bicycle* or cycling).tw.
64	or/39-63
65	CHINESE MEDICINE/
66	traditional chinese exercise.tw.
67	or/65-66
68	(mind adj1 body).tw.
69	TAI CHI/
70	((chi adj1 tai) or (tai adj1 ji*) or taiji* or taichi* or t'ai chi).tw.
71	(wuqinxi or baduanjin or yijiejing).tw.
72	QIGONG/
73	(qi-gong* or qigong* or chi kung* or chigung*).tw.
74	((qi* adj2 (gong* or kung* or chung* or gung*)) or (chi* adj2 (gong* or kung* or chung* or gung*))).tw.

(Continued)

75	yoga.tw.
76	(asana or pranayama or dhyana).tw.
77	pilates.tw.
78	exp ALTERNATIVE MEDICINE/
79	or/68-78
80	REHABILITATION/
81	rehab*.tw.
82	THERAPEUTICS/
83	therap*.tw.
84	physical*.tw.
85	physiotherapy.tw.
86	exercise therapy.tw.
87	exp EXERCISE TEST/
88	exercise test.tw.
89	strengthening program*.tw.
90	progressive resistance training.tw.
91	cardiorespiratory.tw.
92	exp CARDIOVASCULAR SYSTEM/
93	cardiovascular.tw.
94	aqua*.tw.
95	hydrotherapy.tw.
96	(lsvt-big or lsvtbig).tw.
97	("Lee Silverman Voice Treatment" and big).tw.
98	periodicity.tw.
99	socio environmental.tw.
100	or/80-99
101	(whole body adj1 vibration*).tw.
102	23 or 38 or 64 or 67 or 79 or 100 or 101

(Continued)

103	3 and 102
104	(double adj1 blind*).sh,ab,ti. or placebo*.ab,ti. or blind*.ab,ti.
105	3 and 102 and 104
106	limit 105 to medline
107	105 not 106

Appendix 5. CINAHL search strategy

CINAHL (via EBSCO)

#	Searches
1	(MH "PARKINSON DISEASE")
2	TX parkinson*
3	software*
4	game OR gaming OR play*
5	program* OR techni* OR video
6	(MH "VIRTUAL REALITY EXPOSURE THERAPY")
7	user-computer interface
8	interactive OR virtual* OR vr
9	augmented OR exergam* OR kinect OR nintendo wii OR microsoft xbox
10	S3 OR S4 OR S5 OR S6 OR S7 OR S8 OR S9
11	(MH "BIOFEEDBACK")
12	biofeedback
13	(MH "MOVEMENT+")
14	movement
15	(MH "PHYSICAL THERAPY+")
16	(MH "PHYSICAL FITNESS+")
17	fitness
18	(MH "MUSCLE STRENGTH+")
19	strength OR muscle OR locomot*

(Continued)

20	(MH "BODY WEIGHT+")
21	(weight* N1 body*) OR (weight* N2 training*) OR motor activity
22	S11 OR S12 OR S13 OR S14 OR S15 OR S16 OR S17 OR S18 OR S19 OR S20 OR S21
23	(MH "EXERCISE+")
24	exercise* OR activit* OR sport*
25	train* OR intervention* OR condition*
26	(MH "PHYSICAL ENDURANCE+")
27	endurance
28	(MH "Gait+") OR (MH "Gait Training+")
29	gait* OR postural balance
30	(MH "Dancing+")
31	danc* OR tango
32	(MH "MARTIAL ARTS")
33	martial art* OR aerobic OR ((boxing or shadowboxing)) OR treadmill* OR karate
34	(MH "WALKING+")
35	walking
36	(MH "CYCLING")
37	bicycle* OR cycl*
38	S23 OR S24 OR S25 OR S26 OR S27 OR S28 OR S29 OR S30 OR S31 OR S32 OR S33 OR S34 OR S35 OR S36 OR S37
39	(MH "MEDICINE, CHINESE TRADITIONAL+")
40	traditional chinese exercise
41	S39 OR S40
42	(MH "MIND BODY TECHNIQUES+")
43	mind body
44	(MH "TAI CHI")
45	chi N1 tai OR tai N1 ji* OR taiji* OR taichi* OR t'ai chi
46	wuqinxi OR baduanjin OR yijiejing
47	(MH "QIGONG")

(Continued)

48	qi-gong* OR qigong*
49	(qi* N2 (gong* OR kung* OR chung* OR gung*)) OR (chi* N2 (gong* OR kung* OR chung* OR gung*))
50	(MH "YOGA+")
51	yoga OR asana OR pranayama OR dhyana
52	(MH "PILATES")
53	S42 OR S43 OR S44 OR S45 OR S46 OR S47 OR S48 OR S49 OR S50 OR S51 OR S52
54	(MH "REHABILITATION+")
55	rehab*
56	(MH "THERAPEUTICS")
57	therap* OR physical* OR physiotherapy OR exercise therapy
58	(MH "EXERCISE TEST")
59	exercise test OR strengthening program* OR progressive resistance training
60	(MH "CARDIOVASCULAR SYSTEM+")
61	cardiorespiratory OR cardiovascular
62	(MH "HYDROTHERAPY+")
63	aqua* OR hydrotherapy
64	(lsvt-big OR lsvtbig) OR ("Lee Silverman Voice Treatment" AND big)
65	periodicity OR socio environmental OR (whole body vibration*)
66	S54 OR S55 OR S56 OR S57 OR S58 OR S59 OR S60 OR S61 OR S62 OR S63 OR S64 OR S65
67	S10 OR S22 OR S38 OR S41 OR S53 OR S66
68	(S1 or S2) and S67
69	randomized OR randomised OR treatment outcome* OR clinical trial*
70	S68 AND S69

Appendix 6. SPORTDiscus search strategy

SPORTDiscus (via EBSCO)

#	Searches

(Continued)

1	DE "PARKINSON'S disease"
2	TX parkinson*
3	S1 OR S2
4	DE "ELECTRONIC games" OR DE "COMPUTER games" OR DE "INTERNET games" OR DE "MULTIPLAYER games" OR DE "VIDEO games" OR DE "EXERCISE video games" OR DE "NINTENDO Wii Fit games"
5	TX software OR TX game OR TX gaming OR TX play*
6	TX simulation* OR TX program* OR TX video
7	VIRTUAL REALITY EXPOSURE THERAPY
8	TX user-computer interface OR TX interactive OR TX virtual*
9	TX vr OR TX augmented OR TX exergam*
10	TX kinect OR TX nintendo wii OR TX microsoft xbox
11	S4 OR S5 OR S6 OR S7 OR S8 OR S9 OR S10
12	TX biofeedback
13	(DE "BODY movement" OR DE "ABDUCTION (Kinesiology)" OR DE "ADDUCTION" OR DE "MOVEMENT therapy")
14	TX movement OR TX fitness
15	DE "PHYSICAL therapy" OR DE "BALNEOLOGY" OR DE "COLD therapy" OR DE "ELECTROTHERAPEUTICS" OR DE "HYDROTHERAPY" OR DE "LIANGONG" OR DE "MANIPULATION therapy" OR DE "OCCUPATIONAL therapy" OR DE "PHOTOTHERAPY" OR DE "RECREATIONAL therapy" OR DE "SPORTS physical therapy" OR DE "THERMOTHERAPY" OR DE "VETERINARY physical therapy"
16	DE "PHYSICAL fitness" OR DE "ANAEROBIC exercises" OR DE "ASTROLOGY & physical fitness" OR DE "BODYBUILDING" OR DE "CARDIOPULMONARY fitness" OR DE "CARDIOVASCULAR fitness" OR DE "CIRCUIT training" OR DE "COMPOUND exercises" OR DE "EXERCISE tolerance" OR DE "ISOLATION exercises" OR DE "LIANGONG" OR DE "MUSCLE strength" OR DE "PERIODIZATION training" OR DE "PHYSICAL fitness for children" OR DE "PHYSICAL fitness for girls" OR DE "PHYSICAL fitness for men" OR DE "PHYSICAL fitness for older people" OR DE "PHYSICAL fitness for people with disabilities" OR DE "PHYSICAL fitness for women" OR DE "PHYSICAL fitness for youth" OR DE "SPORT for all"
17	DE "HUMAN locomotion" OR DE "GAIT in humans" OR DE "HOPPING (Locomotion)" OR DE "HUMAN climbing" OR DE "JUMPING" OR DE "PARKOUR" OR DE "RUNNING" OR DE "SKIPPING" OR DE "STAIR climbing" OR DE "SWIMMING" OR DE "WALKING" OR DE "LOCOMOTION" OR DE "ANIMAL locomotion" OR DE "AUTOMOBILES" OR DE "BOATS & boating" OR DE "CYCLING" OR DE "FLIGHT" OR DE "HORSEMANSHIP" OR DE "HUMAN locomotion" OR DE "TURNING (Locomotion)"
18	DE "MUSCLE strength" OR DE "GRIP strength" OR DE "KRAUS-Weber test"
19	DE "STRENGTH training" OR DE "WEIGHT lifting"
20	TX strength OR TX muscle OR TX locomot*

(Continued)

21	DE "BODY weight" OR DE "LEANNESS" OR DE "OBESITY"
22	TX weight* N1 body* OR TX weight* N2 training* AND TX motor activity
23	S12 OR S13 OR S14 OR S15 OR S16 OR S17 OR S18 OR S19 OR S20 OR S21 OR S22
24	DE "EXERCISE" OR DE "ABDOMINAL exercises" OR DE "AEROBIC exercises" OR DE "ANAEROBIC exercises" OR DE "AQUATIC exercises" OR DE "ARM exercises" OR DE "BACK exercises" OR DE "BREATHING exercises" OR DE "BREEMA" OR DE "BUTTOCKS exercises" OR DE "CALISTHENICS" OR DE "CHAIR exercises" OR DE "CHEST exercises" OR DE "CIRCUIT training" OR DE "COMPOUND exercises" OR DE "COOLDOWN" OR DE "DO-in" OR DE "EXERCISE adherence" OR DE "EXERCISE for children" OR DE "EXERCISE for girls" OR DE "EXERCISE for men" OR DE "EXERCISE for middle-aged persons" OR DE "EXERCISE for older people" OR DE "EXERCISE for people with disabilities" OR DE "EXERCISE for women" OR DE "EXERCISE for youth" OR DE "EXERCISE therapy" OR DE "EXERCISE video games" OR DE "FACIAL exercises" OR DE "FALUN gong exercises" OR DE "FOOT exercises" OR DE "GYMNASTICS" OR DE "HAND exercises" OR DE "HATHA yoga" OR DE "HIP exercises" OR DE "ISOKINETIC exercise" OR DE "ISOLATION exercises" OR DE "ISOMETRIC exercise" OR DE "ISOTONIC exercise" OR DE "KNEE exercises" OR DE "LEG exercises" OR DE "LIANGONG" OR DE "METABOLIC equivalent" OR DE "MULAN quan" OR DE "MUSCLE strength" OR DE "PILATES method" OR DE "PLYOMETRICS" OR DE "QI gong" OR DE "REDUCING exercises" OR DE "RUNNING" OR DE "RUNNING -- Social aspects" OR DE "SCHOOL exercises & recreations" OR DE "SEXUAL exercises" OR DE "SHOULDER exercises" OR DE "STRENGTH training" OR DE "STRESS management exercises" OR DE "TAI chi" OR DE "TREADMILL exercise" OR DE "WHEELCHAIR workouts" OR DE "YOGA"
25	TX exercise* OR TX activit* OR TX sport*
26	TX train* OR TX intervention* OR TX condition*
27	PHYSICAL ENDURANCE
28	TX endurance
29	DE "GAIT in humans"
30	TX gait OR TX postural balance
31	DE "DANCE" OR DE "AERIAL dance" OR DE "AEROBIC dancing" OR DE "BALLET" OR DE "BALLROOM dancing" OR DE "BELLY dance" OR DE "BREAK dancing" OR DE "CHA-cha (Dance)" OR DE "COUNTRY dancing" OR DE "DANCE & globalization" OR DE "DANCE for people with disabilities" OR DE "FLAMENCO" OR DE "FOLK dancing" OR DE "FREE skating" OR DE "HIP-hop dance" OR DE "ICE dancing" OR DE "JAZZ dance" OR DE "LINE dancing" OR DE "LION dance" OR DE "MODERN dance" OR DE "MOVEMENT notation" OR DE "ORIGINAL set pattern dance (Skating)" OR DE "POLE dancing" OR DE "ROUND dancing" OR DE "SALSA (Dance)" OR DE "SHISHIMAI (Dance)" OR DE "STEP dancing" OR DE "TANGO (Dance)" OR DE "TAP dancing"
34	TX danc* OR TX tango
35	DE "MARTIAL arts" OR DE "ARCHERY" OR DE "BUDO" OR DE "DUELING" OR DE "EAST Asian martial arts" OR DE "ESCRIMA" OR DE "HAND-to-hand fighting" OR DE "JEET Kune Do" OR DE "JUkenpo" OR DE "KAJUKENBO" OR DE "KALARIPPAYATTU" OR DE "KENJUTSU" OR DE "KENPO" OR DE "KICKBOXING" OR DE "KRAV maga" OR DE "KUN-tao" OR DE "KYUDO (Archery)" OR DE "LION dance" OR DE "MARTIAL arts for children" OR DE "MARTIAL arts for people with disabilities" OR DE "MIXED martial arts" OR DE "NINJUTSU" OR DE "PENCAK silat" OR DE "SAN-jitsu" OR DE "SHISHIMAI (Dance)" OR DE "SPEAR fighting"
36	TX martial art* OR TX aerobic OR TX ((boxing or shadowboxing))

(Continued)

37	TX treadmill* OR TX karate
38	DE "WALKING" OR DE "FITNESS walking" OR DE "GAIT in humans" OR DE "HIKING" OR DE "LONG distance walking" OR DE "VIERDAAGSE (Walking event)"
39	TX walking
40	DE "CYCLING" OR DE "BICYCLE commuting" OR DE "BICYCLE racing" OR DE "BICYCLE touring" OR DE "CYCLING ability testing" OR DE "CYCLING competitions" OR DE "CYCLING for people with disabilities" OR DE "MOTORCYCLING" OR DE "MOUNTAIN biking" OR DE "NIGHT cycling" OR DE "RAILBIKING" OR DE "STUNT cycling" OR DE "URBAN cycling" OR DE "WOMEN'S cycling"
41	TX bicycle*
42	DE "HUMAN locomotion" OR DE "GAIT in humans" OR DE "HOPPING (Locomotion)" OR DE "HUMAN climbing" OR DE "JUMPING" OR DE "PARKOUR" OR DE "RUNNING" OR DE "SKIPPING" OR DE "STAIR climbing" OR DE "SWIMMING" OR DE "WALKING" OR DE "LOCOMOTION" OR DE "ANIMAL locomotion" OR DE "AUTOMOBILES" OR DE "BOATS & boating" OR DE "CYCLING" OR DE "FLIGHT" OR DE "HORSEMANSHIP" OR DE "HUMAN locomotion" OR DE "TURNING (Locomotion)"
43	S24 OR S25 OR S26 OR S27 OR S28 OR S29 OR S30 OR S31 OR S32 OR S33 OR S34 OR S35 OR S36 OR S37 OR S38 OR S39 OR S40 OR S41OR S42
44	TX traditional chinese N1 exercise
45	DE "MIND & body" OR DE "ALEXANDER technique" OR DE "BIOFEEDBACK training" OR DE "BODY image" OR DE "INFLUENCE of age on ability" OR DE "MIND-body walking" OR DE "PSYCHOSOMATIC medicine"
46	mind N1 body
47	(DE "TAI chi" OR DE "TAI chi for children") OR (DE "TAI chi" OR DE "TAI chi for children")
48	TX chi N1 tai OR TX tai N1 ji* OR TX taiji* OR TX taichi* OR TX t'ai chi
49	TX wuqinxi OR TX baduanjin OR TX yijiejing
50	TX qi-gong* OR TX qigong* OR TX (qi* N2 (gong* OR kung* OR chung* OR gung*)) OR TX (chi* N2 (gong* OR kung* OR chung* OR gung*))
51	DE "YOGA" OR DE "ASTANGA yoga" OR DE "CHAKRAS" OR DE "HATHA yoga" OR DE "KUNDALINI yoga" OR DE "MUSIC for yoga" OR DE "SIDDHA yoga (Service mark)" OR DE "YIN yoga" OR DE "YOGA for children" OR DE "YOGA for people with disabilities"
52	TX yoga OR TX asana OR TX pranayama OR TX dhyana
53	DE "PILATES method"
54	TX pilates
55	S44 OR S45 OR S46 OR S47 OR S48 OR S49 OR S50 OR S51 OR S52 OR S53 OR S54
56	DE "REHABILITATION" OR DE "AQUATIC exercises -- Therapeutic use" OR DE "MEDICAL rehabilitation" OR DE "NEUROPSYCHOLOGICAL rehabilitation"
57	TX rehab*

(Continued)

58	DE "THERAPEUTICS"
59	TX therap*
60	TX physical* OR TX physiotherapy OR TX strengthening program*
61	DE "PHYSIOLOGICAL therapeutics" OR DE "CRANIOSACRAL therapy" OR DE "DIET therapy" OR DE "ELECTROTHERAPEUTICS" OR DE "EXERCISE therapy" OR DE "EXTRACORPOREAL shock wave therapy" OR DE "MAGNETOTHERAPY" OR DE "MASSAGE therapy" OR DE "MECHANOTHERAPY" OR DE "OCCUPATIONAL therapy" OR DE "PHOTOTHERAPY" OR DE "PHYSICAL therapy" OR DE "REFLEXOTHERAPY" OR DE "REST" OR DE "PHYSICAL therapy"
62	DE "CARDIOVASCULAR system" OR DE "ANAEROBIC capacity" OR DE "BLOOD-vessels" OR DE "HEART"
63	TX progressive resistance N1 training OR TX cardiorespiratory OR TX cardiovascular
64	DE "HYDROTHERAPY"
65	TX lsvt-big OR TX lsvtbig OR TX (("Lee Silverman Voice Treatment" AND big)
66	TX periodicity OR TX socio environmental
67	TX whole body N1 vibration
68	S56 OR S57 OR S58 OR S59 OR S60 OR S61 OR S62 OR S63 OR S64 OR S65 OR S66 OR S67
69	S11 OR S23 OR S43 OR S55 OR S68
70	S3 AND S69
71	TX ((clinic$ or controlled or comparative or placebo or prospective or randomised or randomized) and (trial or study))
72	TX (random* and (allocat* or allot* or assign* or basis* or divid* or order*))
73	TX ((singl* or doubl* or trebl* or tripl*) and (blind* or mask*))
74	TX (cross?over or (cross over))
75	TX "randomi?ed control* trial*"
76	TX ((allocat* or allot* or assign* or divid*) and (condition* or experiment* or intervention* or treatment* or therap* or control* or group*))
77	TX placebo*
78	S71 OR S72 OR S73 OR S74 OR S75 OR S76 OR S77
79	S70 AND S78

Appendix 7. AMED search strategy

AMED (Allied and Complementary Medicine) (via Ovid)

#	Searches
1	PARKINSON DISEASE/
2	parkinson*.tw.
3	or/1-2
4	exp SOFTWARE/
5	software.tw.
6	game.tw.
7	gaming.tw.
8	play*.tw.
9	simulation*.tw.
10	program*.tw.
11	techni*.tw.
12	video.tw.
13	VIRTUAL REALITY/
14	user-computer interface.tw.
15	interactive.tw.
16	virtual*.tw.
17	vr.tw.
18	augmented.tw.
19	exergam*.tw.
20	kinect.tw.
21	nintendo wii.tw.
22	microsoft xbox.tw.
23	biofeedback.tw.
24	MOVEMENT/
25	movement.tw.
26	PHYSICAL FITNESS/
27	exp PHYSICAL THERAPY MODALITIES/

(Continued)

28	MUSCLE STRENGTH/
29	strength.tw.
30	muscle.tw.
31	locomot*.tw.
32	exp BODY WEIGHT/
33	(weight* adj1 body*).tw.
34	(weight* adj2 training*).tw.
35	motor activity.tw.
36	exp EXERCISE/
37	exercise*.tw.
38	activit*.tw.
39	SPORT/
40	sport*.tw.
41	train*.tw.
42	intervention*.tw.
43	condition*.tw.
44	ENDURANCE/
45	endurance.tw.
46	exp GAIT/
47	gait*.tw.
48	postural balance.tw.
49	exp DANCING/
50	danc*.tw.
51	tango.tw.
52	exp MARTIAL ARTS/
53	martial art*.tw.
54	aerobic.tw.
55	BOXING/

(Continued)

56	(boxing or shadowboxing).tw.
57	treadmill*.tw.
58	karate.tw.
59	exp WALKING/
60	walking.tw.
61	BYCYCLING/
62	(bicycle* or cycling).tw.
63	TRADITIONAL MEDICINE CHINESE/
64	traditional chinese exercise.tw.
65	(mind adj1 body).tw.
66	exp TAI CHI/
67	((chi adj1 tai) or (tai adj1 ji*) or taiji* or taichi* or t'ai chi).tw.
68	(wuqinxi or baduanjin or yijiejing).tw.
69	QIGONG/
70	(qi-gong* or qigong* or chi kung* or chigung*).tw.
71	((qi* adj2 (gong* or kung* or chung* or gung*)) or (chi* adj2 (gong* or kung* or chung* or gung*))).tw.
72	YOGA/
73	yoga.tw.
74	(asana or pranayama or dhyana).tw.
75	pilates.tw.
76	REHABILITATION/
77	rehab*.tw.
78	THERAPEUTICS/
79	therap*.tw.
80	PHYSICAL FITNESS/
81	physical*.tw.
82	physiotherapy.tw.

(Continued)

83	PHYSICAL THERAPY MODALITIES/ or exp EXERCISE MOVEMENT TECHNIQUES/ or exp EXERCISE THERAPY/
84	exercise therapy.tw.
85	exp EXERCISE TESTING/
86	exercise test.tw.
87	strengthening program*.tw.
88	progressive resistance training.tw.
89	cardiorespiratory.tw.
90	exp CARDIOVASCULAR SYSTEM/
91	cardiovascular.tw.
92	aqua*.tw.
93	HYDROTHERAPY/
94	hydrotherapy.tw.
95	(lsvt-big or lsvtbig).tw.
96	("Lee Silverman Voice Treatment" and big).tw.
97	periodicity.tw.
98	socio environmental.tw.
99	(whole body adj1 vibration*).tw.
100	or/4-99
101	randomized controlled trial.tw.
102	controlled clinical trial.tw.
103	randomized.ab.
104	placebo.ab.
105	drug therapy.tw.
106	randomly.ab.
107	trial.ab.
108	groups.ab.
109	or/101-108
110	ANIMALS/ not HUMANS/

(Continued)

111	109 not 110
112	3 and 100 and 111

Appendix 8. REHABDATA search strategy

Containing all of the words: Parkinson*,
containing at least one of the word(s): "software" or "game" or "gaming" or "play* or "simulation" or "program*" or "techni*" or "video" or "interface" or "virtual" or "vr" or "augmented" or "exergam*" or "Kinect" or "Nintendo wii" or "xbox" or "biofeedback" or "movement" or "fitness" or "strength" or "muscle" or "locomot*" or "body weight" or "exercise" or "activit*" or "sport*" or "train*" or "intervention*" or "condition*" or "endurance" or "gait" or "danc*" or "tango" or "martial art*" or "aerobic" or "boxing" or "shadowboxing" or "treadmill*" or "karate" or "walking" or "bicycli*" or "cycl*" or " "mind body" or "body mind" or "tai ji" or "rehab*" or "telerehab*" or "therap*" or "physical*" or "physiotherapy*" or "strengthening" or "cardiorespiratory" or "cardiovascular" or "aqua*" or "hydrotherapy*" or "lsvtbig" or "lsvt big" or "periodicity" or "socio environmental" or "whole body"

Appendix 9. PEDro search strategy

Title & abstract: parkinson* and method: clinical trial

Appendix 10. Trial register search strategies (Clinicaltrials.gov, WHO ICTRP, ISRCTN, EUCTR)

Clinicaltrials.gov search strategy:

Advanced search
Conditions: Parkinson
Interventions: software OR game OR play OR simulation OR program OR video OR interface OR virtual OR vr OR augmented OR exergame OR Kinect OR Nintendo OR wii OR Recruitment: All studies
Study type: Interventional studies
Conditions: Parkinson
Interventions: biofeedback OR movement OR fitness OR strength OR muscle OR locomot OR body weight OR exercise OR activit OR sport* OR train* OR intervention* OR endurance OR gait Recruitment: All studies
Study type: Interventional studies
Conditions: Parkinson
Interventions: dance OR tango OR martial art OR aerobic OR boxing OR shadowboxing OR treadmill OR karate OR walking OR bicycli OR cycl OR mind body OR tai ji Recruitment: All studies
Study type: Interventional studies
Conditions: Parkinson
Interventions:rehabilitation OR telerehabilitation OR physical OR physiotherapy OR strengthening OR cardiorespiratory OR cardiovascular Recruitment: All studies
Study type: Interventional studies
Conditions: Parkinson
Interventions: aqua OR hydrotherapy OR lsvtbig OR lsvt-big OR Lee Silverman Voice OR periodicity OR socio environmental OR whole body Recruitment: All studies
Study type: Interventional studies

WHO ICTRP search strategy:

Advanced search
Condition: Parkinson*
Intervention: software OR gam*
Recruitment status: ALL
Condition: Parkinson*
Intervention: play* OR simulation OR program* OR techni* OR video OR interface
Recruitment status: ALL
Condition: Parkinson*
Intervention: virtual OR vr OR augmented OR exergam*
Recruitment status: ALL
Condition: Parkinson*
Intervention: kinect OR Nintendo wii OR xbox
Recruitment status: ALL

Condition: Parkinson*
Intervention: biofeedback OR movement OR fitness
Recruitment status: ALL
Condition: Parkinson*
Intervention: strength OR muscle OR locomot*
Recruitment status: ALL
Condition: Parkinson*
Intervention: body weight OR exercise
Recruitment status: ALL
Condition: Parkinson*
Intervention: activit* OR sport* OR train*
Recruitment status: ALL
Condition: Parkinson*
Intervention: condition* OR endurance OR gait
Recruitment status: ALL
Condition: Parkinson*
Intervention: danc* OR tango
Recruitment status: ALL
Condition: Parkinson*
Intervention: martial art* OR aerobic OR boxing OR shadowboxing OR treadmill* OR karate
Recruitment status: ALL
Condition: Parkinson*
Intervention: walking OR bicycli* OR cycl* OR mind body OR tai ji
Recruitment status: ALL
Condition: Parkinson*
Intervention: rehab* OR telerehab* OR therap* OR physical* OR physiotherapy*
Recruitment status: ALL
Condition: Parkinson*
Intervention: strengthening OR cardiorespiratory OR cardiovascular OR aqua* OR hydrotherapy*
Recruitment status: ALL
Condition: Parkinson*
Intervention: Lee Silverman Voice OR lsvtbig OR lsvt-big OR periodicity OR socio environmental OR whole body
Recruitment status: ALL

ISRCTNsearch strategy:
Condition: Parkinson

EU clinical trials register search strategy:
Parkinson

Appendix 11. Network estimates of effects and prediction intervals for physical exercise in people with Parkinson's disease on severity of motor signs

Patient or population: people with Parkinson's disease
Interventions: physical exercise including aqua-based training, dance, endurance training, flexibility training, gait/balance/functional training, gaming, LSVT BIG, mind-body training, multi-domain training, and strength/resistance training
Comparison: passive control group (mean [median] UPDRS-M score = 21.34 [19.80])*
Outcome: severity of motor signs, measured with UPDRS-M, scale from 0 to 108 (worse)
Settings: inpatient and outpatient care

Total studies: 71 RCTs **Total participants:** 3196	**Estimated absolute effects on severity of motor signs (SMD and 95% PI)**
Dance (5 RCTs; 169 participants)	-0.77 (-1.64 to 0.11)
Aqua-based training	-0.58 (-1.46 to 0.30)

(Continued)

(2 RCTs; 30 participants)	
Gait/balance/functional training (3 RCTs; 137 participants)	-0.55 (-1.38 to 0.28)
Multi-domain training (7 RCTs; 271 participants)	-0.52 (-1.34 to 0.29)
Strength/resistance training (2 RCTs; 52 participants)	-0.52 (-1.38 to 0.34)
Mind-body training (10 RCTs; 323 participants)	-0.49 (-1.31 to 0.34)
Endurance training (5 RCTs; 227 participants)	-0.48 (-1.32 to 0.35)
LSVT BIG (1 RCT; 39 participants)	-0.41 (-1.45 to 0.63)
Flexibility training (No direct evidence, indirect evidence only)	0.15 (-0.78 to 1.09)
Gaming (No direct or indirect evidence)	Not applicable**

Footnotes

MD: mean difference; **PI:** prediction interval; **SMD:** standardized mean difference; **UPDRS-M:** Unified Parkinson Disease Rating Scale - motor scale

* Scores were calculated based on mean UPDRS-M scores (post-intervention) reported in 23 studies (317 participants) which were included in the network meta-analysis.
** None of the studies provided data on the effect of gaming on severity of motor signs.

Appendix 12. Network estimates of effects and prediction intervals for physical exercise in people with Parkinson's disease on quality of life

Patients or population: people with Parkinson's disease
Interventions: physical exercise including aqua-based training, dance, endurance training, flexibility training, and gait/balance/functional training, gaming, LSVT BIG, mind-body training, multi-domain training, and strength/resistance training
Comparison: passive control group (mean [median] PDQ-39 score = 32.72 [29.50])*

Outcome: quality of life, measured with PDQ-39, scale from 0 to 100 (worse)

Settings: inpatient and outpatient care

Total studies: 55 RCTs **Total participants:** 3283	**Estimated absolute effects on quality of life (SMD and 95% PI)**

(Continued)

Aqua-based training (1 RCT; 18 participants)	-0.85 (-1.7 to 0.01)
Endurance training (3 RCTs; 90 participants)	-0.52(-1.32 to 0.27)
Mind-body training (5 RCTs; 155 participants)	-0.50 (-1.27 to 0.28)
Gaming (No direct evidence, indirect evidence only)	-0.40 (-1.37 to 0.56)
Strength/resistance training (3 RCTs; 87 participants)	-0.36 (-1.14 to 0.42)
Gait/balance/functional training (5 RCTs; 745 participants)	-0.32 (-1.06 to 0.43)
Multi-domain training (7 RCTs; 575 participants)	-0.30 (-1.04 to 0.44)
Dance (4 RCTs; 130 participants)	-0.23 (-1.05 to 0.58)
LSVT BIG (No direct evidence, indirect evidence only)	0.13 (-1.14 to 1.39)
Flexibility training (No direct evidence, indirect evidence only)	0.07 (-0.94 to 1.08)

Footnotes

MD: mean difference; **PDQ-39:** Parkinson's Disease Questionnaire 39; **PI:** prediction interval; **SMD:** standardized mean difference

* Scores were calculated based on mean PDQ-39 scores (post-intervention) reported in 21 studies (642 participants) which were included in the network meta-analysis.

WHAT'S NEW

Date	Event	Description
16 May 2023	Amended	An Editorial note was added to make the interactive summary of findings table more prominent to readers.

HISTORY

Protocol first published: Issue 2, 2021
Review first published: Issue 1, 2023

Date	Event	Description
14 March 2023	Amended	An interactive summary of findings table was added to present key results of the network meta-analyses.

CONTRIBUTIONS OF AUTHORS

ME: methodological expertise, conception, and writing of the review
AF: methodological expertise, conception, and writing of the review
RG: support in data extraction
EL: support in data extraction
JCV: support in data extraction
NC: support in data extraction
AA: carried out the network meta-analyses
IM: development of the search strategy
AD: methodological expertise, conception, and writing of the review
MR: methodological expertise, conception, and writing of the review
CE: clinical expertise and advice
NS: methodological expertise, conception, and writing of the review
EK: methodological expertise, conception, and writing of the review

DECLARATIONS OF INTEREST

ME is associated with the Cochrane Haematology group, but was not involved in the editorial process of this review.
AF has been involved in an ongoing study eligible for inclusion (Gooßes 2020). She was not involved in the assessment of the study's eligibility and she will not be involved in the data extraction or the assessment of risk of bias in the future.
RG: none known
EL: none known
JCV is associated with the Cochrane Haematology group, but was not involved in the editorial process of this review.
NC is associated with the Cochrane Haematology group, but was not involved in the editorial process of this review.
AA is associated with the Cochrane Haematology group, but was not involved in the editorial process of this review.
IM is associated with the Cochrane Haematology group, but was not involved in the editorial process of this review.
AD: none known
MR: none known
CE: none known
NS is associated with the Cochrane Haematology group, but was not involved in the editorial process of this review.
EK has been involved in an ongoing study eligible for inclusion (Gooßes 2020). She was not involved in the assessment of the study's eligibility and she will not be involved in the data extraction or the assessment of risk of bias in the future.

SOURCES OF SUPPORT

Internal sources

- University Hospital of Cologne, Faculty of Medicine and University Hospital, University of Cologne, Germany

  Cochrane Haematology, Department I of Internal Medicine

External sources

- German Federal Ministry of Education and Research (BMBF), Germany

  Grant no: 01KG1902

DIFFERENCES BETWEEN PROTOCOL AND REVIEW

This section records differences between the methods described in the protocol (Roheger 2021), and the methods used in the review.

Primary outcomes

One of our primary outcomes was originally labelled 'clinician-rated impairment and disability', based on a previous Cochrane Review. We rephrased the outcome to 'severity of motor signs' to improve accuracy and readability.

Selection of studies

We had planned to perform the screening of all titles and abstracts in duplicate. In light of the large number of search results (21,981), only one review author (ME) performed the initial screening of titles and abstracts for clearly irrelevant results (16,129), before the remaining results were screened in duplicate and independently by two authors (ME, AF).

Measures of treatment effect

For binary outcomes, we had planned to extract number of participants and number of events per arm, whenever possible. However, we were not able to retrieve the relevant information, and conduct a quantitative synthesis on the number of participants with any adverse event using a network meta-analysis, given the heterogeneity in measuring and reporting of adverse events. Therefore, we did not calculate risk ratios with 95% confidence intervals for each trial.

Pairwise comparisons

At protocol stage, we described methods to be used for the conduct of both network meta-analyses and pairwise meta-analyses. However, pairwise comparisons are part of the network meta-analysis and, based on the available data, we were able to conduct network meta-analysis for all pre-planned comparisons across the efficacy outcomes, and did not need to perform additional pairwise meta-analyses. Therefore, we did not explicitly describe the methods to be used for pairwise meta-analyses in the review. Nevertheless, we do present the estimates for all pairwise comparisons provided by the network meta-analyses, i.e. in the upper triangle of each league table (Table 1; Table 2; Table 3; Table 4).

Risk of bias

We had planned to use the Cochrane risk of bias 2 (RoB 2) tool to assess risk of bias for the severity of motor signs, quality of life (QoL), and adverse events (Sterne 2019). However, we only used RoB 2 to asses risk of bias for study results on the severity of motor signs and QoL. Since it was not feasible to retrieve effect estimates for a network meta-analysis and conduct a formal assessment of risk of bias for adverse events, we made an informal judgment of the risk of bias for this outcome.

Confidence in the evidence and summary of findings tables

We had planned to rate the confidence in the evidence of effects on the severity of motor signs, QoL, and adverse events using the Confidence in Network Meta-Analysis (CINeMA) approach (Nikolakopoulou 2020). However, as we could not conduct a quantitative synthesis on the number of participants with any adverse event using a network meta-analysis, we instead used the GRADE approach to assess our confidence in the evidence for this outcome (Schünemann 2022). Accordingly, the format of the summary of findings (SoF) table for our main findings on adverse events (Summary of findings 3) differs from the format of the SoF tables for the severity of motor signs (Summary of findings 1) and QoL (Summary of findings 2). In particular, we did not stratify the narrative summary of adverse events in the main text by type of intervention. Correspondingly, we did not stratify the results on adverse events by type of intervention in the SoF table either.

INDEX TERMS

Medical Subject Headings (MeSH)

Exercise; Gait; Network Meta-Analysis; *Parkinson Disease [therapy]; Quality of Life; *Resistance Training

MeSH check words

Adult; Humans