CLINICAL PRACTICE GUIDELINE FOR THE PHYSICAL THERAPIST MANAGEMENT OF PARKINSON DISEASE

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Disclaimer

This clinical practice guideline was developed by an American Physical Therapy (APTA) volunteer guideline development group consisting of physical therapists and a neurologist. It was based on systematic reviews of current scientific literature, clinical information, and accepted approaches to the physical therapist management of Parkinson disease. This clinical practice guideline is not intended to be a fixed protocol, as some patients may require more or less treatment. Clinical patients may not necessarily be the same as participants in a clinical trial. Patient care and treatment should always be based on a clinician's independent medical judgment, given the individual patient's clinical circumstances.

Disclosure Requirement

In accordance with APTA policy, all individuals whose names appear as authors or contributors to this clinical practice guideline filed a disclosure statement as part of the submission process. All panel members provided full disclosure of potential conflicts of interest prior to voting on the recommendations contained within this clinical practice guideline.

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Table 1. Summary of Recommendations

AEROBIC EXERCISE

Physical therapists should implement moderate- to high-intensity aerobic exercise to improve oxygen consumption (V02), reduce motor disease severity, and improve functional outcomes in individuals with Parkinson disease.

Evidence Quality: High
Recommendation Strength: Strong

RESISTANCE TRAINING

Physical therapists should implement resistance training to reduce motor disease severity, and improve strength, power, nonmotor symptoms, and functional outcomes, and quality of life in individuals with Parkinson disease.

Evidence Quality: High
Recommendation Strength: Strong

BALANCE TRAINING

Physical therapists should implement balance-training intervention programs to reduce postural control impairments, and improve balance and gait outcomes, mobility, balance confidence, and quality of life in individuals with Parkinson disease.

Evidence Quality: High
Recommendation Strength: Strong

FLEXIBILITY EXERCISES

Physical therapists may implement flexibility exercises to improve range of motion (ROM) in individuals with Parkinson disease.

Evidence Quality: Limited
Recommendation Strength: Weak

EXTERNAL CUEING

Physical therapists should implement external cueing to reduce motor disease severity and freezing of gait, and to improve gait outcomes in individuals with Parkinson disease.

Evidence Quality: High
Recommendation Strength: Strong

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COMMUNITY-BASED EXERCISE

Physical therapists should recommend community-based exercise to reduce motor disease severity, and improve nonmotor symptoms, functional outcomes, and quality of life in individuals with Parkinson disease.

Evidence Quality: High
Recommendation Strength: Strong

GAIT TRAINING

Physical therapists should implement gait training to reduce motor disease severity, and improve stride length, gait speed, mobility, and balance in individuals with Parkinson disease.

Evidence Quality: High
Recommendation Strength: Strong

TASK-SPECIFIC TRAINING

Physical therapists should implement task-specific training to improve task-specific impairment levels and functional outcomes for individuals with Parkinson disease.

Evidence Quality: High
Recommendation Strength: Strong

BEHAVIOR-CHANGE APPROACH

Physical therapists should implement behavior-change approaches to improve physical activity and quality of life in individuals with Parkinson disease.

Evidence Quality: High
Recommendation Strength: Moderate

INTEGRATED CARE

Physical therapist services should be delivered within an integrated care approach to reduce motor disease severity and improve quality of life in individuals with Parkinson disease.

Evidence Quality: High
Strength of Recommendation: Strong

TELEREHABILITATION

Physical therapist services may be delivered via telerehabilitation to improve balance in individuals with Parkinson disease.

Evidence Quality: Moderate
Recommendation Strength: Weak

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SUMMARY OF BEST-PRACTICE STATEMENTS

The following recommendations are consensus statements by the guideline development group based on current clinical practice norms and clinical expertise.

DEEP BRAIN STIMULATION

In the absence of reliable evidence, the opinion of the guideline development group is that more research is needed on the effects of physical therapist interventions in individuals undergoing deep brain stimulation.

Recommendation Strength: Best practice

EXPERT CARE

In the absence of reliable evidence, the opinion of the guideline development group is that physical therapist services delivered by physical therapists with expertise in Parkinson disease may result in improved outcomes compared with services provided by those without expertise.

Recommendation Strength: Best practice

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Introduction

Overview

This clinical practice guideline (CPG) is based on a systematic review of published studies involving the physical therapist management of individuals with Parkinson disease (PD). In addition to providing practice recommendations, this guideline also highlights limitations in the literature, areas that require future research, intentional vagueness, and potential benefits, risks, harms, and costs to implementing each recommendation.

This CPG is intended to be used by all qualified and appropriately trained physical therapists and physical therapist assistants involved in the management of individuals with PD. It also is intended to be an information resource for decision makers, health care providers, and consumers.

Goals and Rationale

The purpose of this CPG is to help improve the physical therapist management of individuals with Parkinson disease based on the current best evidence. Current evidence-based practice standards demand that clinicians use the best available evidence in their clinical decision-making, incorporate clinical expertise, and consider the patient's wants and needs. To assist clinicians, this CPG contains a systematic review of the available literature regarding the management of individuals with PD. This review included randomized controlled trials published between January 1, 1994, and June 16, 2020, and identifies where there is strong evidence, where evidence is lacking, and topics that future research must target to improve the management of individuals with PD.

Neurological care is provided in diverse settings by many different providers. This CPG is an educational tool to guide qualified clinicians through a series of treatment decisions in an effort to improve quality and efficiency and reduce unwarranted variation of care. Recommendations guide evidence-based practice while considering the patient's wants and needs in the clinical decision-making process. This CPG should not be construed as including all proper methods of care or excluding methods of care reasonably directed at obtaining the same results. The ultimate judgment regarding the application of any specific procedure or treatment must be made in light of all circumstances presented by the patient, including safety, preferences, and disease stage, as well as the needs and resources particular to the locality or institution.

Intended Users

This CPG is intended to be used by physical therapists, and physical therapist assistants under the direction of physical therapists, for the management of individuals with Parkinson disease. Physical therapists are health care professionals who help individuals maintain, restore, and improve movement, activity, and functioning to enable optimal performance and enhance health, well-being, and quality of life. Neurologists, adult primary care clinicians, geriatricians, rehabilitation medicine provider, nurse practitioners, physician assistants, occupational therapists, speech language pathologists, and other health care professionals who routinely see patients with PD in various practice settings also may benefit from this guideline. This guideline is not intended for use as an insurance benefit determination document.

Care for individuals with PD is based on decisions made by them in consultation with their health care team, which may comprise movement disorder specialists, general neurologists, geriatricians, primary care physicians, nurses, physical therapists, occupational therapists, speech language pathologists, registered dieticians, social workers and other professionals. Care includes medical and pharmacological

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management and consideration of quality indicator guidelines such as those from the American Academy of Neurology (AAN).[1]

Once the individual (or advocate) has been informed of the nature of the available therapies and their rationale, duration, benefits, risks, costs, and has discussed the options with their health care provider, an informed and shared decision can be made.

Patient Population

This CPG addresses the management of adult idiopathic, typical Parkinson disease. It is not intended to address management of individuals with atypical Parkinsonism disorders or other neurodegenerative conditions. Most studies reviewed include individuals in the early to mid-stages of PD as measured by Hoehn & Yahr (H&Y) stages 1-3.[2] Recommendations may not generalize to those in the advanced H&Y stages 4-5[2] of the disease.

Burden of Disease

As of 2017, over 1 million (1.04) people in the United States have been diagnosed with PD, and that number is expected to increase to nearly 1.64 million in 20 years.[3] Ninety-one percent of these individuals were over the age of 65 and eligible for Medicare, and 54% were men.[3] Globally, PD is the fastest growing of all neurological disorders, with a prevalence of 6.1 million, which is projected to increase to over 12 million worldwide by 2050.[4] The total U.S. economic burden of PD was estimated to be $51.9 billion in 2017, with $25.4 billion representing direct medical costs and $26.5 billion representing indirect and nonmedical costs including premature death and lost employment of people with PD and their care partners.[3] In 20 years, the total U.S. economic burden of the disease is estimated to be $79.1 billion.[3] The average direct medical cost in 2017 for a person with PD eligible for Medicare was nearly $25,000.[3] The average combined economic loss of a person with PD and their care partner was nearly $25,600 in 2017, for an aggregate total economic impact of over $50,000 per year.[3] In the U.S., people with PD are hospitalized 1.44 times more than those without the disease and experience rehospitalization at a higher rate.[5] In addition, during hospitalization, people with PD experience worsening symptoms and a decline in functional status that is below their baseline ability.[5] A review of the literature indicates that there is a higher prevalence of PD among White and Hispanic populations globally than among those of African or Asian descent.[6] In the U.S., the incidence of PD by race is difficult to isolate from disparities in health care utilization affecting the actual occurrence of PD among different ethnic groups.[7] Therefore it is unclear if there is a biological basis that might explain the lower prevalence among those of African Americans or if this is due to disparities in health care utilization. Community-based studies that allow for a direct comparison of ethnic groups to determine disease prevalence and economic impact by race or ethnicity are currently not available. However, it has been found that allied health utilization is lower in African American and Hispanic individuals compared with Caucasian individuals with PD.[8] Therefore, understanding this impact is an important area for future research to provide insight into disparities that exist between groups in terms of access to health care-related resources.

Etiology

The etiology of PD is unknown.[9] The degree to which environmental hazards, genetic susceptibility, head injury, or sedentary lifestyle contribute to the development of PD is not well understood. This diversity in the potential cause or causes of this disease leads to extensive variation in motor and nonmotor symptoms that affects both the central nervous system and many peripheral tissues in the body.[9]

Risk Factors

Because the disease etiology is not well understood, relevant risk factors that influence the development of the disease are difficult to determine. Age is a known risk factor for disease development and peaks around age 80.[9] Men and those of Hispanic origin develop the disease at higher rates than do women or those of other ethnicities.[9] Environmental risk factors such as pesticide or herbicide exposure, prior head injury, β-blocker use, rural living, agricultural occupation, and well-water drinking have been linked to the development of the disease, while other environmental risk factors such as tobacco, caffeine, physical activity, NSAIDs, calcium channel blockers, and alcohol have been associated with a reduced risk of developing the disease.[9, 10] Additionally, at least 23 loci or genetic locations have been identified as causing symptoms related to PD.[11]

Potential Benefits, Risks, Harms, and Costs

The potential benefits, risks, harms, and costs are provided for each recommendation within this document.

Emotional and Physical Impact

Disease duration in those diagnosed with PD can span decades.[4] Due to the progressive nature of the disease, there is considerable emotional, social, and physical impact. These impacts include compromised functional status and quality of life, social isolation due to the presence and severity of motor and nonmotor symptoms, and increased burden on care partners.[12]

Future Research

Consideration for future research is provided for each recommendation within this document.

Methods

The methods used to develop this CPG were employed to minimize bias and enhance transparency in the selection, appraisal, and analysis of the available evidence. These processes are vital to the development of reliable, transparent, and accurate clinical recommendations for physical therapist management of Parkinson disease. Methods from the *APTA Clinical Practice Guideline Manual*[13] and *AAOS Clinical Practice Guideline Methodology*[14] were used in development of this CPG.

This CPG evaluates the effectiveness of approaches in the physical therapist management of Parkinson disease. APTA sought out the expertise of the AAOS Evidence-Based Medicine Unit as paid consultants to assist in the methodology of this CPG. The guideline development group (GDG) consisted of physical therapist members from APTA and its representative sections and academies, AAOS, the American Parkinson's Disease Association, and a neurologist from the American Academy of Neurology. All GDG members, APTA staff, and methodologists were free of potential conflicts of interest relevant to the topic under study, as recommended by the National Academies of Sciences and Medicine's *Clinical Guidelines We Can Trust*.[15]

This CPG was prepared by the APTA Parkinson Disease Clinical Practice Guideline Development Group (clinical experts) with the assistance of the AAOS Clinical Quality and Value (CQV) Department (methodologists). To develop this guideline, the GDG held an introductory meeting on April 4, 2019, to establish the scope of the CPG. The GDG defined the scope of the CPG by creating PICOT questions (eg, population, intervention, comparison, outcome, and time) that directed the literature search. The AAOS medical librarian created and executed the search (see Appendix 3 for search strategy). AAOS appraised the included randomized controlled trial studies and performed quality assessments based on the published guideline methodology. The GDG performed final reviews of the literature and created the recommendations, provided rationale in the context of physical therapist practice, and adjusted the strength of the recommendations depending on the magnitude of benefit, risk, harm, and cost.

Best Evidence Synthesis

This CPG includes only the best available evidence for any given outcome addressing a recommendation. Accordingly, the highest quality evidence for any given outcome is included first if it was available. In the absence of 2 or more occurrences of an outcome based on the highest-quality (Level I) evidence, outcomes based on the next level of quality were considered until at least 2 or more occurrences of an outcome had been acquired (see Table 2). For example, if there were 2 "moderate" quality (Level II) occurrences of an outcome that addressed a recommendation, the recommendation does not include "low" quality (Level III) occurrences of evidence for this outcome. A summary of excluded articles can be viewed in Appendix 2.

Literature Searches

The medical librarian conducted a comprehensive search of PubMed, Embase, and the Cochrane Central Register of Controlled Trials based on key terms and concepts from the PICOT questions. Bibliographies of relevant systematic reviews were hand searched for additional references. All databases were last searched on June 16, 2020, with limits for publication dates from 1994 through 2020, English language, and only randomized controlled trials. The PICOT questions used to define the literature search and inclusion criteria, and the literature search strategy used to develop this CPG, can be found in Appendix 3.

Defining the Strength of the Recommendations

Judging the quality of evidence is only a steppingstone toward arriving at the strength of a CPG recommendation. The operational definitions for the quality of evidence are listed in Table 2, and rating of magnitude of benefits versus risk, harms, and cost is provided in Table 3. The strength of recommendation (Table 4) also takes into account the quality, quantity, and trade-off between the benefits and harms of a treatment, the magnitude of a treatment's effect, and whether there is data on critical outcomes. Table 5 addresses how to link the assigned grade with the language of obligation of each recommendation.

Patient Involvement

An individual with Parkinson disease participated in the development of this CPG through the peer-review process. The reviewer provided important feedback on the draft from the perspective of a physical therapy user and commented on the clarity and feasibility of implementing the recommendations. The GDG took the reviewer's feedback into consideration in making any necessary edits to the CPG (see Supplementary Appendix X.).

Voting on the Recommendations

GDG members agreed on the strength of every recommendation, which were approved and adopted when a majority of 60% of the GDG voted to approve. All recommendations received 100% agreement among the quorum of the voting GDG. No disagreements were recorded during recommendation voting. When changes were made to the strength of a recommendation based on the magnitude of benefit or potential risk, harm, or cost, the GDG voted and provided an explanation in the rationale.

Structure of the Recommendations

The outcome categories included in each recommendation statement are organized according to the World Health Organization's International Classification of Functioning, Disability, and Health (ICF) Model domains in the following order: impairment level, activity level, and participation level. This order does not reflect prevalence or strength of findings.

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Outcome Measures

The body of evidence for this CPG is comprised of 242 articles (see Study Attrition Flowchart). While several studies examined the same intervention, the outcome measures used to assess the effectiveness of each intervention varied considerably and hence there are many outcome measures referred to in the rationale section within each recommendation. The large number of outcome measures utilized could contribute to unwanted variation in practice and led to challenges when determining the effect size of a particular intervention. The GDG supports the use of the outcome measures identified in the Parkinson Evidence Database to Guide Effectiveness (PDEDGE), developed and supported by the Academy of Neurologic Physical Therapy.[16] Throughout this CPG, the outcome measures recommended by PDEDGE are identified in bold and citations to test summaries on apta.org and the Shirley Ryan Ability Lab Rehabilitation Measures Database are provided, when available. More recently, a clinical practice guideline recommending a core set of outcome measures for adults with neurologic conditions was published in an effort to streamline the assessments utilized across patients with neurological conditions.[17] These largely align with the recommendations of the PDEDGE taskforce, providing additional guidance in the choice of outcome measures implemented.

Role of the Funding Source

The American Physical Therapy Association, which funded the travel for 1 GDG meeting and for the AAOS services, provided coordination and played no role in the design, conduct, and reporting of the recommendations.

Table 2. Rating Quality of Evidence

RATING OF OVERALL QUALITY OF EVIDENCE	DEFINITION
High	Preponderance of Level I or II evidence with at least 1 Level I study. Indicates a high level of certainty that further research is not likely to change outcomes of the combined evidence.
Moderate	Preponderance of Level II evidence. Indicates a moderate level of certainty that further research is not likely to change the outcomes direction of the combined evidence; however, further evidence may impact the magnitude of the outcome.
Low	A moderate level of certainty of slight benefit, harm, or cost, or a low level of certainty for moderate-to-substantial benefit, harm, or cost. Based on Level II thru V evidence. Indicates that there is some but not enough evidence to be confident of the true outcomes of the study and that future research may change the direction of the outcome and/or impact magnitude of the outcome.
Insufficient	Based on Level II thru V evidence. Indicates that there is minimal or conflicting evidence to support the true direction and/or magnitude of the outcome. Future research may inform the recommendation.

Table 3. Magnitude of Benefit, Risk, Harms, or Cost

RATING OF MAGNITUDE	DEFINITION
Substantial	The balance of the benefits versus risk, harms, or cost overwhelmingly supports a specified direction.
Moderate	The balance of the benefits versus risk, harms, or cost supports a specified direction.
Slight	The balance of the benefits versus risk, harms, or cost demonstrates a small support in a specified direction.

Table 4. Strength of Recommendations

Strength	Strength Visual	Definition
Strong	★★★★	A high level of certainty of moderate-to-substantial benefit, harms, or cost, or a moderate level of certainty for substantial benefit, harms, or cost (based on a preponderance of Level I or II evidence with at least 1 Level I study).
Moderate	★★★☆	A high level of certainty of slight-to-moderate benefit, harms, or cost, or a moderate level of certainty for a moderate level of benefit, harms, or cost (based on a preponderance of Level II evidence, or a single high-quality RCT).
Weak	★★☆☆	A moderate level of certainty of slight benefit, harms, or cost, or a low level of certainty for moderate-to-substantial benefit, harms, or cost (based on Level II thru V evidence).
Theoretical/ foundational	★☆☆☆	A preponderance of evidence from animal or cadaver studies, from conceptual/theoretical models/principles, or from basic science/bench research, or published expert opinion in peer-reviewed journals that supports the recommendation.
Best Practice	★☆☆☆	Recommended practice based on current clinical practice norms; exceptional situations in which validating studies have not or cannot be performed yet there is a clear benefit, harm, or cost; or expert opinion.
Research		An absence of research on the topic or disagreement among conclusions from higher-quality studies on the topic.

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Table 5. Linking the Strength of Recommendation, Quality of Evidence, Rating of Magnitude, and Preponderance of Risk vs Harm to the Language of Obligation

RECOMMENDATION STRENGTH	QUALITY OF EVIDENCE AND RATING OF MAGNITUDE	PREPONDERANCE OF BENEFIT OR RISK, HARMS, OR COST	LEVEL OF OBLIGATION TO FOLLOW THE RECOMMENDATION
Strong	High quality and moderate-to-substantial magnitude *or* Moderate quality and substantial magnitude	Benefit	Must or Should
		Risk, harms, or cost	Must not or Should not
Moderate	High quality and slight-to-moderate magnitude *or* Moderate quality and moderate magnitude	Benefit	Should
		Risk, harms, or cost	Should not
Weak	Moderate quality and slight magnitude *or* Low quality and moderate-to-substantial magnitude	Benefit	May
		Risk, harms, or cost	May not
Theoretical/ foundational	N/A	Benefit	May
		Risk, harms, or cost	May not
Best Practice	Insufficient quality and clear magnitude	Benefit	Should or May
		Risk, harms, or cost	Should not or May not
Research	Insufficient quality and unclear magnitude *or* Conflicting high-to-moderate-quality and conflicting magnitude	Varies	N/A

Peer Review and Public Commentary

Following the formation of a final draft, the CPG draft was subjected to a 3-week peer review for additional input from external content experts and stakeholders. More than 250 comments from 12 societies (Appendix X) were collected via an electronic structured review form. All peer reviewers were required to disclose any potential conflicts of interest, which were recorded and, as necessary, addressed.

After modifying the draft in response to peer review, the CPG was subjected to a 2-week public comment period. Commenters consisted of the APTA Board of Directors (Board), the APTA Scientific and Practice Affairs Committee (SPAC), all relevant APTA sections and academies, stakeholder organizations, and the physical therapy community at large. More than X public comments were received. Revisions to the draft were made in response to relevant comments.

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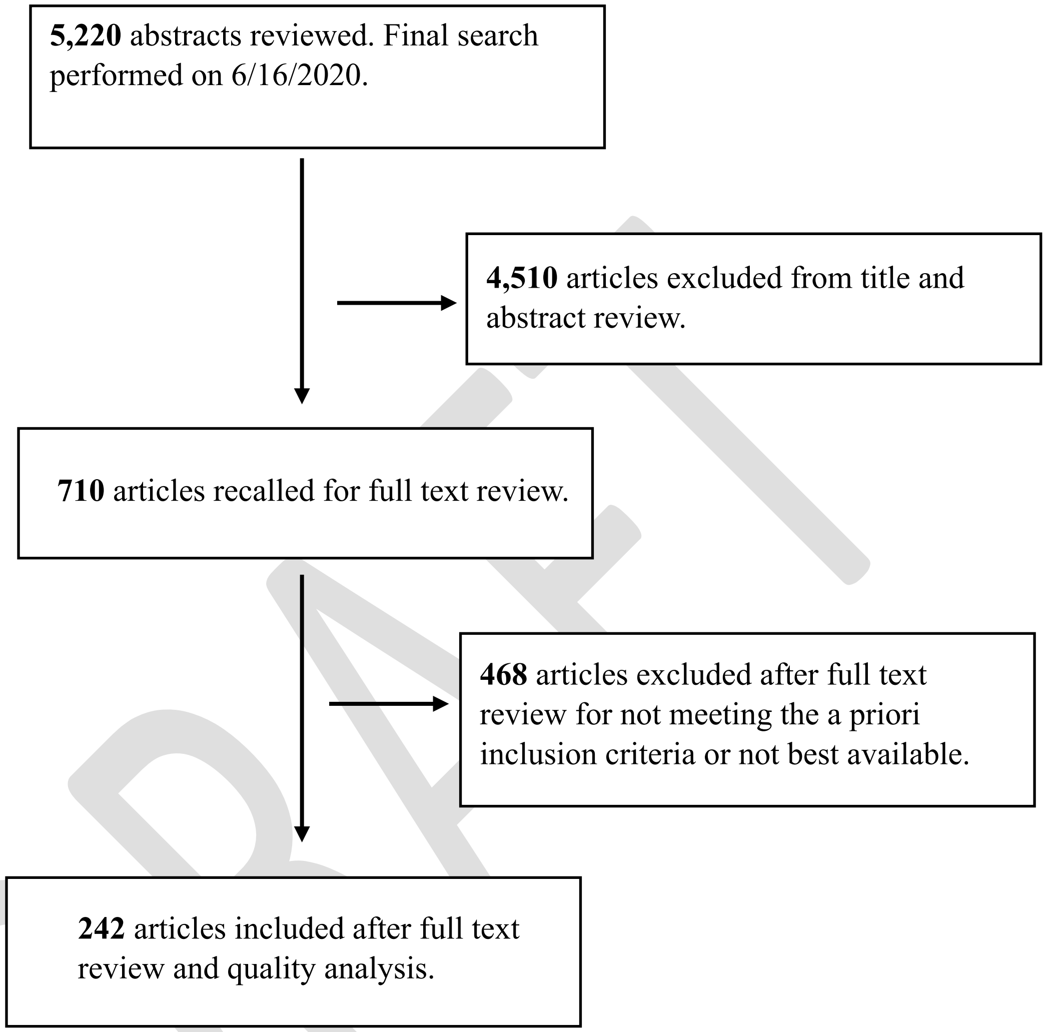
Study Attrition Flowchart



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RECOMMENDATIONS

AEROBIC EXERCISE

Physical therapists should implement moderate- to high-intensity aerobic exercise to improve oxygen consumption ($V0_2$), reduce motor disease severity and improve functional outcomes in individuals with Parkinson disease.

Evidence Quality: High

Recommendation Strength: Strong

Action Statement Profile

Aggregate Evidence Quality: 9 High-Quality Studies[18-26] and 7 Moderate-Quality Studies[27-33]

Rationale

Nine high-quality and 7 moderate-quality studies examined the benefits of aerobic exercise in individuals with Parkinson disease. These studies varied considerably in sample size, comparison group, outcomes measured, mode, and dose of aerobic exercise.

<u>Oxygen Consumption and Motor Disease Severity</u>

Improvements at the impairment level have been demonstrated in many aerobic exercise trials in Parkinson disease. High-[24, 26] and moderate-quality[29, 30, 32] studies found that aerobic exercise, compared with control (eg, usual care, stretching, strengthening) improved VO_2, suggesting a specificity of training effect. Though the effect of aerobic training on motor signs was mixed, 4 high-quality studies[22-24, 26] revealed significantly reduced motor decline as measured by the **Movement Disorders Society Unified Parkinson Disease Rating Scale part III motor examination (MDS-UPDRS III)**.[34, 35] Two of the high-quality aerobic exercise trials with the largest sample sizes[24, 26] found less motor decline compared with a control condition (eg, usual care, stretching) in those with de novo PD or early PD (H&Y 1-2) tested in the "off" state. It has been suggested that dopaminergic replacement medications may mask the benefits of exercise, thus potentially accounting for lack of effects of aerobic exercise on motor symptoms when measured in the "on" state. The variation in the timing of the assessment of motor signs may contribute to the mixed results across studies. Few studies have examined the effects of aerobic exercise on non-motor signs; however, improvements in cognition,[33] sleep,[27] and depression[25] have been revealed compared with a usual care control condition.

Most aerobic exercise studies in individuals with PD consisted of walking on a treadmill or stationary cycling. Few studies have directly compared different modes of aerobic exercise, though no differences have been revealed when direct comparisons were made.[18] Results across studies using different modes of aerobic exercise were comparable[24, 26] suggesting no 1 form of aerobic exercise was superior to another. The intensity of aerobic exercise varied across studies. Improvements have been observed with both moderate- and high-intensity aerobic exercise across a variety of outcomes. Studies that have

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directly compared moderate- and high-intensity aerobic exercise[24, 32] have found no differences between groups. However, in a 6-month phase II trial,[24] reduced motor decline was found in the high-intensity aerobic condition versus usual care control but not in the moderate-intensity aerobic condition versus usual care condition. This suggests a potential differential effect of high-intensity exercise on motor disease severity, though additional studies directly comparing moderate- and high-intensity aerobic exercise are needed to determine if there is a dose-response effect.

Functional Outcomes and Quality of Life

Aerobic exercise has also been shown to improve various aspects of function and quality of life in individuals with PD. Two high-quality[19, 25] and 2 moderate-quality studies[29, 32] revealed improvements in gait-related outcomes including the **Six-Minute Walk Test (6MWT)**[36, 37] compared with usual care, strengthening, or low-intensity exercise. Other high-quality studies found improvements in balance and activities of daily living (ADLs)[22, 25] compared with usual care or low-intensity exercise. Aerobic exercise has also been shown to improve global physical status or quality of life related to mobility[25, 29] compared with a usual care control condition, though the evidence is limited to 1 high-quality and 1 moderate-quality study.

Potential Benefits, Risks, Harms, and Costs of Implementing This Recommendation

Benefits are as follows:

- Improvements in oxygen consumption
- Improvements in motor and nonmotor impairments
- Improvements in functional activities (eg, gait, balance, ADLs)
- Improvements in quality of life

Risk, harms, and/or cost are as follows:

- Aerobic exercise does not cause harm when therapists follow appropriate screening procedures to ensure there are no other medical conditions (eg, cardiac) that would preclude engagement in moderate- to high-intensity aerobic exercise.
- Some studies reveal that individuals with PD experienced minor musculoskeletal injuries with participation in aerobic exercise; however, most resolved without incident. Gradually progressing the duration and intensity of the aerobic exercise is recommended to reduce risk of injury.
- The mode of aerobic exercise should be chosen to ensure safe participation. For example, cycling rather than treadmill walking may be a safer aerobic exercise option in those who are at high risk of falling and/or with freezing of gait.

Benefit-harm assessment: The balance of the benefits versus risk, harms, or cost overwhelmingly supports this recommendation.

Future Research

Additional studies are necessary to determine the optimal intensity of aerobic exercise. Large adequately powered studies directly comparing high- and moderate-intensity exercise are needed to determine if high-intensity aerobic exercise is superior to moderate-intensity exercise in reducing motor disease severity and in improving functional outcomes and quality of life. It is also important to determine if the benefits of aerobic exercise modify symptoms versus the disease in people with PD. More guidance on the optimal frequency and duration of aerobic exercise is also needed. In addition, more studies are

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warranted to determine the effects of aerobic exercise on nonmotor outcomes (eg, cognition, depression, sleep, anxiety). Furthermore, the adoption of a common set of outcome measures across aerobic exercise trials would facilitate the direct comparison of studies, thereby advancing the field forward more expeditiously.

Value Judgments

Given the potential benefits of moderate- to high-intensity aerobic exercise to reduce motor disease severity in PD, the GDG recommends that physical therapists prescribe aerobic exercise very early in the course of the disease. Though it is not clear whether the effects of aerobic exercise are disease modifying, the potential to reduce motor disease severity with aerobic exercise warrants early intervention.

Intentional Vagueness

Given the variability in the dosing of aerobic exercise across studies, the optimal dosing of aerobic exercise has not been determined. However, many studies reveal a benefit of aerobic exercise when implemented at least 3 days per week for 30-40 minutes each at moderate to high intensity. Although the length of the trials and timing of follow-up assessments varies considerably among studies, it appears that gains dissipate if exercise is discontinued. This suggests that regular, long-term engagement in aerobic exercise is needed to sustain a benefit.

Exclusions

Most aerobic exercise studies include individuals with mild to moderate PD (H&Y 1-3). These recommendations may not apply to those with severe PD who do not have the capacity to engage in moderate- to high-intensity aerobic exercise.

RESISTANCE TRAINING

Physical therapists should implement resistance training to reduce motor disease severity, and improve strength, power, nonmotor symptoms, functional outcomes, and quality of life in individuals with Parkinson disease.

Evidence Quality: High

Recommendation Strength: Strong

Action Statement Profile

Aggregate Evidence Quality: 19 High-Quality Studies [22, 38-55] and 28 Moderate-Quality Studies[28, 32, 56-81]

Rationale

<u>Strength and Power</u>

Physical therapists should implement resistance training programs that are progressive in nature. Benefits were observed whether resistance training was carried out alone or as part of a multimodal program to improve strength and power in individuals with PD. There are 3 high-quality[42, 46, 77] and 3 moderate-quality studies[71, 79, 80] that favor resistance training compared with control to improve strength and power. The control groups in these studies included pharmacologic treatment alone,[26,30] nonexercise, education-based interventions,[61,63,64] or a low-intensity home-based exercise intervention.[55] When comparing resistance training to other modes of exercise there are 2 high-quality studies[41, 47] and 1 moderate-quality study[64] that favor resistance training to improve strength and power. A progressive resistance training program was shown to be more effective than a nonprogressive exercise intervention (modified from the Fitness Counts Booklet, Parkinson's Foundation) for improving elbow flexion and extension torque[64] and elbow flexion torque.[41] A progressive resistance training protocol using a weighted vest and ankle weights (60-minute class, twice weekly for 24 weeks) was superior to either tai chi or a stretching program to improve knee flexion and knee extension peak torque value as measured with use of isokinetic dynamometer.[47]

There was 1 high-quality[77] and 2 moderate-quality studies[59, 79] that compared resistance training with other forms of resistance training. Resistance training with instability (RTI) was favored compared with resistance training alone to improve strength/power of the plantar flexors and knee extensors as measured via surface EMG signals identified during submaximal isometric contractions on an isokinetic dynamometry.[77, 79] RTI is described as resistance training (leg press, latissimus dorsi pulldown, ankle plantarflexion, chest press, and half squat) with an added progressive and concomitant increase in resistance and instability applied via unstable devices (eg, balance pad, dyna discs, balance discs, BOSU®, and Swiss ball).

In one moderate-quality study[59] strength training was favored compared with power training to improve strength/power as measured by the chest press normalized at 80% of 1 repetition maximum (1RM.) In this same study, power training was favored over strength training to improve strength/power as measured by the leg press normalized at 40% of 1RM.

One high-quality study[50] and 2 moderate-quality studies[69, 70] favored multimodal interventions that included resistance training when compared with nonexercise, education-based controls to improve strength and power in people with Parkinson disease. However, 2 high-quality studies found no difference between multimodal interventions that included resistance training and usual care control

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groups to improve strength and power in people with PD.[38, 39] Multimodal interventions that included resistance training were not superior to modes of intervention that did not include resistance training (low-intensity trunk exercise and turning training control[24] and nonexercise, education-based control[54]) to improve lower extremity strength and power in individuals with PD, as indicated by 2 high-quality studies.[40, 70] However, one moderate-quality study[32] favored resistance training compared with high-intensity treadmill training to improve lower extremity strength via the leg press.

<u>Nonmotor Symptoms</u>

Physical therapists should implement resistance training that follows guidelines from the American College of Sports Medicine (ACSM) for progression, to reduce nonmotor symptoms in individuals with PD. There are 3 high-quality studies that favor resistance training compared with control (not engaged in exercise) to improve nonmotor function.[42, 44, 77] There is one moderate-quality study[78] that favored resistance training compared with control. One high-quality study[42] favored progressive resistance training compared with a nonexercising control group (standard pharmacological treatment only) for depression (Hamilton Depression Rating Scale). Silva-Batista 2018[77] favored progressive resistance training with instability for improvements in cognition (**Montreal Cognitive Assessment**).[82] Ferreira 2018[44] favored resistance training over standard pharmacological treatment to improve anxiety (Beck Anxiety Inventory). All 3 of these studies followed ACSM guidelines on progression of resistance.

Three high-quality[22, 49, 50] and 3 moderate-quality studies[57, 60, 61] identified no difference between multimodal interventions that included resistance training and controls that received a low-intensity exercise intervention,[10] nonexercise, education-based interventions,[33,34,44] or a handwriting intervention[41,45] to improve nonmotor symptoms. This evidence suggests that 1 mode of resistance training intervention is not superior to another to improve nonmotor symptoms.

<u>Motor Disease Severity</u>

Physical therapists should implement resistance training to reduce motor disease severity and can include it as 1 component of a multimodal program. Two high-quality studies favor resistance training when compared with a stretching, balance, and strengthening program[25] or a stretching intervention[31] to improve UPDRS motor scores. There are 2 high-quality studies[22, 50] and 4 moderate-quality studies[60, 67, 68, 70] that favor multimodal interventions that included resistance training compared with a low-intensity exercise intervention,[10] nonexercise, education-based interventions,[34,54] handwriting interventions,[44] a pharmacologic intervention,[52] or no treatment[51] to improve motor disease severity as measured by UPDRS motor scores. There are 5 high-quality[42, 43, 48, 53, 55] and 1 moderate-quality study[78] that found no differences in disease severity when comparing resistance training with a control group.

<u>Functional Outcomes</u>

There are 5 high-quality studies that favor resistance training in comparison with controls to improve function.[42, 46, 48, 53, 77] Progressive resistance training was favored over a pharmacologic treatment to improve mobility [Timed Up & Go (TUG) & 2-minute sit to stand],[26,30] gait speed,[26,30] flexibility,[26] and balance (Tinetti & Sit & Reach).[30] Resistance training was favored over usual physical activity to improve fast gait speed on the **10-Meter Walk Test (10MWT)**,[83, 84] and progressive resistance training with instability was favored over a nonexercise, education-based intervention to improve balance (BESTest) and stability (Biodex Balance system).[61] Progressive resistance training plus movement

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strategy training and falls education was favored over a control group that engaged in guided education and discussion to improve fall rate over 12 months and activities of daily living (UPDRS activities of daily living score). All 5 of these high-quality studies followed a systematic progression of resistance with 4 of them following recommendations from the ACSM on progression of resistance.

One high-quality study[77] and 3 moderate-quality studies[59, 78, 79] addressed 3 different modes of resistance training to improve balance and stability in people with PD. Resistance training with instability (RTI) was favored over resistance training to improve balance on all domains of the BESTest except reactive postural responses and sensory orientation.[77] RTI was also favored over resistance training to improve stability as measured by an overall stability index on the Biodex Balance System®.[76, 77]

The effects of resistance training on gait velocity were mixed. One high-quality study[52] measured the effect of a 24-month progressive strengthening program of trunk and upper/lower extremity (PRET-PD) on gait velocity (meters/second), stride length (meters), cadence (steps/minute), and double support time (% of gait cycle). At 24 months, there were no significant differences between groups (PRET-PD versus modified Fitness Count) on gait measures. However, both groups increased fast gait velocity, comfortable cadence, and fast cadence while in an "off" medication state compared with baseline and increases in comfortable and fast cadence while in the "on" medication state. Another high-quality study[47] demonstrated improvements in stride length and walking velocity that were similar to a tai chi group.

<u>Multimodal Interventions</u>

Physical therapists should implement resistance training, either alone or as a part of a multimodal intervention, to improve function. Three high-quality studies[22, 45, 70] favored multimodal interventions that included resistance training when compared with control to improve balance as measured by the **Mini BESTest**,[85, 86] the Functional Reach Test, and the Berg Balance Scale. One of these studies identified these improvements both in the "on" and "off" medication state for individuals with PD.[22]

Three high-quality studies[40, 50, 51] and 1 moderate-quality study[62] compared multimodal interventions that included a resistance training component to another active intervention (eg, power yoga, low intensity exercise, turning-based training, conventional physical therapy). No clear pattern was observed to indicate superiority of multimodal interventions with a resistance training component versus other active interventions.

<u>Quality of Life</u>

There are 2 high-quality studies[44, 53] that endorse the use of resistance training to improve quality of life compared with pharmacologic treatment[28] or usual care.[37] One high-quality study[25] and 1 moderate-quality study[16] favored resistance training over a multimodal program (Modified Fitness Counts) and over aerobic training to improve quality of life. In contrast, there are 2 high-quality[42, 48] and 3 moderate-quality studies[28, 56, 78] that found no difference in the effect of resistance training on quality of life when compared with pharmacologic treatment,[42, 56] a nonexercise, education-based intervention,[48, 78] or usual care.[28] Another high-quality study[38] endorsed resistance training as part of a multimodal intervention to improve quality of life. These findings suggest that implementing resistance training for individuals with PD can influence quality of life.

Potential Benefits, Risks, Harms and Costs of Implementing this Recommendation

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Benefits are as follows:

- Improvements in strength/power
- Improvements in nonmotor symptoms (anxiety, cognition, depression)
- Reductions in motor disease severity
- Improvements in activities (gait speed, balance, mobility, stability)
- Improvements in quality of life
- Improvements in fall rate

Risk, harms, and/or costs are as follows:

- There are 6 studies[22, 28, 41, 49, 52, 87] that found no significant difference in adverse events with resistance training compared with control or another active condition. In these studies, adverse events included strains and sprains, delayed onset muscle soreness, fatigue, cardiovascular events, pain, and falls. In 2 studies, hospitalizations and deaths occurred that were deemed unrelated to participation in these studies.[35,76] In 1 study, injurious falls were reported; however, there were similar rates of injurious falls in the experimental group (progressive resistance strength training and movement strategy training) and the control group (education-based life skills training).[43]

Benefit-harm assessment: The balance of the benefits versus risk, harms, or cost overwhelmingly supports this recommendation.

Future Research

Studies are needed to determine the effects of resistance training on nonmotor outcomes (eg, cognition, depression, sleep, anxiety), functional outcomes (eg, gait, balance, falls), and quality of life. Of importance, a common set of outcome measures is needed across these trials to allow direct comparison of results. More research is also needed to determine the lasting effects and/or long-term benefits of resistance training in those with mild, moderate, and severe PD.

Value Judgments

Physical therapists should be aware that improvement in outcomes due to resistance training is likely dose-specific (eg, greater improvement in outcomes with longer duration or higher intensity of resistance training.) Some outcomes that did not show change with resistance training may show change after implementation of a longer or more intense resistance training dose. Resistance exercise may yield different outcomes when assessments are performed during the “on” medication state versus the “off” medication state. Outcomes may vary for individuals at more advanced stages of the disease.

The value of specific modes of resistance exercise (eg, free weights, weighted vests, weight machines, closed- versus open-chain activities, body weight resistance) has not been compared and therefore 1 mode cannot be recommended over another.

Intentional Vagueness

Given the variability in the dosing of resistance exercise across studies, the optimal dosing of resistance training has not been determined. However, many studies reveal a benefit of resistance exercise when implemented 1-2 days per week for 30-60 minutes while applying 80% of the repetition maximum to achieve strength gains and 40% of the repetition maximum to improve power. Studies also support progressively increasing the load by 2% when 3 sets of 15 repetitions are achieved with good form. Although the length of the trials and timing of follow-up assessments varies considerably among studies, it appears that gains dissipate if exercise is discontinued. This suggests that regular, long-term engagement in resistance exercise is needed to sustain a benefit.

Exclusions

Studies included only individuals in the early to moderate stages of PD without cognitive impairment; therefore, these recommendations may not apply to individuals with advanced Parkinson disease (H&Y 5) or significant cognitive impairment.

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BALANCE TRAINING

Physical therapists should implement balance training intervention programs to reduce postural control impairments, and improve balance and gait outcomes, mobility, balance confidence, and quality of life in individuals with Parkinson disease.

Evidence Quality: High

Recommendation Strength: Strong

Action Statement Profile

Aggregate Evidence Quality: 32 High-Quality Studies[38-40, 45, 88-115] and 20 Moderate-Quality Studies[31, 75, 116-133]

Rationale:

Of the 52 aggregated articles related to balance training, 12 high-quality studies[38, 39, 45, 88, 92, 98, 101, 105, 111-113, 115] and 10 moderate-quality studies[31, 116, 118, 123-125, 128, 129, 133, 134] examined the benefits of balance training in individuals with PD compared with usual medical care (eg, medications only), conventional physical therapy (eg, without balance protocol), or general exercise (eg, calisthenics, stretching). These 22 studies varied considerably with regard to sample size, comparison group, outcomes measured, type and dose of balance intervention. The remaining 30 articles addressed aspects of balance training that are included in the detailed rationale when appropriate (eg, physical activity, technology, comparing different types of balance interventions).

<ins>Postural Control Impairments Outcomes</ins>

Improvements in postural control were found in 3 high-quality studies[98, 112, 115] and 2 moderate-quality studies.[125, 128] Postural control impairment measures included sway, the Sensory Organization Test, limits of stability measured with technology (Balance Master/SMART Balance System) and the Functional Reach Test, and subscales of the **Mini-BESTest**[85, 86] (reactive postural control). Interventions that improved postural control tended to include aspects of task specificity such as weight shifting with and without technology[98, 115, 128] and perturbation training.[125] There were no significant changes in impairment measures in 3 high-quality studies of primarily home-based, minimally supervised interventions compared with control.[38, 39, 88]

<ins>Balance Outcomes</ins>

Balance outcomes improved in studies comparing a balance intervention group with a control group (usual care, gentle exercise, no intervention) in 6 high-quality studies[45, 92, 101, 111-113] and 5 moderate-quality studies.[116, 118, 125, 133, 134] There was variation in the intervention approaches used to target balance, but most studies included multimodal balance training that incorporated elements of strengthening, sensory integration, anticipatory postural adjustments, compensatory postural adjustments, gait and functional task training. The **Mini-BESTest**[85, 86] was the most frequently used primary outcome measure (4 out of 7 high-quality studies). Additional balance measures reported in the high-quality articles included Berg Balance Scale and single-leg stance. High-quality studies that demonstrated favorable outcomes ranged in frequency (2-3 times per week) and duration (10 to 30 total hours: 5 to 12 weeks).

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Mobility Outcomes

Improvements in mobility outcome measures were identified in 3 high-quality studies[92, 112, 113] and 2 moderate-quality studies.[116, 118] Mobility improved in individuals with PD when a supervised multimodal balance program was implemented 2 to 3 times per week, 16 to 30 total hours, for at least 5 and up to 10 weeks. Due to variability in settings, frequency, and delivery patterns, sessions durations ranged from 30-120 minutes. Common among these intervention programs was an emphasis on multidirectional stepping, motor agility, anticipatory postural control and reactive balance. However, balance training that was a primarily home-based, minimally supervised intervention did not show significant improvements in mobility.[38, 39, 45, 105]

Gait Outcomes

Improvements in gait outcomes, including gait velocity, **Functional Gait Assessment (FGA)**,[135, 136] **Freezing of Gait (FOG-Q)**[137] and spatiotemporal measures (step length and stride) were found in 4 high-quality studies[38, 92, 98, 111] and 1 moderate-quality study.[128] Each study that noted improvement in gait outcomes included an aspect of gait training in the intervention in addition to balance training; therefore, it is not possible to isolate the effects of balance training alone on gait outcomes.

Balance Confidence Outcomes

Outcomes related to balance confidence including the Falls Efficacy Scale-International and Activities Specific Balance Confidence Scale improved in 2 high-quality studies[39, 45] and 3 moderate-quality studies[116, 118, 134] compared with control. Changes in balance confidence were not significant in 3 high-quality studies[38, 92, 105] and 1 moderate-quality study.[128]

Quality of Life Outcomes

Of the 12 high-quality studies considered for this recommendation statement, only 5 included measures of quality of life, including **Parkinson's Disease Quesionnaire-39 (PDQ-39)**[38, 39, 101, 138, 139] Euro-QoL-5 Dimension (EQ-5D)[45, 88] Short-form Health Survey – 6 Dimension (SF-6D),[39] 12-item Short Form Health Survey (SF-12)[39] and Positive Affect Scale.[39] Of these, balance intervention was favored over control in **PDQ-39**[38, 138, 139] and EQ-5D.[88] This finding should be interpreted cautiously, as the other studies that measured quality of life either favored control[101] or showed no significant difference between balance intervention and control.[39, 45]

Falls Outcomes

The effect of balance training on falls outcomes is mixed. Several studies have examined the effect of balance training on fall rate and found no significant effect.[39, 45, 88, 112, 113, 116] Interestingly, 1 high-quality study using a 6 month duration, primarily home-based, minimally supervised exercise program targeting fall risk factors found that falls were reduced in individuals with mild PD, but not in people with more severe PD.[39] Similarly, another moderate-quality study found in a secondary analysis that individuals with more moderate disease but not severe disease had decreased fall rates in the experimental group.[118] This would suggest that physical therapists may consider intervening earlier in the disease process with balance interventions intended to reduce fall rates.

Nonmotor Symptom Outcomes

Moderate strength evidence suggests that balance training could be used to improve nonmotor symptoms compared with usual medical care or control interventions. Two moderate-quality studies supported improvements in depression as measured by the Geriatric Depression Scale.[116, 118] One moderate-quality study supported improvements in cognition as measured by the Wechsler Memory Scale difficult III subscore when balance interventions were performed for at least 4 months.

Physical Activity Outcomes

Limited evidence supports the effect of balance training on physical activity. One high-quality study[45] demonstrated that recreational physical activity increased following balance training. Two high-quality[92, 111] and 2 moderate-quality studies[116, 118] demonstrated no difference in physical activity as measured by daily steps or the Physical Activity Scale for the Elderly, between a balance training intervention and usual care.

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Intervention Comparisons

Technology

Balance interventions using technology were compared with traditional balance interventions without technology in 11 high-quality[40, 91, 95, 98-100, 104, 108, 109, 114, 115] and 5 moderate-quality studies.[119-121, 127, 128] Strong evidence supports the use of technology to reduce motor disease severity,[91, 108] and improve balance outcomes[91, 109] and postural control impairment measures of stability (sway, and the Sensory Organization Test).[40, 91, 104] There is moderate-strength evidence based on 1 high-quality study supporting the use of technology over traditional balance interventions for mobility outcomes,[91] balance confidence,[109] falls,[109] depression,[108] and quality of life.[109] However, heterogenous outcome measures and frequent equivocal results make it challenging to formulate a definitive recommendation. Many of the studies that demonstrated benefits of using technology required equipment that is not yet commercially available, such as wearable sensors,[91, 109] research-grade force plates,[108] rotational treadmills,[40] or exergaming systems that are discontinued.[104]

Supervision

One high-quality study[96] and 1 moderate-quality study[117] compared more supervised with less supervised balance interventions. There is moderate-quality evidence that suggests physical therapists should use greater levels of supervision to have greater gains in self-efficacy,[96] motivation, and step length.[117]

Balance Training Compared With Dynamic Gait Training

Five high-quality studies[93, 97, 99, 106, 107] and 2 moderate-quality studies[31, 122] examined dynamic gait training interventions (low, moderate, and vigorous aerobic intensities) compared with balance training. Although results are mixed, moderate-to-vigorous aerobic training conducted on a treadmill may be superior to balance training to improve balance outcomes based on 1 high-quality[106] and 1 moderate-quality study.[31] Additionally, aerobic exercise conducted on a treadmill may improve gait outcomes to a greater extent than balance training based on 2 high-quality studies.[97, 107] Because aerobic treadmill training can also challenge gait and balance, it is challenging to determine which aspect of the intervention accounts for the improvements observed.

Balance Training Compared With Resistance Training

Physical therapists should use balance training over resistance training with improve postural control, balance outcomes, and spatiotemporal gait impairments. This statement is supported by 1 high-quality study[102] and 3 moderate-quality studies.[75, 130, 131] The high-quality study suggests that the outcomes of balance and amount of sway are significantly improved with balance training compared with resistance training.[102] Two moderate-quality studies suggest that gait related measures may be improved with balance training over resistance training.[75, 131]

Core Strengthening for Balance Compared With Conventional Physical Therapy

Two high-quality studies[89, 94] compared core strengthening with conventional physical therapy, with conflicting findings related to balance. Therefore, no definitive statement can be made. One high-quality study suggested that core strengthening may improve balance [anticipatory, reactive postural control and dynamic gait items of the **Mini BESTest**,[85, 86] **Activities-specific Balance Confidence Scale (ABC)**[140]] and stability (forward and left directions on the Limits of Stability Test).[78] Another high-quality study suggested that improvements in sway (electronic platform)[83] resulted from core strengthening. The GDG concluded that physical therapists could recommend core strengthening as a part of balance training interventions if the goal was to improve balance, stability, and sway as measured above. Conventional physical therapy may be more effective than core strengthening to improve range of motion or quality of life.[94]

Aquatic Balance Training Compared With Land-Based Balance Training

Physical therapists may consider aquatic therapy over land-based therapy to improve fear of falling and quality of life. One high-quality study favored aquatic-based balance exercise over land-based exercise for improving postural sway and quality of life in individuals with PD.[103] Another high-quality study favored aquatic-based balance exercise over land-based balance exercise to improve fear of falling as measured by the Falls Efficacy Scale, but showed no difference in postural sway.[110]

Potential Benefits, Risks, Harms, and Costs of Implementing This Recommendation

Benefits are as follows:

- Improvements in postural control impairments
- Improvements in balance outcomes
- Improvements in mobility outcomes
- Improvements in gait outcomes
- Improvements in outcomes related to balance confidence
- Improvements in quality of life
- Improvements in nonmotor symptoms

Risk, harms, and/or cost are as follows:

- Falls are a potential risk when individuals with PD are implementing balance exercises. However, few studies reported adverse events, but those that did, reported a small

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number of adverse events that were minor in nature and found no difference in number of adverse events between intervention groups and control.[116, 118]

- One study published cost-effectiveness data,[124] noting that balance intervention provided in a group setting was more costly than the usual care control group, but yielded greater gains in balance, gait, and quality adjusted life years for individuals with PD.
- Many high- and moderate-quality studies[40, 91, 95, 100, 104, 108, 109, 114, 115, 119-121, 127, 128] used technology to deliver balance interventions. The cost of using many of these technologies may be prohibitive to clinical facilities and therefore less accessible to some individuals with PD.

Benefit-harm assessment: The balance of the benefits versus risk, harms, or cost overwhelmingly supports this recommendation.

Future Research

Additional high-quality research is needed in several areas. More research is needed to determine the benefits of balance training in reducing fall rates. Given mixed results, the essential ingredients of balance training necessary to reduce fall rate remain unclear and need to be determined to better inform practice. More research is also needed to determine which patients with PD benefit most from balance training when the goal is to reduce fall risk and rate. It is important to determine the cost-effectiveness of balance training relative to the cost of adverse events including injurious falls, hospitalizations, and transition to supported living environments. Research is also needed to compare different types of balance interventions (eg, dynamic gait training compared to traditional balance training), various doses of balance interventions, and methods of delivery (individual, group, home) to better inform care delivery patterns. Research is also needed to determine which gait outcomes benefit from balance interventions when these interventions are delivered separate from gait interventions. Future research should also focus on standardizing outcomes across studies and incorporating evidence-based balance and functional outcomes that are responsive to change. Due to mixed evidence or a paucity of evidence, more research is needed to assess the benefits of balance training on nonmotor signs, physical activity levels, and quality of life.

Value Judgments

Physical therapists should include balance training interventions as part of a comprehensive exercise program to improve postural control, balance, and functional mobility. Given the high prevalence of falls in PD and evidence from 2 studies[39, 118] revealing reduced fall rates in those with lower disease severity, physical therapists should consider initiating balance training early in the course of the disease.

Intentional Vagueness

The dosing of balance interventions varies across studies. However, many studies reveal a benefit of balance training when implemented 2-3 times per week for 16 to 30 total hours over 5 to 10 weeks. Given that falls are multifactorial in PD, balance training may need to be combined with other interventions to reduce fall rate, particularly those with greater disease severity.

Exclusions

The included studies only included individuals with disease severity classified as H&Y stages 1-4; therefore, these recommendations may not apply to individuals with advanced PD (H&Y 5).

FLEXIBILITY EXERCISES

Physical therapists may implement flexibility exercises to improve range of motion (ROM) in individuals with Parkinson disease.

Evidence quality: Moderate

Recommendation Strength: Weak

Action Statement Profile

Aggregate Evidence Quality: One Moderate-Quality Study[141]

Rationale

One moderate-quality study[141] found that exercise specifically designed to improve spinal flexibility improved axial rotation, while other measures (functional reach and timed supine to and from standing) were unchanged compared with a waitlist control condition. This study did not examine flexibility of the extremities.

Potential Benefits, Risks, Harms, and Cost of Implementing This Recommendation

Benefits are as follows:

- Improvements in axial ROM

Risk, harms, and/or cost are as follows:

- No adverse events were noted.

Benefit-harm assessment: The balance of the benefits versus risk, harms, or cost demonstrates a small support for this recommendation.

Future Research

Additional high-quality studies to examine the effects of stretching and flexibility (axial and appendicular) on ROM and function are necessary. Studies are warranted to determine which modes of exercise or combinations of ROM exercises (axial mobility, general flexibility) are most effective in preserving or restoring ROM and function in individuals with PD. Continued comparative studies are also needed to determine if supervised or unsupervised programs are superior for improving flexibility. Last, studies are needed to determine optimal outcome measures for determining improvement in flexibility and effect on motor symptoms, function, and quality of life in individuals with PD.

Value Judgments

Given that rigidity is a prominent symptom of PD that can lead to ROM restrictions, physical therapists may include general stretching and flexibility for individuals with PD at all stages of the disease.

Intentional vagueness. Given the limited research available, recommendations regarding target muscle groups, dosing parameters, mode of flexibility exercise, and supervised versus unsupervised exercise cannot be made.

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Exclusions. None were identified.

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EXTERNAL CUEING

Physical therapists should implement external cueing to reduce motor disease severity and freezing of gait and to improve gait outcomes in individuals with Parkinson disease.

Evidence Quality: High

Recommendation Strength: Strong

Action Statement Profile

Aggregate Evidence Quality: 13 High-Quality Studies[90, 108, 142-152] and 16 Moderate-Quality Studies[67, 134, 153-166]

Rationale

Thirteen high-quality and 16 moderate-quality studies examined the benefits of external cueing in individuals with PD. External cueing was defined for the purposes of this CPG as an external temporal or spatial stimuli[148] including rhythmic auditory cueing,[90, 143, 149, 151] visual cues,[108, 145, 147, 152]verbal cues, or attentional cues.[167, 168] These studies varied considerably regarding sample size, comparison group, outcomes measured, mode, frequency, duration, and type of external cueing.

<u>Motor Disease Severity</u>

Four high-quality studies[90, 108, 145, 151] and 1 moderate-quality study[156] identified that external cueing was superior than other modes of intervention or no cueing training at all for reducing motor disease severity as measured by the UPDRS III. Gait training with visual cues was superior to overground training without cues,[145] and visual feedback during balance training was superior to conventional balance training without visual feedback.[108] Rhythmic auditory stimuli (RAS) provided during balance training was superior to a general educational program,[90] RAS during treadmill training was superior to treadmill training without RAS,[156] and cueing training that included visual, auditory, or somatosensory cues during standing balance and gait tasks[151] was superior to no cueing training. Cueing in all of these studies was delivered between 20 minutes to 1 hour, 2 to 5 times per week for 3 to 8 weeks.

Three high-quality studies[142, 147, 149] and 1 moderate-quality study[154] identified reductions in motor disease severity when different modes of external cueing were compared, indicating that no 1 mode of external cueing is superior to another. An additional high-quality study[152] and a moderate-quality study[164] also identified no difference in motor disease severity when external cueing was compared with conventional physical therapy. External cueing in these studies included visual and auditory cues delivered during gait training on a treadmill instrumented with a visual display,[147] visual and auditory cues provided during overground gait training,[147, 149, 152] cues with an internal focus of attention,[142, 154] visual cues placed on the limbs with emphasis on an external focus during limb movements[142, 154] and active music therapy.[164]

One moderate-quality study identified that music delivered continuously during overground walking was superior to music that played only if the participant achieved a predetermined stride length via a preprogrammed wearable sensor.[155] Two moderate-quality studies favored an attentional strategy using cues to produce large amplitude whole body movements (LSVT BIG) delivered for 1 hour, 4 times per

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week for 8 weeks compared with 1 hour of Nordic walking 2 times per week for 8 weeks.[160] LSVT BIG was also favored over a shortened amplitude-oriented training delivered 5 times per week for 2 weeks.[162]

<u>Gait Outcomes</u>

Spatiotemporal Parameters of Gait

Four high-quality studies[146, 150-152] and 2 moderate-quality studies[156, 165] identified that external cueing was superior to usual physical therapy care,[146, 152] overground gait training without cues,[150] treadmill gait training without cues,[156] and no treatment[151, 165] to improve gait speed as measured by an instrumented treadmill[146, 152] during a 20-meter walk[150] and during the **10MWT**.[83, 84, 151, 156, 165] External cueing in these studies included augmented proprioceptive stimuli applied to the feet through shoe sensors during treadmill training[146] and overground gait training using visual cues[150]; a multimodal exercise program that included overground gait training with visual cues[152]; cueing training that included visual, auditory or somatosensory cues during standing balance and gait tasks[151, 165]; and treadmill training using RAS.[156] Cueing interventions in all of these studies was delivered 2 to 5 times per week for 3 to 8 weeks.

An additional high-quality study[147] identified that visual and auditory cues delivered during gait training on a treadmill instrumented with a visual display were superior to visual and auditory cues provided during overground gait training to improve gait speed, measured using an instrumented treadmill, and delivered 7 times per week for 4 weeks.

In addition to gait speed, other spatiotemporal parameters of gait positively influenced by external cueing includes stride length in 2 high-quality studies[146, 147] and cadence in 2 high-quality stidies.[146, 152]

Overall, external cueing provided during overground or treadmill training or during standing balance training that includes visual, auditory and/or proprioceptive cues has immediate and positive impact on spatiotemporal parameters of gait including gait speed, stride length and cadence in individuals with PD.

<u>Functional Gait Outcomes</u>

One high-quality study[90] and 3 moderate-quality studies[157, 158, 160] identified that external cueing was superior to general education,[90] traditional overground gait training,[158] home-based nonsupervised exercise,[160] and home-based walking without cues[157] to improve mobility as measured by the TUG[90, 157, 158, 160] and the **Dual Task TUG**[169] (item 14 of the **Mini BESTest**).[85, 86, 90] External cueing in these studies included RAS-supported multimodal balance training performed 2 times per week for 5 weeks,[90] treadmill training that integrated RAS with auditory cues provided by music performed 3 times per week for 8 weeks,[158] LSVT BIG performed 4 times per week for 4 weeks,[160] and treadmill training using music cues combined with a home walking without cues performed 6 times per week for 8 weeks.[157]

Capato et al[90] also identified improvements in turning with RAS-supported balance training. An additional moderate-quality study[166] identified improvements in single- and dual-task foot clearance during 5 practice trials of a clock-turn intervention.

Three high-quality studies[147, 148, 150] and 2 moderate-quality studies[157, 160] identified that external cueing was also beneficial for improving longer distance walking as measured by the **6MWT**[36, 37, 147] and the number of steps taken over a 20-meter walkway.[150]

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Overall, external cueing provided during overground or treadmill training, or during standing balance training that includes visual and/or auditory cues has immediate and positive impact on mobility, turning, and distance walked in individuals with PD.

Freezing of Gait

Freezing of gait (FOG) was shown to improve with cueing compared with a no-cueing condition in 1 high-quality study.[90] In this study, balance training plus RAS was superior to an educational control in improving FOG.[90] In a high-quality, randomized cross-over trial, FOG was not significantly affected by the cueing intervention.[151] However, when a subgroup of freezers was analyzed, there was a significant reduction in freezing severity **(FOG-Q**[137] scores) with cueing compared with a no-cueing condition.[151] Greater improvement in FOG was shown with treadmill training plus visual and auditory cues compared with overground gait training with visual and auditory cues.[147] It is plausible that the treadmill itself may provide an additional form of cueing. One high-quality study[149] revealed that no 1 form of auditory cueing [ecological stimuli = footstep recordings vs artificial (metronome)] was superior to another in reducing FOG.

Potential Benefits, Risks, Harms, and Cost of Implementing This Recommendation

Benefits are as follows:

- Improvements in motor disease severity
- Improvements in spatiotemporal parameters of gait
- Improvements in functional gait outcomes
- Improvements in freezing of gait

Risk, harms, and/or cost are as follows:

- Gait training with external cues should not cause harm as long as routine safety procedures are followed.
- The cost of utilizing technology for the external cueing source should be considered.

Benefit-harm assessment: The balance of the benefits versus risk, harms, or cost overwhelmingly supports this recommendation.

Future Research

Additional high-quality studies are needed to determine the most effective timing, intensity, and mode of external cueing depending on the outcome of interest and disease severity. More studies are also needed to determine the optimal type, timing, and dosing of cueing to reduce FOG. No studies were identified that investigated the effects of external cueing on fall rate or number of falls, indicating an important area for further research. Optimal modes of delivery leveraging advances in technology should also be examined. The lasting effects of cueing are unclear, as benefits appear to dissipate over time. More studies are needed to determine optimal dosing to sustain benefits over time (eg, ongoing use versus booster sessions).

Value Judgments

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Given the early changes observed in spatiotemporal parameters of gait, the predominance of walking limitation in individuals with PD, and the lack of robust benefits from pharmacological interventions, the GDG recommends initiating gait training with external cues early in the course of the disease.

Intentional Vagueness

Given the variability in the dosing of external cueing, optimal dosing recommendations cannot be provided. Given that effects appear to dissipate when the cues are removed, ongoing gait and standing balance training with cueing may be necessary.

Exclusions

none

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COMMUNITY-BASED EXERCISE

Physical therapists should recommend community-based exercise to reduce motor disease severity, and improve non-motor symptoms, functional outcomes, and quality of life in individuals with Parkinson disease.

Evidence Strength: High
Recommendation Strength: Strong

Action Statement Profile

Aggregate evidence quality: 27 High-Quality Studies,[38, 39, 45, 47, 50, 51, 96, 126, 170-188] 29 Moderate-Quality Studies[60, 61, 66, 67, 81, 123, 189-211] and 1 Low-Quality Study[212]

Rationale

Fifty-seven total studies examined the effects of community-based exercise in individuals with PD. These studies varied considerably in sample size, comparison group, outcomes measured, mode, and dose of exercise.

Community-based exercise is defined in this CPG as follows: (1) programs in which groups of individuals exercise together or (2) programs in which individuals follow a predetermined exercise program in a community setting either at home or in a community facility. These programs often include a home exercise component. It is not necessary for community exercise programs to be led by a physical therapist, nor are they associated with periodic assessments of individualized physical therapy programs.

<u>Motor Disease Severity</u>

Four high-quality studies[50, 170, 173, 177] and 6 moderate-quality studies[60, 192, 197, 200, 207, 212] indicated that community-based exercise programs reduced motor disease severity as measured by the **MDS-UPDRS III**.[34, 35] All of the high-quality studies consisted of varied interventions (yoga, dance, Pilates, power training); however, the doses were consistent (1 hour sessions 2 times per week for 12-13 weeks). There was greater variability in dosing in the moderate-quality studies with a minimum of 16 sessions and a maximum of 96 sessions, ranging from 1 time per week for 16 weeks to 2 times per week for 12 months. The intervention types were also varied and included aerobic and anerobic exercise via a booklet, tango dance, tai chi, power training, Dance for PD, and qigong.

<u>Nonmotor Symptoms</u>

Two high-quality studies[176, 182] and 1 moderate-quality study[211] found that community-based exercise improved depression as measured by the Hospital Anxiety and Depression Scale (HADS), Beck Depression Inventory (BDI), and the Geriatric Depression Scale (GDS), and improved cognition as measured by **Montreal Cognitive Assessment**,[82] Mini-Mental State Examination, and Wechsler Memory. One high-quality[176] and 1 moderate-quality study[211] revealed improvements in anxiety as measured by the HADS and State-Trait Anxiety Inventory. One high-quality study found improvements in sleep as measured by the Parkinson Disease Sleep Scale.[170] The studies that improved nonmotor symptoms all included interventions for breathing and relaxation, with frequency and duration ranging from 1-2 hours per week for 8-25 weeks.

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Functional Outcomes

Ten high-quality studies[38, 39, 45, 50, 51, 172-174, 178, 181] and 8 moderate-quality studies[81, 189-192, 198, 209, 211] were in favor of community-based exercise for improving function (walk tests, balance, mobility, falls, fall fear/risk, and ADLs). These community-based exercise programs include tai chi,[172] resistance training,[51] action observation training,[178] dance,[174, 181, 192] balance exercise and lower extremity strengthening,[38, 39, 45, 81] Pilates,[189, 191] Nordic walk,[190] qigong,[198] mindful meditation,[211] Feldenkrais,[209] and power yoga.[200] High-speed yoga[50] and action observation training[178] led to improvements in gait speed, while tai chi and dance led to improvements in functional mobility as measured by the TUG test and improvements in turning as measured by the 360-degree Turn Test and 3-dimensional motion analysis.[172-174, 181, 209]

The effect of community-based exercise on balance is not clear, as there were 8 high-quality studies[38, 126, 172, 175, 178, 183, 188, 196] that demonstrated no significant improvements in balance while 5 high-quality studies[45, 50, 51, 173, 181] favored community-based exercise to improve balance. There is not a clear explanation for these conflicting results, as the aforementioned studies examined community-based exercise programs with similar outcome measures and nonactive control comparisons. The studies that did not demonstrate significant improvements included strength and balance training, tai chi, ai chi, dance, qi dance, yoga, and action observation training. The studies that did demonstrate significant improvements in balance included strength and balance training, resistance training, tai chi, power yoga, and tango. There was not a consistent difference in dose or mode of exercise that might explain this discrepancy.

Three high-quality studies[50, 96, 184] and 1 moderate-quality study[203] demonstrated improvements in gait-related outcomes including sway, stride, FOG, and balance as measured by the Berg Balance Scale compared with power training, individual training, routine physical therapy, and home exercise program.

Quality of Life

Five high-quality studies[38, 126, 176, 182, 185] and 2 moderate-quality studies[81, 211] support the use of community-based exercise to improve quality of life in individuals with PD. These studies measured quality of life using a variety of measurements including the **PDQ-39 and -8**,[138, 139] Holistic Well-Being Scale, or Parkinson's Disease Quality of Life Questionnaire (PDQL). Most studies that demonstrated improvements in quality of life included some aspect of mindful movement or awareness of movement.[126, 176, 182, 185, 211]

Intervention Comparisons

Community-based exercise studies in PD consisted of a variety of exercise modes such as tai chi, ai chi, power yoga, hatha yoga, Pilates, group multimodal training, dance, noncontact boxing, Nordic walking, qigong, action observation training, mindful meditation, and the Feldenkrais method. Several studies have made direct comparisons between community-based exercise programs. Results across several high-quality studies using different modes of exercise in community-based programs appear comparable for impairment and participation-based measures,[171, 180, 204] suggesting no 1 mode of exercise in a community exercise program is superior to another. However, other comparisons suggest that 1 intervention is favored over another. Several studies examined the effect of community-based exercise

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on balance outcomes. Three high-quality studies[47, 171, 179] and 1 moderate-quality study[201] indicate superior balance outcomes when comparing boxing over traditional multi-modal exercise,[171] tai chi over stretching exercise,[47] ai chi exercise over dry land exercise,[179] and Pilates over conventional physical therapy.[201] Similarly, studies of tai chi,[47] ai chi[179] and Pilates[201] found superior mobility outcomes as measured by the TUG. The essential components that distinguish more effective from less effective community-based exercise programs are not clear.

Two high-quality studies[96, 187] and 1 moderate-quality study[203] examined an intervention delivered in a community-based group exercise program versus an individual-based program. One of those high-quality studies showed improved adherence to the community-based exercise program as compared with an individual-based program.[187] Another high-quality study showed improved quality of life as measured by the **PDQ-39**.[96, 138, 139] This suggests there may be some benefit to a community-based group exercise over individual exercise programs.

Potential Benefits, Risks, Harms, and Cost of Implementing This Recommendation

Benefits are as follows:

- Improvements in motor (strength/power, posture, hand-upper extremity dexterity, hand-eye coordination) and nonmotor symptoms (anxiety, depression, cognition and sleep)
- Improvements in functional outcomes (eg, gait, balance, mobility, ADLs, walking capacity and velocity, walking measures, turning) and falls/fear of falling
- Improvements in quality of life

Risk, harms, and/or cost are as follows:

- Three high-quality studies[176, 181, 184] and 2 moderate-quality studies[60, 207] found no significant differences in adverse events between community-based exercise and the comparison groups.

Benefit-harm assessment: The balance of the benefits versus risk, harms, or cost overwhelmingly supports this recommendation.

Future Research

Given the benefits associated with participation in community-based exercise programs for individuals with PD, more information about adherence rates and long-term outcomes compared with individual home exercise programs would help to inform exercise recommendations provided by physical therapists. Additionally, a meta-analysis of the effect of community-based exercise on balance is warranted given the conflicting evidence in several high-quality studies. Finally, future research should stratify analyses by disease severity, sub-type of PD, functional ability, or focus on intervention studies that are targeted to sub-groups of individuals with PD.

Value Judgments

Given the potential benefits of community-based exercise programs to improve motor and nonmotor symptoms, the work group recommends that physical therapists encourage individuals with PD to

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participate in community-based exercise programs. Though it is not clear what mode of exercise yields the most optimal results, 1 that targets the most relevant areas of concern (eg, balance, aerobic conditioning, strength, flexibility) for a given individual may be most beneficial. Considering that PD is a progressive disease, regular access to and participation in community-based exercise is recommended.

Intentional Vagueness

Given the variability in the study interventions, with no clear mode of exercise shown to be superior, the work group cannot recommend 1 community-based exercise program over another.

Exclusions

Most studies include individuals with mild to moderate PD (H&Y 1-3). These recommendations may not apply to individuals with severe PD, who may not have the capacity to engage in community-based exercise programs. Most studies limited participation to those who did not have cognitive impairments. These recommendations may not apply to individuals with cognitive impairments.

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GAIT TRAINING

Physical therapists should implement gait training to reduce motor disease severity, and improve stride length, gait speed, mobility, and balance in individuals with Parkinson disease.

Evidence Quality: High

Recommendation Strength: Strong

Action Statement Profile

Aggregate evidence quality: 20 High-Quality Studies[97, 99, 106, 107, 213-228] and 13 Moderate-Quality Studies[122, 229-240]

Rationale

Most studies examining the benefits of gait training in individuals with PD compare 1 form of gait training to another. Fewer studies compare gait training with a usual care control intervention or with other types of interventions. The approaches to gait training and the outcomes assessed vary widely across studies.

Motor Disease Severity

Gait training has been shown to reduce motor disease severity (**UPDRS III**)[34, 35] in individuals with PD. When comparing different types of gait training within a study, 4 high-quality studies[99, 213, 214, 227] and 3 moderate-quality studies[122, 229, 234] found that motor disease severity was reduced with the gait training interventions, although 2 high-quality studies[215, 220] and 1 moderate-quality study[230] indicated no reduction in motor disease severity with any of the gait training interventions. In 1 moderate-quality study,[236] a decrease in motor disease severity was found with partial weight-supported treadmill training (PWSTT) when compared with usual care. When comparing gait training with other treatments, a reduction in motor disease severity was found for gait training (curved walking rotating treadmill) when compared with general exercise.[216] Both robotic-assisted gait training (RAGT) and balance training reduced motor disease severity compared with general exercise.[223]

Step Length and Cadence

Three high-quality studies[216, 223, 224] and 1 moderate-quality study[240] compared gait training with other treatment approaches, revealing improvements in step length. One high-quality study found that step length improved for 2 types of gait training interventions (treadmill and RGAT), while proprioceptive neuromuscular facilitation (PNF)-based (nonambulatory) gait training (rhythmic initiation, slow reversal, and agonistic reversal exercises applied to the pelvic region) did not improve step length.[223] One high-quality study[224] and 1 moderate-quality study[240] compared gait training interventions with conventional multimodal therapies (RAGT and downhill treadmill training), finding the gait interventions had greater step length improvements. Curved walking training improved step length and cadence in both straight path and curved path walking compared with the control exercise program.[216]

There are mixed results when comparing step length outcomes with different types of gait training. Two high-quality studies[219, 223] and 1 moderate-quality study[238] found that gait training improved stride length in individuals with PD, regardless of which gait training interventions were provided (treadmill with and without virtual reality, treadmill training, RGAT). Three high-quality studies[219, 221, 226] and 1 moderate-quality study[230] found that 1 gait training technique had greater improvements in step length than another technique, but there was no consistent difference between these studies regarding which technique was best (RGAT vs. treadmill; backward vs. forward walking; treadmill vs. overground) .

There are mixed results related to the effects of gait training on cadence. Two high-quality studies showed no improvement in cadence with gait training.[221, 223] However, 1 high-quality study[224] revealed that cadence improves with RAGT compared with conventional therapy, and another high-quality study[219] found that cadence improved with RAGT but not with intensive treadmill training. One moderate study showed improvement in cadence with both treadmill and overground training.[230]

Gait Speed

Three high-quality studies found that the gait training interventions (circular treadmill, RAGT, forward treadmill walking) yielded improvements in gait speed, while other interventions (general exercise, conventional therapy, PNF) did not.[216, 223, 224] Two moderate-quality studies revealed greater improvements in gait speed with downhill treadmill training compared with multimodal conventional therapy, and with aerobic treadmill training plus conventional therapy compared with conventional therapy alone.[237, 240]

Seven high-quality[106, 214, 215, 220, 222, 223, 228] and 3 moderate-quality[229, 230, 238] studies identified that gait speed improved regardless of the mode of gait training applied. Overground and treadmill training,[230] treadmill training forward and backward,[221] treadmill training both with and without repetitive transcranial magnetic stimulation (rTMS),[228] treadmill training with and without perturbations,[106] and a smartphone application that offered positive and corrective feedback on gait and gait training with personalized gait advice[220] yielded similar favorable results within each study. One moderate-quality study measured gait speed while negotiating obstacles, with greater improvement with treadmill training with virtual reality than treadmill training alone;[239] however, another study found that both single and dual task gait speed improved similarly in both treadmill and treadmill with virtual reality training, making the impact of adding virtual reality unclear.[238] One moderate-quality study incorporated the upper extremity during gait training, finding that although both groups improved, Nordic walking on the treadmill had greater improvements than treadmill training alone.[229] Variable gait speed outcomes were found in 4 high-quality studies[214, 215, 219, 226] comparing RAGT with treadmill training. One study found greater gait speed improvements with treadmill training than with RAGT,[215] 2 studies showing RAGT improving greater than treadmill training,[219, 226] and 1 study found similar improvements between treadmill and RAGT.[214]

Only 1 high-quality study found that an alternative treatment to gait training had a greater improvement in gait speed. When comparing virtual reality (in-place walking), conventional overground gait training, and treadmill training, the virtual reality group demonstrated greater improvements in gait speed than the overground training group, but at a similar level to the treadmill training group.[218]

Mobility

Gait training has been shown to improve walking outcomes [**(6MWT)**,[36, 37] 2MWT test, TUG)] in individuals with PD. Two high-quality studies compared gait training interventions with conventional therapy (primarily PNF-based nonambulatory gait training) and found greater improvements in the **6MWT**[36, 37] with RAGT and treadmill training.[223, 224] Two high-quality studies found greater improvements on the TUG with RAGT than with other physical therapist interventions not aimed at improving balance[225] or physical therapist interventions that included balance and postural reaction training.[99] Additionally, curved gait training on a treadmill resulted in improved mobility as measured by the TUG, compared with control exercise intervention.[216] One moderate-quality study found similar functional mobility improvements between the gait intervention group (conventional therapy plus moderate aerobic training) and conventional therapy.[237] One high-quality study found virtual reality (VR) with walking in place improved **6MWT**[36, 37] greater than conventional overground gait training, although treadmill-based gait training and the VR group demonstrated similar improvements.[218] Cakit et al[232] found that incremental speed-dependent treadmill training had greater improvement on walking distance than an inactive control group.

Seven high-quality studies[213-215, 220, 222, 223, 228] and 1 moderate-quality study[229] compared different gait training interventions and identified that walking outcomes improved regardless of the mode of gait training applied. In 3 high-quality studies, both conventional treadmill training and RAGT indicated similar improvements in the distance covered during the **6MWT**[36, 37] and mobility as measured by the TUG.[214, 215, 223] One high-quality study[228] identified improvement in mobility (TUG) after treadmill training both with and without rTMS. Another high-quality study[220] compared a smartphone application that offered positive and corrective feedback during gait with gait training with personalized gait advice, finding similar improvements in 2MWT for both groups. One moderate-quality study favored Nordic walking on the treadmill in comparison with treadmill training alone to improve mobility.[229]

In all of the studies assessing the impact of gait training on mobility, only 1 high-quality study[106] and 1 moderate-quality study[230] did not find all gait training interventions to improve all functional mobility outcomes, although some improvements in each study were noted.

Balance

Gait training has been shown to improve balance in individuals with PD, although there are some mixed results. One high-quality study[99] identified improvements in balance and balance confidence as measured by the Berg Balance Scale (BBS) and the **ABC**[140] in the group that participated in RAGT as well as in the group that participated in physical therapist intervention with an emphasis on balance and postural reactions. Alternatively, RAGT resulted in improvements in balance as measured by the BBS compared with physical therapist intervention that did not focus on improvements in postural stability.[225] Another high-quality study found that gait training with RAGT demonstrated greater improvement in balance as measured by the BBS compared with treadmill training alone or PNF-based (nonambulatory) physical therapist interventions.[223] Similarly, a high-quality study identified improvements in balance as measured by the **FGA**[135, 136] using curved gait training on a treadmill compared with the control exercise group.[216]

One moderate-quality study identified that incremental speed-dependent treadmill training had greater improvement than an inactive control group on balance as measured by the BBS and the Dynamic Gait index (DGI) and fear of falling measured by the Falls Efficacy Scale (FES).[232] Another moderate-quality study identified improvements in balance as measured by the BBS in a group that participated in conventional gait training and a group that utilized body weight-supported treadmill training compared with an inactive control group.[236]

Three high-quality[213, 222, 227] and 2 moderate-quality[229, 234] studies compared different gait training interventions and found, regardless of the gait training method used, performing gait training improved balance outcomes, while 3 high-quality studies[97, 106, 220] found gait training interventions did not improve balance. Furnari 2017[234] compared RAGT plus a conventional exercise program with conventional gait training plus conventional exercise program, with both groups having similar significant improvements in balance (Tinetti balance scale). Although both groups improved, Bang et al[229] found that Nordic walking on the treadmill had greater balance improvements than treadmill training alone (BBS). One high-quality study found that treadmill training with 0%, 5%, and 10% additional load applied using a weight belt during treadmill training had similar improvements in balance on the Pull Test.[227] In 2 high-quality studies, gait training on the treadmill or on the treadmill with perturbations did not improve balance (**Mini BESTest**[85, 86] [Mini Balance Evaluation System Test], COP [center of pressure] sway, and **ABC**)[97, 106, 140] Another high-quality study found no improvement in balance (**Mini BESTest**)[85, 86] with either a smartphone application that offered feedback on gait or gait training with personalized gait advice.[220]

Freezing of Gait (FOG)

Four high-quality studies monitored freezing of gait with gait training with mixed results.[214, 216, 220, 222] Two high-quality studies found improvement with gait training including RGAT, treadmill training, and circular treadmill training.[214, 216] Two high-quality studies found that gait training did not improve FOG with gait training, including treadmill training, a FOG phone app that included biofeedback with gait training, and gait training with FOG-specific advice.[220, 222]

Falls

Only 1 high study[222] and 2 moderate-quality[238, 239] studies monitored falls after gait training. The high-quality study found that treadmill training decreased falls and fear of falling.[222] One moderate-quality study found falls decreased during the 6 months post treadmill training with and without virtual reality,[238] while a similar study found only a trend toward decreasing falls.[239]

Fatigue

Two high-quality studies indicated that fatigue improves with treadmill training and RAGT, while not improving in control groups.[223, 224]

Potential Benefits, Risks, Harms, and Cost of Implementing This Recommendation

Benefits are as follows:

- Reduced motor disease severity
- Improved step length
- Improved walking speed
- Improved walking capacity
- Improved functional mobility
- Improved balance

Risk, harms, and/or cost are as follows:

- Gait training should not cause harm as long as routine safety procedures are followed.
- When utilizing treadmill and harness, discomfort from the harness may occur.
- Fatigue can be a side effect of gait training.
- There is a risk of musculoskeletal discomfort with gait training (eg, lower extremity or back pain), which was occasionally reported. In most cases, modification of activity allowed continuation with treatment.
- The cost of gait training to physical therapy clinics can vary depending what equipment is utilized. The cost of robotic-assisted gait training devices and specialized treadmills for perturbations or circular walking can be expensive, so not all clinics will be able to provide these intervention strategies. Additionally, individuals with PD who may benefit from or seek these approaches may be referred to other sites and, depending on distance, this may add to the patients' costs in travel and time.

Benefit-harm assessment: The balance of the benefits versus risk, harms, or cost overwhelmingly supports this recommendation.

Future Research

Further research is needed to determine the optimal dosing of gait training. In addition, the critical elements of gait training that optimize outcomes in PD need to be identified. Identifying those components of gait training that are most beneficial for various gait profiles (eg, FOG) or stages of PD is needed. Most gait training studies focus on impairment and activity-based outcomes, whereas it would be beneficial to have a better understanding of the impact of gait training on participation level outcomes. Last, a standard set of outcomes should be used across studies to facilitate direct comparisons between studies.

Value Judgments

Given that a decline in walking ability occurs over the disease continuum in PD and that gait training improves walking and other functional outcomes, the GDG recommends initiating gait training early after diagnosis to optimize walking-related outcomes.

Intentional Vagueness

Given the variability in the dosing of gait training across studies, the optimal dosing has not been determined. However, many studies reveal a benefit of gait training when implemented 20-60 minutes, 3-5 days per week, for 4-12 weeks. It is important to note that most studies that included a long-term follow-up (3-6 months post training) had a variable decline in outcomes with time. Gait training may need to be a continued activity to decrease the decline in functional outcomes.

Gait training was administered on the treadmill with and without robotic assist, with varying amounts of cardiovascular intensities and body weight support. Select parameters may be important for different individuals at various stages, but that specificity is not yet clear.

There was no 1 gait training intervention that demonstrated greater improvement than other types of gait training (eg, overground vs treadmill vs robotic assisted).

Exclusions

Individuals who are at H&Y 4-5 stage of PD were not included in many of the studies, and this information may not be generalizable to those populations.

Individuals who are at high risk for falls may require a harness or safety device to optimize safety. Screening for the presence of comorbidities that may interfere with participation in gait training should be implemented.

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TASK-SPECIFIC TRAINING

Physical therapists should implement task specific training to improve task-specific impairment level and functional outcomes for individuals with Parkinson disease.

Evidence Quality: High

Recommendation Strength: Strong

Action Statement Profile

Aggregate Evidence Quality: 15 High-Quality Studies[40, 48, 241-253] and 7 Moderate-Quality Studies[118, 166, 254-258]

Rationale

In the 15 high-quality studies and 7 moderate-quality studies, there were a variety of tasks trained and therefore outcomes assessed. Overall, studies suggest that task-specific training improves the outcome targeted using a variety of approaches. The articles assessed were sub-grouped based on the task trained including mental imagery, upper extremity training, turning training, fall prevention training, dual task training, bladder training, and multimodal training.

<u>Mental Imagery</u>

Task-specific mental imagery (with sufficient repetitions) paired with actively performing the task resulted in improvements in the target outcome. In 4 high-quality studies[241, 242, 244, 247] and 1 moderate-quality study,[254] individuals were specifically trained with various mental imagery or gait observation techniques yielding mixed results**.** Mental imagery training using dynamic neurocognitive imagery (DNI), with the goal of developing an individual's imagery skills, kinesthetic and proprioceptive sense, and motor self-awareness, improved mental imagery ability (Movement imagery questionnaire-revised 2nd edition and Kinesthetic and Visual Imagery Questionnaire, and Vividness of movement imagery questionnaire-revised version) and pelvic schema (measured by the ability to draw a pelvis) when compared with a group that read health and wellness literature and performed video-based gross and fine motor exercises.[241, 242] When functional outcomes were assessed following DNI mental imagery, there was an improvement in **6MWT**[36, 37] and TUG but not pain, UPDRS, **ABC**,[140] 30-second chair stand test, **Mini BESTest**,[85, 86] **TUG dual task**,[169] or 360 degree turn.[241] Watching videos of individuals with and without PD walk and being trained to discriminate between them (8 days of training) did not demonstrate any spatiotemporal gait improvements either at home or in a lab environment.[247] Locomotor imagery including 10 minutes of watching their own gait and that of an adult male without PD from various views in addition to physical therapist interventions, however, improved lower extremity joint kinematics and functional gait (**Functional Gait Assessment**)[135, 136] compared with physical therapist services alone.[244] One moderate-quality study found no significant improvement in functional gait outcomes (**10MWT**[83, 84] or TUG) when utilizing mental imagery embedded in the therapy session.[254] However, the task-specific mental imagery may not have been as effective due to the limited repetitions of imagery in this study.

<u>Upper Extremity</u>

Task-specific training that is focused on the upper extremities should improve strength and manual dexterity and may improve sensation and goal attainment. Three high-quality studies[243, 249, 252] focused

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on upper extremity impairments (weakness, poor manual dexterity, and decreased sensation), and 1 moderate-quality study[258] focused on upper extremity function (goal attainment).

Task-specific training of the upper extremity (based on patient-specified goals, dexterity training, and specific finger strengthening with therapy putty) compared with a more general upper extremity exercise program (generalized ROM, grasp, and manipulation; general resistance band exercises, and general exercises) in 3 high-quality studies found greater improvement in pinch and grip strength, dexterity (**9 hole peg test**, Dexterity Questionnaire 24, Purdue Pegboard Test and Chessington Occupational Therapy Neurologic Assessment Battery dexterity task), and patient-specified goal attainment.[243,252,249]

One moderate-quality study compared sensorimotor-specific training versus current rehabilitation in the upper extremity, finding improved wrist proprioception, touch threshold (Weinstein enhanced sensory test), the ability to sense weight and texture of objects (hand active sensation test), and hand dexterity (in dominant hand only, Purdue pegboard test) with the sensorimotor-specific training.[258] This study did not find an improvement in haptic object test recognition or functional use as assessed with the box and box test.

Turning

Task-specific turning practice should be utilized for individuals with PD. Two high-quality studies[40, 253] and 1 moderate-quality study[166] focused on turning training using different modalities. One high-quality study compared a turning-based training program performed on a rotational treadmill, an exercise group focused on balance and strengthening exercises to target turning, and a general exercise group, with all groups including turning training on level surfaces each session.[40] The study found that both the turning-based rotational treadmill program and turning-specific exercise group had greater turning improvement than the general exercise group, indicating the benefit of task-specific training.[40] Furthermore, this study found that the impairments that improved were different based on the specific training received, although the overall improvement in turning was similar.[40] Another high-quality study looked at training functional turning in an aquatic setting[253] and found that focusing on obstacles (slalom walking, obstacle circling, crossing over a step, and walking back and forth in a narrow passage) had significantly greater improvement in TUG and FOG than general aquatic therapy. Non-task-specific measures of balance (Berg balance scale and functional reach test), however, improved in both groups similarly.[253] A moderate-quality study observed ability to learn the clock-turning strategy and performance of turns within only 1 session.[166] The single session may not have been enough time to learn the new strategy, as it did not improve TUG time or decrease the number of steps for turning, but it did improve foot clearance, decreased step variability, and improved step symmetry.[166]

Dual Task

Physical therapists may consider using dual task training to improve functional dual task walking, as there were mixed results in the 3 high-quality studies focused on specifically training dual tasks in individuals with PD.[246, 248, 251] One high-quality study found decreased dual task cost on gait speed, improved balance (**Mini BESTest**),[85, 86] and improved perception of freezing of gait (**FOG-Q**)[137] when comparing agility boot camp utilizing cognitive challenges during tasks compared with education as the control (80min, 3 times/week, 6 weeks).[248] Two high-quality studies[246, 251] (same data set) found that specifically training cognition and gait together during the session (dual task training) did not lead to better dual task outcomes than cognition and gait trained separately within the same session. Both dual- and single-task training (70min, 2 times/week, 6 weeks) demonstrated similar improvements as measured by dual-task gait speed and spatiotemporal gait parameters during dual-task walking under 3 different dual-task conditions (with auditory stroop, backward digit span, and using a mobile phone).[246, 251]

Falls

Interventions focused on task-specific training to decrease falls have mixed results, with 1 high-quality study[48] demonstrating decreased falls and 1 moderate-quality study[118] demonstrating no difference in falls. The high-quality study had 3 groups, including fall prevention education with movement strategy training (strategies to prevent falls and improve mobility and balance during functional tasks using attention; mental rehearsal and visualization of the movement; verbal, rhythmical, and visual cues; training of caregiver in the home environment), fall prevention education paired with progressive resistance strength training, and life skills information (not fall or mobility related).[48] This study found that movement strategy training or progressive resistance strength training paired with falls prevention education can prevent falls prospectively for 12 months better than the control group, with the resistance training program being more effective at preventing falls than the movement strategy training. The moderate-quality study shows task-specific training for fall prevention that includes a home assessment of fall risk factors, strengthening and balance training, and functional practice of turning and complex environments can improve balance, fear of falling, and ability to get out of a chair, but it did not decrease falls compared with an inactive control group.[118] This study also found that task-specific training for fall prevention may increase fall risk in individuals at the H&Y stage 4 and have better improvement in moderate disease severity.

Bladder Training

One moderate study looked at lower urinary tract symptoms in individuals with PD and found that task-specific training for bladder management versus conservative advice can improve number of voids per day and amount voided with each micturition, and can decrease incontinence and bladder interference with daily life, but it did not improve overall quality of life or urgency.[256]

Multimodal

Physical therapy is usually delivered in a multimodal manner, not targeting only one specific outcome but rather designed to improve multiple deficits of an individual with PD. It may be beneficial to include task-specific training within a multimodal treatment plan based on 3 high-quality studies,[245, 250, 257] although it is important to note that, due to the multimodal nature of the studies, the improvement in the task-specific outcomes cannot be considered causal, as the outcomes could be from any of the treatments or the combination provided within each study. One high-quality study[250] in an inpatient setting compared movement strategy training (cognitive-focused planning for movements, mental rehearsal, avoiding dual task, and cuing) with musculoskeletal exercise (focused on strengthening, ROM/flexibility, and postural alignment) and identified greater improvements in balance for the movement strategy training as measured by the Pull Test. It is important to note that participants received usual inpatient care, and the extent that these interventions contributed to the results was not measured. Another high-quality study[245] included functional training, functional strengthening, gait training overground and on treadmill, balance training, and recreational games compared with a medication-only control group. They identified improvements in the targeted activities of daily living

(ADLs- **UPDRS II**),[34, 35] motor disease severity (**UPDRS III),**[34, 35] gait speed, and quality of life (SIP-68- Sickness impact profile) in the functional training group. A moderate-quality study[257] compared aerobic training plus task-oriented circuit training with 11 different stations focused on balance, walking, and reaching to aerobic training alone. This study looked at many outcomes, but the outcomes that directly related to the specific tasks trained included TUG, Berg Balance Scale, limits of stability, postural stability test, Pull Test, and **6MWT**.[36, 37] All the outcomes improved in both groups, with only the limits of stability, Pull Test, and postural stability demonstrating greater improvement in the task-oriented circuit training group.

Potential Benefits, Risks, Harms, and Cost of Implementing This Recommendation

Benefits as follows:

- Improvement in the task that was specifically trained
- Improvement in upper extremity strength, dexterity, sensation, and goal attainment
- Improvement in mental imagery
- Improvement in turning and functional mobility
- Improvement in bladder function

Risk, harms, and cost are as follows:

- No increased risk was noted.
- Dropouts across studies were primarily related to lack of enjoyment with engaging in a particular activity, suggesting that patient preferences should be considered.
- There is typically no increased cost to utilizing task-specific training.

Benefit-harm assessment: The balance of the benefits versus risk, harms, or cost overwhelmingly supports this recommendation.

Future Research

Additional studies are needed to determine the benefit of task-specific training for varying levels of cognition. Additionally, studies are needed to determine the optimal dosage of task-specific training needed to optimize outcomes as well as to determine lasting effects of task-specific training to inform duration of training needed. It may be important to determine which impairments and functional tasks require task-specific training and which may improve by more general training to allow for greatest utilization of time.

Value Judgments

Based on this evidence, task-specific training is important for individuals with PD. Patient preference should be strongly considered when choosing targeted outcomes for task-specific training.

Intentional Vagueness

Given the variability in the dosing of task-specific training across studies, the optimal dosing has not been determined for any specific task. However, the studies with single-day training frequencies had less robust improvement than other studies with longer training durations. Most studies looking at task-specific training utilized 30-90 minute sessions, 2-5/week, for 2-12 weeks.

Exclusions

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Individuals who are H&Y stages 4-5 and have impaired cognition were not included in many of the studies, and this information may not be generalizable to those populations. Screening is required for the presence of comorbidities that may interfere with participation in task-specific training.

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BEHAVIOR-CHANGE APPROACH

Physical therapists should implement behavior-change approaches to improve physical activity and quality of life in individuals with Parkinson disease.

Evidence Quality: Strong

Recommendation Strength: Moderate – downgraded

Action Statement Profile

Aggregate Evidence Quality: 4 High-Quality Studies[259-262] and 5 Moderate-Quality Studies[60, 61, 263-265]

Rationale: Four high-quality and 5 moderate-quality studies examined the benefits of physical therapy and/or exercise interventions combined with behavior-change approaches in individuals with PD. Behavior-change approaches generally include strategies applying health behavior change theories (eg, self-determination theory, social cognitive theory, transtheoretical model) and behavioral-change strategies such as goal setting, coaching, and/or problem solving. These studies varied considerably with regard to the types of behavior change approach used, outcomes measured, and comparison groups (usual medical care, self-guided exercise, and general physical therapy), which contributed to the GDG's decision to downgrade the recommendation strength to moderate.

<u>Motor Disease Severity</u>

One moderate-quality study[60] found that exercise combined with behavior-change approaches improved motor disease severity (UPDRS-III) compared with usual care.

<u>Physical Activity</u>

One high-quality study[260] of exercise combined with behavior-change approaches and 1 moderate-quality[264] study of physical therapist interventions using behavior-change approaches found physical activity improved in individuals with PD compared with self-guided exercise or physical therapy only. In another high-quality study,[259] physical activity did not improve significantly following physical therapy with behavior-change approaches delivered using a mobile health application compared with physical therapy with a less intense behavior-change approach.[259]

<u>Walking Capacity</u>

One moderate-quality study[264] of physical therapy using behavior-change approaches found improved walking capacity (**6MWT**)[36, 37] compared with physical therapy alone, while 1 high-quality study[259] found no significant difference between physical therapy with behavior-change approaches using mobile health technology compared with a less-intense behavior-change intervention. However, there was a significant within-group improvement in walking capacity in the behavior-change intervention condition using mobile health technology.[259]

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Quality of Life

One high-quality study[261] supported the use of physical therapy with behavior-change approaches to improve PD-related quality of life (**PDQ-39**)[138, 139] compared with general physical therapy and usual care control groups. However, a moderate-quality study[60] revealed no improvement in quality of life compared with usual care using non-disease-specific quality-of-life measures (EQ-5D and SF-36).

Other

One high-quality study[262] found that bladder retraining combined with behavior-change approaches improved bladder control-related outcomes compared with bladder diary alone.

Potential Benefits, Risks, Harms, and Cost of Implementing This Recommendation.

Benefits are as follows**:**

- Improved participation: disease-related quality of life and physical activity
- Improved activities: walking capacity
- Improved body structure and function: motor disease severity, bladder function

Risk, harm, and/or cost:

- There are no significant risks or harms associated with the use of behavior change approaches with physical therapy compared with physical therapy alone.
- Additional training of physical therapists may be necessary to optimize delivery of behavior change approaches within physical therapist practice.
- Enhancing behavior change approaches with psychoeducation[260] and mobile health technology[259] may increase the costs for the health care team and/or for the patient but may also mitigate costs for patients and care partners related to reduced travel to the health care facility.

Benefit-harm assessment: The balance of the benefits versus risk, harms, or cost supports this recommendation.

Future Research

Additional research is needed to determine the benefits of behavior change approaches combined with physical therapy compared with physical therapy alone to improve engagement in exercise and/or increase physical activity in persons with PD. The components of behavior change approaches should be clearly described. Additional research is needed to identify the critical elements of behavior change approaches (eg, goal setting, action planning, feedback) that are most likely to result in optimal engagement in the desired behavior (eg, exercise, physical activity). Outcomes should include feasibility, adherence, and cost as well as disease severity, physical function, quality of life, and physical activity.

Value Judgments

Given the importance of increasing self-efficacy and long-term engagement in exercise to optimize health in people with PD, the GDG recommends that physical therapists include behavior change approaches as part of their intervention.

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Intentional Vagueness

The types of behavioral change approaches described in the studies reviewed varied considerably, thus the GDG did not make a recommendation related to implementing a particular type of behavior change approach.

Exclusions

The studies reviewed included people with mild to moderate PD (H&Y stage 1-3). The benefits of behavior change approaches are not known among people with greater disease severity or cognitive impairments.

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INTEGRATED CARE

Physical therapist services should be delivered within an integrated care approach to reduce motor disease severity and improve quality of life in individuals with Parkinson disease.

Evidence Quality: Strong

Recommendation Strength: Strong

Action Statement Profile

Aggregate Evidence Quality: Eight High-Quality Studies[261, 266-272] and 8 Moderate-Quality Studies[265, 273-279]

Rationale: There are 8 high-quality studies[261, 266-272] and 8 moderate-quality studies[265, 273-279] providing strong evidence comparing an integrated care approach to control. Integrated care approaches include multidisciplinary, interdisciplinary, and interprofessional health care teams working to improve quality and safety of services provided to people with medically complex needs.[280] Integrated care approaches for individuals with PD involve a variety of professionals, which may include but are not limited to physical therapists or movement disorder specialists, neurologists, rehabilitation medicine providers, nurses, social workers, speech therapists, occupational therapists, and others. In most studies, integrated care was compared with medical management by a neurologist only, except for Monticone,[270] which used a comparison with an exercise-only control group.

<u>Motor Disease Severity</u>

Three high-quality studies revealed reductions in motor disease severity (**UPDRS-III**)[34, 35] with integrated care compared with control.[268-270] Participants in 2 studies completed 4-week intensive inpatient rehabilitation programs with 2 hours of physical therapy and 1 hour of occupational therapy per day, 5 times per week compared with a control group that received medical management alone.[268, 269] The third study compared 8 weeks of inpatient rehabilitation with a multidisciplinary approach including physical therapy, occupational therapy, and cognitive training provided by psychologists with inpatient physical therapy alone for 8 weeks, finding improved **UPDRS-III**[34, 35] scores in the group receiving multidisciplinary care.[270] Three additional moderate-quality studies supported that **UPDRS-III**[34, 35] scores were improved compared with medical management alone using varied integrated care approaches, including: intensive inpatient rehabilitation,[281] outpatient care with movement disorders specialists, nurses, and social workers,[278] and outpatient care with movement disorders specialists, nurses, physical therapists, occupational therapists, and speech-language pathologists.[274] The addition of aquatic therapy to the integrated care team in an intensive inpatient rehabilitation environment was not associated with any significant benefits in **UPDRS-III**.[34, 35, 266]

<u>Nonmotor Symptoms</u>

Three moderate-quality studies reported improved nonmotor symptoms (anxiety, depression, and psychosocial consequences) following various integrated care approaches compared with usual medical care control groups.[274, 276, 278] These integrated care approaches included outpatient care with movement disorders specialists, nurses, and social workers (no rehabilitation therapies specified),[278] outpatient care

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with movement disorders specialists, nurses, physical therapists, occupational therapists, and speech-language pathologists (individually tailored therapies with no set dose),[274] and home health care with a nurse, physical therapist, occupational therapist, and speech-language pathologist (approximately 9 hours of therapy over 6 weeks).[276] Gage et al[276] found less anxiety with home-based multidisciplinary care compared with a usual care control after 6 weeks.[276]

Functional Outcomes (Gait, Mobility, Balance, and Activities of Daily Living)

Three high-quality studies[268, 270, 272] and 2 moderate-quality studies[275, 279] favored integrated care versus control for functional activities, but there was high variability in the functional measures used across studies. One high-quality study found improvements in walking activities including gait speed and spatiotemporal gait parameters, physical performance, and stability (tandem stance and Pastor test).[272] Another high-quality study revealed improvements in balance as measured by the Berg Balance Scale.[270] Two high-quality studies supported improvements in activities of daily living compared with control;[268, 270] however, 1 moderate-quality study indicated no difference in activities of daily living between a group receiving physical therapist services and occupational therapist services compared with a group that received no therapy.[273]

Quality of Life Outcomes

Three high-quality studies supported improvements in health-related quality of life (**PDQ-39**)[138, 139] with integrated care compared with usual medical care control.[261, 267, 270] These programs compared usual medical management without rehabilitation with a 4-week inpatient intensive rehabilitation with physical, occupational, and speech therapy (60 hours of therapy);[267] or a six-week outpatient rehabilitation program with physical, occupational, and speech therapist services (18-27 hours of therapy).[261] A third study compared 8 weeks of inpatient multidisciplinary rehabilitation with physical therapy, occupational therapy, and cognitive training provided by psychologists with inpatient physical therapy alone.[270] Two additional moderate-quality studies supported the finding that integrated care was associated with better quality-of-life outcomes compared with medical management alone.[273, 278]

Levodopa Equivalent Daily Dose

One high-quality study[268] and three moderate-quality studies[274, 275, 278] compared the effect of an integrated care model to usual medical care on levodopa equivalent daily dose (LEDD). The integrated care model that included neurologists, physiatrists, psychologists, nurses, physical therapists, and occupational therapists resulted in no significant increase in LEDD,[275] compared with usual care group where a significant increase in the LEDD was observed, suggesting worsening disease severity. However, other models with physical therapist and occupational therapist services,[268] individualized treatment plan, home visits by a PD nurse and access to a hotline[274] or care from a movement disorders specialist, nurse, and social worker[278] did not result in a significant difference in LEDD compared to control conditions.

Comparisons of Types of Integrated Care Models

One high-quality[266] and 2 moderate-quality studies[276, 277] compared integrated care models with different numbers of providers. In 1 study, the group with more team members (12 team members versus 6), had a greater improvement in quality of life (**PDQ-39**).[138, 139, 277] In another study, a 6-week home-based

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multidisciplinary team (MDT) approach alone was compared with the MDT followed by 4 months of Parkinson-trained caregiver assist (PCA).[276] MDT followed by PCA had better QOL outcomes (less long-term decline in mental component of SF36; EQ5D slightly improved).[276]

One high-quality study[261] and 1 moderate-quality study[265] from the same trial compared an integrated self-management approach with usual care. Participants were randomly assigned to 1 of 3 conditions for 6 weeks of intervention: 0 hours of rehabilitation; 18 hours of clinic group rehabilitation plus 9 hours of attention-control social sessions; or 27 hours of rehabilitation, with 18 hours in clinic group rehabilitation and 9 hours of rehabilitation designed to transfer clinic training into home and community routines. At 6 weeks, there was a beneficial effect of increased rehabilitation hours on quality of life (**PDQ-39**),[138, 139] and effects persisted at 6 months. The difference between 18 and 27 hours was not significant.[261] There were no significant differences in walking function between groups.[261, 265]

Potential Benefits, Risks, Harms, and Cost of Implementing This Recommendation.

Benefits are as follows:

- Reductions in motor disease severity
- Improvements in nonmotor symptoms (anxiety, depression, and psychosocial consequences)
- Improvements in functional outcomes (walking activities including gait speed and spatiotemporal gait parameters, activities of daily living, physical performance, balance, and stability)
- Improvements in quality of life
- Improvements in health care utilization (levodopa equivalent daily dose)

Risks, harms, and/or cost are as follows:

- One high-quality study[270] and 1 moderate-quality study[273] found that there were no significant differences in adverse events in those who participated in integrated care versus a control condition.
- One moderate-quality study[276] suggested that compared with usual medical management care, the integrated care model was associated with improved pain management (Pain Visual Analog Scale on medication) but also with more accident and emergency adverse events. Discussion of this finding suggested that this might be explained by many adverse events coming to the attention of the multidisciplinary team or personal care assistant during their visits, while this attention did not occur in the control condition.
- Increasing the size of the team and the duration of care each week may require changes to the current health care system, increasing costs and negatively affecting feasibility and acceptability. One moderate-quality study[276] directly measured costs and found no significant differences in the overall health care costs between 2 integrated care approaches (multidisciplinary care and multidisciplinary care combined with extra caregiver support).
- Use of integrated care approaches varies widely across health care organizations. True interdisciplinary integrated care approaches, which would require team meetings and increased lines of communication between physicians and physical therapists, may present a greater challenge in some organizations. The presence of physical therapists with expertise in PD may not be feasible in all neurology clinics due to organizational and health system structures. This could require significant changes in processes, staffing, and organization.

Benefit-harm assessment: The balance of the benefits versus risk, harms, or cost overwhelmingly supports this recommendation.

Future Research

The research supporting integrated care approaches over usual care or neurologist care alone is promising. However, additional high-quality research is needed regarding the optimal time to initiate integrated care and the composition of the team. In addition, more research is needed on the long-term benefits and costs related to health care utilization, hospitalizations, falls, and institutionalization related to maintaining integrated care approaches from diagnosis to advanced PD care.

Value Judgment

Due to the complex nature of signs and symptoms associated with PD, the GDG suggests adopting an integrated care approach for management of PD over the course of the disease.

True integration of care, communication, and coordination between team members should be addressed to prevent overburdening the individual with PD and their care partners with multiple team members' input.[282]

Intentional Vagueness

Our description of integrated care approaches is intentionally vague due to the heterogeneity of intervention types and timing.

Exclusions

Most studies included individuals with mild to moderate PD (H&Y stage 1-3). These recommendations may not apply to those with severe PD. Most studies limited participation to those who did not have cognitive impairments. These recommendations may not apply to those with cognitive impairments (Mini-Mental State Exam < 24).

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TELEREHABILITATION

Physical therapist services may be delivered via telerehabilitation to improve balance in individuals with Parkinson disease.

Evidence Quality: Moderate

Recommendation Strength: Weak - downgraded

Aggregate Evidence Quality: 1 High-Quality Study[259] and 1 Moderate-Quality Study[121]

Rationale:
The Centers for Medicare & Medicaid Services definition of telemedicine was used, which is "the exchange of information via telecommunication systems between the provider and the patient to improve a patient's health."[283] There is limited evidence available based on 1 moderate-quality study[121] to support the use of telehealth (specifically, remotely supervised Wii-based balance training) for improvements in balance based on the Berg Balance Scale compared with in-person sensory integration balance training for individuals with PD. One high-quality study[259] showed that quality of life, walking capacity (**6MWT**),[36, 37] and physical activity did not improve significantly with a mobile health-mediated behavior change approach compared with a less-intense intervention using activity diaries. However, the intervention using a mobile health application appeared to differentially benefit the less active subgroup for improvement in health-related quality-of-life mobility subscore (**PDQ-39** mobility score).[138, 139, 259] Variability in the outcome measures and the specifics of the interventions used between the 2 included studies contributed to the GDG's decision to downgrade the recommendation strength to weak.

Potential Benefits, Risks, Harms, and Cost of Implementing This Recommendation:

Benefits are as follows**:**

- Improved activities: Balance
- Improved Participation

Risk, harms, and/or cost are as follows**:**

- The studies included reported no significant differences in adverse events between the telerehabilitation/mobile health and the control groups.
- No falls were reported. Gandolfi et al[121] had a caregiver always present to monitor the patients (H&Y stages 2.5-3.0) for safety. Independent participation by patients in such a program without caregiver monitoring remains to be determined.
- The use of telerehabilitation and mobile technologies may be better suited for individuals with no cognitive impairment and low fall risk.
- Cost analyses of the telerehabilitation intervention compared with the control intervention showed that the total cost for rehab per patient was 36% lower in the telerehabilitation group versus the in-person rehabilitation group.[121] Equipment costs were 94% greater in the telerehabilitation group, but these were surpassed by in-person treatment costs, which were 50% greater for the in-person rehabilitation group.
- The use of mobile health technology may increase the costs for the health care team or for the patient but may also decrease costs related to travel and access to care for patients and care partners.

Benefit-harm assessment: The balance of the benefits versus risk, harms, or cost demonstrates a small support for this recommendation.

Future Research

Further research is needed with robust study designs to examine the benefits of telerehabilitation and mobile health technology for safety, feasibility (and usability for patients and providers), efficacy for disease severity, physical function, quality of life, physical activity, and cost and resource utilization.

Value Judgments

Besides the reduced burden of travel, access, inclement weather, and other barriers to long-term engagement in in-person programs, the utilization of telerehabilitation is especially important in light of low referral rates (14.2%) to rehabilitation and inequitable care with referral rates even lower in African American patients (7.6%).[8] Song et al[284] reported that during the COVID-19 pandemic, the amount, duration, and frequency of exercise were reduced in individuals with PD, associated with a worsening of motor and nonmotor symptoms. Telerehabilitation and the use of mobile technology may be a viable option for intervention in light of this and similar situations limiting in-person access to rehabilitation, especially since individuals with PD are predominantly older adults with other preexisting health conditions, who often rely on transportation support to get to in-person health care appointments.

Intentional Vagueness

Due to the limited evidence available, we do not make specific recommendations about the type of technology to be used or dosage of interventions.

Exclusions

The articles included people with mild to moderate PD (H&Y stage 1-3), without cognitive impairments. The use of telerehabilitation or mobile technology may be less effective or unsuitable for people with advanced PD or cognitive impairments.

BEST-PRACTICE STATEMENTS

DEEP BRAIN STIMULATION

In the absence of reliable evidence, the opinion of the guideline development group is that more research is needed on the effects of physical therapist interventions in individuals undergoing deep brain stimulation.

Strength of Recommendation: Consensus

Rationale

There are no studies that meet inclusion criteria and answer the question of interest regarding deep brain stimulation (DBS) surgery and physical therapist interventions.

Future Research

Future research should examine the effects of physical therapist interventions when included as part of management either pre- or post-deep brain stimulation surgery. Duncan et al[285] published a protocol paper for a pilot randomized controlled trial investigating gait and balance interventions following subthalamic nucleus (STN)-DBS versus usual care following STN-DBS. At the time of this CPG publication, this trial is in progress and may contribute, along with other studies, to the body of evidence.

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EXPERT CARE

In the absence of reliable evidence, the opinion of the guideline development group is that physical therapist services delivered by physical therapists with expertise in Parkinson disease may result in improved outcomes compared with those without expertise.

Strength of Recommendation: Consensus

Rationale

In an observational study,[286] health insurance claims were analyzed from a database that included a population of patients with Parkinson disease in the Netherlands over a 3-year period. Health care use and outcomes were compared between patients who received physical therapy by a specialized physical therapist (N=2129) and those who received usual care (N=2252). A specialized physical therapist was 1 who was trained in PD as part of the ParkinsonNet. The primary outcome measure was the percentage of patients who experienced a PD-related complication, which consisted of a visit or admission to a hospital because of fracture, other orthopedic condition, or pneumonia. There was reduced probability of experiencing a PD-related complication in patients who received specialized physical therapy (17%) compared with the usual care group (21%).

The European Physiotherapy Guidelines for Parkinson's Disease[287] recommends that health professionals who treat these individuals have Parkinson disease expertise. Both the National Institute for Health and Care Excellence (NICE) Guidelines[288] and the Canadian Guideline for Parkinson Disease[289] support the delivery of physical therapist services by clinicians with experience in PD. Specifically, the Canadian Guideline for Parkinson Disease states that "consideration should be given to referring people who are in the early stages of Parkinson Disease to a physiotherapist with experience of the disease for assessment, education and advice, including information about physical activity."[289]

Future Research

Further research is needed comparing rehabilitation outcomes in patients receiving physical therapy by clinicians trained in Parkinson disease-specific management with outcomes in patients treated by untrained clinicians.

NONRECOMMENDATIONS

Due to the unavailability of randomized controlled trial evidence as dictated by the literature search criteria, the GDG refrained from creating recommendations on the following topics:

1. Risk Factors
2. Motor Learning

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Revision Plans

This CPG represents a cross-sectional view of current management strategies and may become outdated as new evidence becomes available. In 5 years, this CPG will be either (1) revised by APTA in accordance with new evidence, changing practice, rapidly emerging treatment options, and new technology; (2) reaffirmed; or (3) withdrawn.

Dissemination Plans

The primary purpose of this CPG is to provide interested readers with full documentation of the best available evidence for various intervention strategies associated with the physical therapist management of Parkinson disease. Publication of this CPG will be in *PTJ—Physical Therapy & Rehabilitation Journal*, the journal of the American Physical Therapy Association. This CPG is available in Spanish; see Supplementary Material X.

Education and awareness about this CPG will be disseminated via online resources, such as webinars, podcasts, pocket guides INSERT GUIDELINE CENTRAL LINK, and continuing education courses; at professional annual meetings; and via social media. A CPG+, which includes an appraisal rating using the AGREE II tool, highlights, a check-your-practice section, and review comments, is available on apta.org for this CPG.INSERT LINK Additional implementation tools will be forthcoming.

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Appendix 1

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Appendix 2

Excluded Literature

Authors	Article Title	Year	Reason for Exclusion
	Deep brain stimulation better than best medical therapy for Parkinson disease	2009	Abstract only
	Impaired motor skill acquisition using mirror visual feedback improved by transcranial direct current stimulation (tDCS) in patients with Parkinson's disease	2019	Fewer than 10 patients in PD comparison groups
Adams, V.; Mathisen, B.; Baines, S.; Lazarus, C.; Callister, R.	A systematic review and meta-analysis of measurements of tongue and hand strength and endurance using the Iowa Oral Performance Instrument (IOPI)	2013	References reviewed
Advocat, J.; Enticott, J.; Vandenberg, B.; Hassed, C.; Hester, J.; Russell, G.	The effects of a mindfulness-based lifestyle program for adults with Parkinson's disease: A mixed methods, wait list controlled randomised control study	2016	Doesn't address question of interest
Ajimsha, M. S.; Majeed, N. A.; Chinnavan, E.; Thulasyammal, R. P.	Effectiveness of autogenic training in improving motor performances in Parkinson's disease	2014	Doesn't address comparison of interest
Alashram, A. R.; Padua, E.; Annino, G.	Effects of Whole Body Vibration on Motor Impairments in Patients with Neurological Disorders: A Systematic Review	2019	Systematic review
Albiol-Perez, S.; Gil-Gomez, J. A.; Munoz-Tomas, M. T.; Gil-Gomez, H.; Vial-Escolano, R.; Lozano-Quilis, J. A.	The Effect of Balance Training on Postural Control in Patients with Parkinson's Disease Using a Virtual Rehabilitation System	2017	Not RCT
Alcock, L.; Galna, B.; Hausdorff, J. M.; Lord, S.; Rochester, L.	Gait & Posture Special Issue: Gait adaptations in response to obstacle type in fallers with Parkinson's disease	2018	Not RCT
Allen, N. E.; Song, J.; Paul, S. S.; Sherrington, C.; Murray, S. M.; O'Rourke, S. D.; Lord, S. R.; Fung, V. S. C.; Close, J. C. T.; Howard, K.; Canning, C. G.	Predictors of Adherence to a Falls Prevention Exercise Program for People with Parkinson's Disease	2015	No comparison group
Allen, N. E.; Song, J.; Paul, S. S.; Smith, S.; O'Duffy, J.; Schmidt, M.; Love, R.; Sherrington, C.; Canning, C. G.	An interactive videogame for arm and hand exercise in people with Parkinson's disease: A randomized controlled trial	2017	Does not address comparison of interest
Alloni, A.; Quaglini, S.; Panzarasa, S.; Sinforiani, E.; Bernini, S.	Evaluation of an ontology-based system for computerized cognitive rehabilitation	2018	No PT intervention
Alves, M. L. M.; Mesquita, B. S.; Morais, W. S.; Leal, J. C.; Satler, C. E.; Dos Santos Mendes, F. A.	Nintendo WiiTM Versus Xbox KinectTM for Assisting People With Parkinson's Disease	2018	Fewer than 10 patients in each group
Alves, W. M.; Alves, T. G.; Ferreira, R. M.; Lima, T. A.; Pimentel, C. P.; Sousa, E. C.; Abrahin, O. S.; Alves, E. A.	Strength training improves the respiratory muscle strength and quality of life of elderly with Parkinson's disease	2019	Duplicate of AAOS ID 6867

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Authors	Article Title	Year	Reason for Exclusion
Alwardat, M.; Etoom, M.	Effectiveness of robot-assisted gait training on freezing of gait in people with Parkinson disease: evidence from a literature review	2019	References reviewed
Alzahrani, H.; Venneri, A.	Cognitive Rehabilitation in Parkinson's Disease: A Systematic Review	2018	References reviewed
Amboni, M.; Iuppariello, L.; Iavarone, A.; Fasano, A.; Palladino, R.; Rucco, R.; Picillo, M.; Lista, I.; Varriale, P.; Vitale, C.; Cesarelli, M.; Sorrentino, G.; Barone, P.	Step length predicts executive dysfunction in Parkinson's disease: a 3-year prospective study	2018	Not RCT
Antonini, A.; Gentile, G.; Giglio, M.; Marcante, A.; Gage, H.; Touray, M. M. L.; Fotiadis, D. I.; Gatsios, D.; Konitsiotis, S.; Timotijevic, L.; Egan, B.; Hodgkins, C.; Biundo, R.; Pellicano, C.; P. D_Manager consortium	Acceptability to patients, carers and clinicians of an mHealth platform for the management of Parkinson's disease (PD_Manager): study protocol for a pilot randomised controlled trial	2018	No result sections
Apte, S.; Plooij, M.; Vallery, H.	Influence of body weight unloading on human gait characteristics: A systematic review	2018	References reviewed
Arfa-Fatollahkhani, P.; Safar Cherati, A.; Habibi, S. A. H.; Shahidi, G. A.; Sohrabi, A.; Zamani, B.	Effects of treadmill training on the balance, functional capacity and quality of life in Parkinson's disease: A randomized clinical trial	2019	Fewer than 10 patients per group (controls n=9)
Armitage, L. C.; Kassavou, A.; Sutton, S.	Do mobile device apps designed to support medication adherence demonstrate efficacy? A systematic review of randomised controlled trials, with meta-analysis	2020	References eviewed
Ashburn, A.; Roberts, L.; Pickering, R.; Roberts, H. C.; Wiles, R.; Kunkel, D.; Hulbert, S.; Robison, J.; Fitton, C.	A design to investigate the feasibility and effects of partnered ballroom dancing on people with Parkinson disease: randomized controlled trial protocol	2014	Not a complete study; no result
Ayan, C.; Varela, S.; Vila, M. H.; Seijo-Martinez, M.; Cancela, J. M.	Treadmill training combined with water and land-based exercise programs: Effects on Parkinson's disease patients	2016	Not randomized; fewer than 10 patients per group
Baertschi, M.; Dos Santos, J. F. A.; Burkhard, P.; Weber, K.; Canuto, A.; Favez, N.	The burden of normality as a model of psychosocial adjustment after deep brain stimulation for Parkinson's disease: A systematic investigation	2019	References reviewed
Barbe, M. T.; Tonder, L.; Krack, P.; Debu, B.; Schupbach, M.; Paschen, S.; Dembek, T. A.; Kuhn, A. A.; Fraix, V.; Brefel-Courbon, C.; Wojtecki, L.; Maltete, D.; Damier, P.; Sixel-Doring, F.; Weiss, D.; Pinsker, M.; Witjas, T.; Thobois, S.; Schade-Brittinger, C.; Rau, J.; Houeto, J. L.; Hartmann, A.; Timmermann, L.; Schnitzler, A.; Stoker, V.; Vidailhet, M.; Deuschl, G.; Earlystim study group	Deep Brain Stimulation for Freezing of Gait in Parkinson's Disease With Early Motor Complications	2020	Doesn’t address question of interest

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Authors	Article Title	Year	Reason for Exclusion
Barboza, N. M.; Terra, M. B.; Bueno, M. E. B.; Christofoletti, G.; Smaili, S. M.	Physiotherapy Versus Physiotherapy Plus Cognitive Training on Cognition and Quality of Life in Parkinson Disease: Randomized Clinical Trial	2019	No PT intervention
Beall, E. B.; Lowe, M. J.; Alberts, J. L.; Frankemolle, A. M.; Thota, A. K.; Shah, C.; Phillips, M. D.	The effect of forced-exercise therapy for Parkinson's disease on motor cortex functional connectivity	2013	Not RCT
Behrendt, F.; Schuster-Amft, C.	Using an interactive virtual environment to integrate a digital Action Research Arm Test, motor imagery and action observation to assess and improve upper limb motor function in patients with neuromuscular impairments: a usability and feasibility study protocol	2018	Study protocol
Bekkers, E. M. J.; Dijkstra, B. W.; Dockx, K.; Heremans, E.; Verschueren, S. M. P.; Nieuwboer, A.	Clinical balance scales indicate worse postural control in people with Parkinson's disease who exhibit freezing of gait compared to those who do not: A meta-analysis	2017	References reviewed
Bekkers, E. M. J.; Mirelman, A.; Alcock, L.; Rochester, L.; Nieuwhof, F.; Bloem, B. R.; Pelosin, E.; Avanzino, L.; Cereatti, A.; Della Croce, U.; Hausdorff, J. M.; Nieuwboer, A.	Do Patients With Parkinson's Disease With Freezing of Gait Respond Differently Than Those Without to Treadmill Training Augmented by Virtual Reality?	2020	Doesn't address comparison of interest
Benninger, D. H.; Lomarev, M.; Lopez, G.; Wassermann, E. M.; Li, X.; Considine, E.; Hallett, M.	Transcranial direct current stimulation for the treatment of Parkinson's disease	2010	No DBS intervention (DCS = noninvasive)
Bernini, S.; Alloni, A.; Panzarasa, S.; Picascia, M.; Quaglini, S.; Tassorelli, C.; Sinforiani, E.	A computer-based cognitive training in mild cognitive impairment in parkinson's disease	2019	No PT intervention
Bevilacqua, R.; Maranesi, E.; Di Rosa, M.; Luzi, R.; Casoni, E.; Rinaldi, N.; Baldoni, R.; Lattanzio, F.; Di Donna, V.; Pelliccioni, G.; Riccardi, G. R.	Rehabilitation of older people with Parkinson's disease: an innovative protocol for RCT study to evaluate the potential of robotic-based technologies	2020	Study protocol
Bevilacqua, R.; Maranesi, E.; Riccardi, G. R.; Di Donna, V.; Pelliccioni, P.; Luzi, R.; Lattanzio, F.; Pelliccioni, G.	Non-immersive virtual reality for rehabilitation of the older people: A systematic review into efficacy and effectiveness	2019	References reviewed
Bhatt, T.; Yang, F.; Mak, M. K.; Hui-Chan, C. W.; Pai, Y. C.	Effect of externally cued training on dynamic stability control during the sit-to-stand task in people with Parkinson disease	2013	Fewer than 10 patients
Bhimani, R.	Understanding the burden on caregivers of people with Parkinson's: A scoping review of the literature	2014	References reviewed
Blumen, H. M.; Verghese, J.	Motor imagery of walking and walking while talking: a pilot randomized-controlled trial protocol for older adults	2017	No result sections
Bonnechere, B.; Jansen, B.; Omelina, L.; Van Sint Jan, S.	The use of commercial video games in rehabilitation: a systematic review	2016	Systematic review
Bonni, S.; Ponzo, V.; Tramontano, M.; Martino Cinnera, A.; Caltagirone, C.; Koch, G.; Peppe, A.	Neurophysiological and clinical effects of blindfolded balance training (BBT) in Parkinson's disease patients: a preliminary study	2019	Fewer than 10 patients

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Authors	Article Title	Year	Reason for Exclusion
Bonomo, R.; Mostile, G.; Raciti, L.; Contrafatto, D.; Dibilio, V.; Luca, A.; Sciacca, G.; Cicero, C. E.; Vasta, R.; Nicoletti, A.; Zappia, M.	Quantitative estimation of motor fluctuations in Parkinson's disease	2017	Not RCT
BrÃ¤uninger, I.	The efficacy of dance movement therapy group on improvement of quality of life: A randomized controlled trial	2012	Patient population
Brauer, S. G.; Woollacott, M. H.; Lamont, R.; Clewett, S.; O'Sullivan, J.; Silburn, P.; Mellick, G. D.; Morris, M. E.	Single and dual task gait training in people with Parkinson's disease: a protocol for a randomised controlled trial	2011	No result sections
Brienesse, L. A.; Emerson, M. N.	Effects of resistance training for people with Parkinson's disease: a systematic review	2013	Systematic review
Bryant, M. S.; Workman, C. D.; Jamal, F.; Meng, H.; Jackson, G. R.	Feasibility study: Effect of hand resistance exercise on handwriting in Parkinson's disease and essential tremor	2018	Fewer than 10 patients per group; Group 2 does not have PD
Bueno, M. E. B.; do Nascimento Neto, L. I.; Terra, M. B.; Barboza, N. M.; Okano, A. H.; Smaili, S. M.	Effectiveness of acute transcranial direct current stimulation on non-motor and motor symptoms in Parkinson's disease	2019	No DBS intervention (DCS = noninvasive)
Buhmann, C.; Huckhagel, T.; Engel, K.; Gulberti, A.; Hidding, U.; Poetter-Nerger, M.; Goerendt, I.; Ludewig, P.; Braass, H.; Choe, C. U.; Krajewski, K.; Oehlwein, C.; Mittmann, K.; Engel, A. K.; Gerloff, C.; Westphal, M.; Koppen, J. A.; Moll, C. K. E.; Hamel, W.	Adverse events in deep brain stimulation: A retrospective long-term analysis of neurological, psychiatric and other occurrences	2017	Not RCT
Burchiel, K. J.; Anderson, V. C.; Favre, J.; Hammerstad, J. P.	Comparison of pallidal and subthalamic nucleus deep brain stimulation for advanced Parkinson's disease: results of a randomized, blinded pilot study	1999	Fewer than 10 patients
Butterfield, L. C.; Cimino, C. R.; Salazar, R.; Sanchez-Ramos, J.; Bowers, D.; Okun, M. S.	The Parkinson's Active Living (PAL) Program	2017	Not RCT
Caetano, M. J. D.; Lord, S. R.; Allen, N. E.; Song, J.; Paul, S. S.; Canning, C. G.; Menant, J. C. C.	Executive functioning, muscle power and reactive balance are major contributors to gait adaptability in people with Parkinson's disease	2019	Not RCT
Calomeni, M. R.; Furtado da Silva, V.; Velasques, B. B.; Feijo, O. G.; Bittencourt, J. M.; Ribeiro de Souza, E. Silva A. P.	Modulatory Effect of Association of Brain Stimulation by Light and Binaural Beats in Specific Brain Waves	2017	Patient population-comparing groups not relevant
Cancela, J. M.; Mollinedo Cardalda, I.; Ayan, C.; de Oliveira, I. M.	Feasibility and Efficacy of Mat Pilates on People with Mild-to-Moderate Parkinson's Disease: A Preliminary Study	2018	No comparison group
Cancela, J. M.; Mollinedo, I.; Montalvo, S.; Vila Suarez, M. E.	Effects of a High-Intensity Progressive-Cycle Program on Quality of Life and Motor Symptomatology in a Parkinson's Disease Population: A Pilot Randomized Controlled Trial	2020	Fewer than 10 patients per group

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Authors	Article Title	Year	Reason for Exclusion
Canning, C. G.; Allen, N. E.; Dean, C. M.; Goh, L.; Fung, V. S.	Home-based treadmill training for individuals with Parkinson's disease: a randomized controlled pilot trial	2012	Fewer than 10 patients in each group
Capato, T. T.; Tornai, J.; Avila, P.; Barbosa, E. R.; Piemonte, M. E.	Randomized controlled trial protocol: balance training with rhythmical cues to improve and maintain balance control in Parkinson's disease	2015	No result sections
Capato, T.; De Vries, N.; Barbosa, E.; Nonnekes, J.; Bloem, B.	Multimodal balance training with rhythmical cues in Parkinson's disease: a randomized clinical trial	2019	PDF contains abstracts only
Carroll, L. M.; Morris, M. E.; O'Connor, W. T.; Clifford, A. M.	Is Aquatic Therapy Optimally Prescribed for Parkinson's Disease? A Systematic Review and Meta-Analysis	2020	References reviewed
Carroll, L. M.; Volpe, D.; Morris, M. E.; Saunders, J.; Clifford, A. M.	Aquatic Exercise Therapy for People With Parkinson Disease: A Randomized Controlled Trial	2017	Fewer than 10 patients in each group
Carvalho, A.; Barbirato, D.; Araujo, N.; Martins, J. V.; Cavalcanti, J. L.; Santos, T. M.; Coutinho, E. S.; Laks, J.; Deslandes, A. C.	Comparison of strength training, aerobic training, and additional physical therapy as supplementary treatments for Parkinson's disease: pilot study	2015	Fewer than 10 patients in each group
Cascaes da Silva, F.; Iop Rda, R.; Domingos Dos Santos, P.; Aguiar Bezerra de Melo, L. M.; Barbosa Gutierres Filho, P. J.; da Silva, R.	Effects of Physical-Exercise-Based Rehabilitation Programs on the Quality of Life of Patients With Parkinson's Disease: A Systematic Review of Randomized Controlled Trials	2016	References reviewed
Chang, W. H.; Kim, M. S.; Park, E.; Cho, J. W.; Youn, J.; Kim, Y. K.; Kim, Y. H.	Effect of Dual-Mode and Dual-Site Noninvasive Brain Stimulation on Freezing of Gait in Patients With Parkinson Disease	2017	Noninvasive brain stimulation (not DBS)
Charles, D.; Konrad, P. E.; Neimat, J. S.; Molinari, A. L.; Tramontana, M. G.; Finder, S. G.; Gill, C. E.; Bliton, M. J.; Kao, C.; Phibbs, F. T.; Hedera, P.; Salomon, R. M.; Cannard, K. R.; Wang, L.; Song, Y.; Davis, T. L.	Subthalamic nucleus deep brain stimulation in early stage Parkinson's disease	2014	Does not address question of interest
Chawla, H.; Walia, S.; Behari, M.; Noohu, M. M.	Effect of type of secondary task on cued gait on people with idiopathic Parkinson's disease	2014	No comparison group
Chen, Y. Y.; Guan, B. S.; Li, Z. K.; Yang, Q. H.; Xu, T. J.; Li, H. B.; Wu, Q. Y.	Application of telehealth intervention in Parkinson's disease: A systematic review and meta-analysis	2018	Systematic review
Chen, Y.; Gao, Q.; He, C. Q.; Bian, R.	Effect of Virtual Reality on Balance in Individuals With Parkinson Disease: A Systematic Review and Meta-Analysis of Randomized Controlled Trials	2020	References reviewed
Cheung, C.; Bhimani, R.; Wyman, J.; Konczak, J.; Mishra, U.; Terluk, M.; Kartha, R.; Tuite, P.	Effects of yoga on oxidative stress, motor function, and nonmotor symptoms in Parkinson's disease: a pilot randomized controlled trial	2019	PDF contains abstracts only
Cheung, R.; Wong-Yu, I. S. K.; Mak, M. K. Y.	The protocol for a combined upper limb exercise and Do-It- Yourself community program for people with Parkinson's disease	2019	PDF contains abstracts only
Chiviacowsky, S.; Wulf, G.; Lewthwaite, R.; Campos, T.	Motor learning benefits of self-controlled practice in persons with Parkinson's disease	2012	Does not address question of interest

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Authors	Article Title	Year	Reason for Exclusion
Cholewa, J.; Cholewa, J.; Gorzkowska, A.; Malecki, A.; Stanula, A.	Can Rehabilitation Influence the Efficiency of Control Signals in Complex Motion Strategies?	2017	Not RCT
Christiansen, C.; Moore, C.; Schenkman, M.; Kluger, B.; Kohrt, W.; Delitto, A.; Berman, B.; Hall, D.; Josbeno, D.; Poon, C.; Robichaud, J.; Wellington, T.; Jain, S.; Comella, C.; Corcos, D.; Melanson, E.	Factors Associated With Ambulatory Activity in De Novo Parkinson Disease	2017	Comparison of male and female with exercise endurance
Chung, C. L.; Thilarajah, S.; Tan, D.	Effectiveness of resistance training on muscle strength and physical function in people with Parkinson's disease: a systematic review and meta-analysis	2016	References reviewed
Cikajlo, I.; Peterlin Potisk, K.	Advantages of using 3D virtual reality based training in persons with Parkinson's disease: a parallel study	2019	Does not address comparison of interest
Claesson, I. M.; StÃ¥hle, A.; LÃ¶kk, J.; Grooten, W. J. A.	Somatosensory Focused Balance Training without cues can improve balance and gait in early Parkinsonâ??s diseaseâ??a randomised pilot study	2018	Fewer than 10 patients
Clarke, C. E.; Patel, S.; Ives, N.; Rick, C. E.; Dowling, F.; Woolley, R.; Wheatley, K.; Walker, M. F.; Sackley, C. M.	Physiotherapy and occupational Therapy vs No Therapy in mild to moderate Parkinson disease	2016	Duplicate of AAOS ID 912
Clarke, C. E.; Patel, S.; Ives, N.; Rick, C. E.; Woolley, R.; Wheatley, K.; Walker, M. F.; Zhu, S.; Kandiyali, R.; Yao, G.; Sackley, C. M.	Clinical effectiveness and cost-effectiveness of physiotherapy and occupational therapy versus no therapy in mild to moderate Parkinson's disease: a large pragmatic randomised controlled trial (PD REHAB)	2016	Same study as AAOS ID 912; keep for cost analysis
Colgrove, Yvonne Searls; Sharma, Neena; Kluding, Patricia; Potter, Debra; Imming, Kayce	Effect of yoga on motor function in people with Parkinsonâ??s disease: a randomized, controlled pilot study	2012	Fewer than 10 patients per group
Collett, J.; Franssen, M.; Winward, C.; Izadi, H.; Meaney, A.; Mahmoud, W.; Bogdanovic, M.; Tims, M.; Wade, D.; Dawes, H.	A long-term self-managed handwriting intervention for people with Parkinson's disease: results from the control group of a phase II randomized controlled trial	2017	No PT outcomes
Combs, S. A.; Diehl, M. D.; Filip, J.; Long, E.	Short-distance walking speed tests in people with Parkinson disease: reliability, responsiveness, and validity	2014	Not RCT
Comella, C. L.; Stebbins, G. T.; Brown-Toms, N.; Goetz, C. G.	Physical therapy and Parkinson's disease: a controlled clinical trial	1994	Not relevant to criteria
Conradsson, D.; Lofgren, N.; Stahle, A.; Hagstromer, M.; Franzen, E.	A novel conceptual framework for balance training in Parkinson's disease-study protocol for a randomised controlled trial	2012	No result sections
Contarino, M. F.; Marinus, J.; van Hilten, J. J.	Does deep brain stimulation of the subthalamic nucleus prolong survival in Parkinson's Disease?	2018	Commentary review
Cosentino, C.; Baccini, M.; Putzolu, M.; Ristori, D.; Avanzino, L.; Pelosin, E.	Effectiveness of Physiotherapy on Freezing of Gait in Parkinson's Disease: A Systematic Review and Meta-Analyses	2020	References reviewed
Crizzle, A. M.; Newhouse, I. J.	Is physical exercise beneficial for persons with Parkinson's disease?	2006	Systematic review

Authors	Article Title	Year	Reason for Exclusion
Cruickshank, T. M.; Reyes, A. R.; Ziman, M. R.	A systematic review and meta-analysis of strength training in individuals with multiple sclerosis or Parkinson disease	2015	Systematic review
Cubo, E.; Leurgans, S.; Goetz, C. G.	Short-term and practice effects of metronome pacing in Parkinson's disease patients with gait freezing while in the 'on' state: randomized single blind evaluation	2004	No separate comparison group
Cugusi, L.; Manca, A.; Bergamin, M.; Di Blasio, A.; Monticone, M.; Deriu, F.; Mercuro, G.	Aquatic exercise improves motor impairments in people with Parkinson's disease, with similar or greater benefits than land-based exercise: a systematic review	2019	References reviewed
Cugusi, L.; Manca, A.; Dragone, D.; Deriu, F.; Solla, P.; Secci, C.; Monticone, M.; Mercuro, G.	Nordic Walking for the Management of People With Parkinson Disease: A Systematic Review	2017	References reviewed
Cunnington, R.; Iansek, R.; Bradshaw, J. L.; Phillips, J. G.	Movement-related potentials in Parkinson's disease. Presence and predictability of temporal and spatial cues	1995	Patient population- not all PD
Cwiekala-Lewis, K. J.; Gallek, M.; Taylor-Piliae, R. E.	The effects of Tai Chi on physical function and well-being among persons with Parkinson's Disease: A systematic review	2017	References reviewed
da Silva, F. C.; Iop, R. D. R.; de Oliveira, L. C.; Boll, A. M.; de Alvarenga, J. G. S.; Gutierres Filho, P. J. B.; de Melo, Lmab; Xavier, A. J.; da Silva, R.	Effects of physical exercise programs on cognitive function in Parkinson's disease patients: A systematic review of randomized controlled trials of the last 10 years	2018	References reviewed
DÃez-Cirarda, M.; Ojeda, N.; PeÃ±a, J.; Cabrera-Zubizarreta, A.; Lucas-JimÃ©nez, O.; GÃ³mez-Esteban, J. C.; GÃ³mez-Beldarrain, M. Ã첵; Ibarretxe-Bilbao, N.	Increased brain connectivity and activation after cognitive rehabilitation in Parkinsonâ??s disease: a randomized controlled trial	2017	Not a PT intervention
de Dreu, M. J.; van der Wilk, A. S.; Poppe, E.; Kwakkel, G.; van Wegen, E. E.	Rehabilitation, exercise therapy and music in patients with Parkinson's disease: a meta-analysis of the effects of music-based movement therapy on walking ability, balance and quality of life	2012	References reviewed
De Freitas Tb Ms, P. T.; Leite, Phw Bs; Dona F PhD, P. T.; Pompeu Je PhD, P. T.; Swarowsky A PhD, P. T.; Torriani-Pasin C PhD, P. T.	The effects of dual task gait and balance training in Parkinson's disease: a systematic review	2018	Systematic review
De Luca, R.; Latella, D.; Maggio, M. G.; Di Lorenzo, G.; Maresca, G.; Sciarrone, F.; Militi, D.; Bramanti, P.; Calabro, R. S.	Computer assisted cognitive rehabilitation improves visuospatial and executive functions in Parkinson's disease: Preliminary results	2019	No PT intervention
de Oliveira Braga, H.; Gregorio, E. C.; Myra, R. S.; de Souza, A. S. K.; Kunh, T. V.; Klug, J.; de Azevedo Guimaraes, A. C.; Swarowsky, A.	EMPOWER-PD - A physical therapy intervention to empower the individuals with Parkinson's disease: a study protocol for a feasibility randomized controlled trial	2019	No result sections
de Oliveira Lira, J. L.; Ugrinowitsch, C.; Fecchio, R.; Coelho, D. B.; Moreira-Neto, A.; Germano, R.; de Lima Miliatto, A. C.; Dos Santos Vieira Yano, B. C.; Silva-Batista, C.	Minimal detectable change for balance using the Biodex Balance System in patients with Parkinson's disease	2019	Not RCT

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Authors	Article Title	Year	Reason for Exclusion
De Santis, K. K.; Kaplan, I.	The motor and the non-motor outcomes of Nordic Walking in Parkinson's disease: A systematic review	2020	References reviewed
Deane, K. H.; Jones, D.; Playford, E. D.; Ben-Shlomo, Y.; Clarke, C. E.	Physiotherapy for patients with Parkinson's Disease: a comparison of techniques	2001	Systematic review
Del Din, S.; Elshehabi, M.; Galna, B.; Hobert, M.; Warmerdam, E.; Suenkel, U.; Brockmann, K.; Metzger, F.; Hansen, C.; Berg, D.; Rochester, L.; Maetzler, W.	Gait analysis with wearables predicts conversion to Parkinson's disease	2019	Not RCT
Del Din, S.; Galna, B.; Lord, S.; Nieuwboer, A.; Bekkers, E. M. J.; Pelosin, E.; Avanzino, L.; Bloem, B. R.; Olde Rikkert, M. G. M.; Nieuwhof, F.; Cereatti, A.; Della Croce, U.; Mirelman, A.; Hausdorff, J. M.; Rochester, L.	Falls Risk in Relation to Activity Exposure in High-Risk Older Adults	2020	Doesn't address comparison of interest
Del Olmo, M. F.; Sanchez-Molina, J. A.; Fernandez-Lago, H.; Morenilla-Burlo, L.; Gomez-Varela, J.	Effects of computerized cognitive training, with and without concurrent exercise, on executive functions in Parkinson's disease	2019	PDF contains abstracts only
Deuschl, G.; Schade-Brittinger, C.; Krack, P.; Volkmann, J.; SchÃ¤fer, H.; BÃ¶tzel, K.; Daniels, C.; DeutschlÃ¤nder, A.; Dillmann, U.; Eisner, W.; et al.,	A randomized trial of deep-brain stimulation for Parkinson's disease	2006	Doesn't address question of interest
Devos, H.; Ranchet, M.; Emmanuel Akinwuntan, A.; Uc, E. Y.	Establishing an evidence-base framework for driving rehabilitation in Parkinson's disease: A systematic review of on-road driving studies	2015	References reviewed
Di Giulio, I.; St George, R. J.; Kalliolia, E.; Peters, A. L.; Limousin, P.; Day, B. L.	Maintaining balance against force perturbations: impaired mechanisms unresponsive to levodopa in Parkinson's disease	2016	Not RCT
Dibble, L. E.; Addison, O.; Papa, E.	The effects of exercise on balance in persons with Parkinson's disease: a systematic review across the disability spectrum	2009	References reviewed
Dibilio, V.; Nicoletti, A.; Mostile, G.; Portaro, G.; Luca, A.; Patti, F.; Zappia, M.	Computer-assisted cognitive rehabilitation on freezing of gait in Parkinson's disease: A pilot study	2017	Fewer than 10 patients
Dibilio, V.; Nicoletti, A.; Mostile, G.; Toscano, S.; Luca, A.; Raciti, L.; Sciacca, G.; Vasta, R.; Cicero, C. E.; Contrafatto, D.; Zappia, M.	Dopaminergic and non-dopaminergic gait components assessed by instrumented timed up and go test in Parkinson's disease	2017	Not RCT
Djuric-Jovicic, M.; Belic, M.; Stankovic, I.; Radovanovic, S.; Kostic, V. S.	Selection of gait parameters for differential diagnostics of patients with de novo Parkinson's disease	2017	Patient population
Dobkin, B. H.; Duncan, P. W.	Should body weight-supported treadmill training and robotic-assistive steppers for locomotor training trot back to the starting gate?	2012	Commentary review- mixed population
Dobkin, R. D.; Mann, S. L.; Gara, M. A.; Interian, A.; Rodriguez, K. M.; Menza, M.	Telephone-based cognitive behavioral therapy for depression in Parkinson disease: A randomized controlled trial	2020	Cognitive behavioral therapy- not PT administered

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Authors	Article Title	Year	Reason for Exclusion
Dockx, K.; Bekkers, E. M.; Van den Bergh, V.; Ginis, P.; Rochester, L.; Hausdorff, J. M.; Mirelman, A.; Nieuwboer, A.	Virtual reality for rehabilitation in Parkinson's disease	2016	References reviewed
Doruk, D.; Gray, Z.; Bravo, G. L.; Pascual-Leone, A.; Fregni, F.	Effects of tDCS on executive function in Parkinson's disease	2014	No DBS intervention (DCS = noninvasive)
Dos Santos Delabary, M.; Komeroski, I. G.; Monteiro, E. P.; Costa, R. R.; Haas, A. N.	Effects of dance practice on functional mobility, motor symptoms and quality of life in people with Parkinson's disease: a systematic review with meta-analysis	2018	References reviewed
Duncan, R. P.; Van Dillen, L. R.; Garbutt, J. M.; Earhart, G. M.; Perlmutter, J. S.	Physical therapy and deep brain stimulation in Parkinson's Disease: protocol for a pilot randomized controlled trial	2018	No result sections
Earhart, G. M.; Duncan, R. P.; Huang, J. L.; Perlmutter, J. S.; Pickett, K. A.	Comparing interventions and exploring neural mechanisms of exercise in Parkinson disease: a study protocol for a randomized controlled trial	2015	No result sections
Ebersbach, G.; Grust, U.; Ebersbach, A.; Wegner, B.; Gandor, F.; Kuhn, A. A.	Erratum to: Amplitude-oriented exercise in Parkinson's disease: a randomized study comparing LSVT-BIG and a short training protocol	2015	Not a full study
Elbers, R. G.; van Wegen, E. E.; Verhoef, J.; Kwakkel, G.	Is gait speed a valid measure to predict community ambulation in patients with Parkinson's disease?	2013	Not relevant to criteria
Elbers, R.; van Wegen, E. E. H.; Rochester, L.; Hetherington, V.; Nieuwboer, A.; Willems, A. M.; Jones, D.; Kwakkel, G.	Is impact of fatigue an independent factor associated with physical activity in patients with idiopathic Parkinson's disease?	2009	Doesn’t address question of interest
Erb, M. K.; Karlin, D. R.; Ho, B. K.; Thomas, K. C.; Parisi, F.; Vergara-Diaz, G. P.; Daneault, J. F.; Wacnik, P. W.; Zhang, H.; Kangarloo, T.; Demanuele, C.; Brooks, C. R.; Detheridge, C. N.; Shaafi Kabiri, N.; Bhangu, J. S.; Bonato, P.	mHealth and wearable technology should replace motor diaries to track motor fluctuations in Parkinsonâ??s disease	2020	Not RCT
Farag, I.; Sherrington, C.; Hayes, A.; Canning, C. G.; Lord, S. R.; Close, J. C.; Fung, V. S.; Howard, K.	Economic evaluation of a falls prevention exercise program among people With Parkinson's disease	2016	Cost analysis
Fellman, D.; Salmi, J.; Ritakallio, L.; Ellfolk, U.; Rinne, J. O.; Laine, M.	Training working memory updating in Parkinson's disease: A randomised controlled trial	2018	No PT intervention
Fernandez-Gonzalez, P.; Carratala-Tejada, M.; Monge-Pereira, E.; Collado-Vazquez, S.; Sanchez-Herrera Baeza, P.; Cuesta-Gomez, A.; Ona-Simbana, E. D.; Jardon-Huete, A.; Molina-Rueda, F.; Balaguer-Bernaldo de Quiros, C.; Miangolarra-Page, J. C.; Cano-de la Cuerda, R.	Leap motion controlled video game-based therapy for upper limb rehabilitation in patients with Parkinson's disease: a feasibility study	2019	Doesn’t address comparison of interest
Fidan, O.; Seyyar, G. K.; Aras, B.; Colak, E.; Aras, O.	The effect of Tai Chi and Qigong on health-related quality of life in Parkinson's disease: a systematic review and meta-analysis of systematic reviews	2019	References reviewed

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Authors	Article Title	Year	Reason for Exclusion
Fietzek, U. M.; Schroeteler, F. E.; Ziegler, K.; Zwosta, J.; Ceballos-Baumann, A. O.	Randomized cross-over trial to investigate the efficacy of a 2-week physiotherapy programme with repetitive exercises of cueing to reduce the severity of freezing of gait in patients with Parkinson's disease	2014	Fewer than 10 patients
Fil-Balkan, A.; Salci, Y.; Keklicek, H.; Armutlu, K.; Aksoy, S.; Kayihan, H.; Elibol, B.	Sensorimotor integration training in Parkinson`s disease	2018	Fewer than 10 patients in each group
Flach, A.; Jaegers, L.; Krieger, M.; Bixler, E.; Kelly, P.; Weiss, E. P.; Ahmad, S. O.	Endurance exercise improves function in individuals with Parkinson's disease: A meta-analysis	2017	References reviewed
Fletcher, E.; Goodwin, V. A.; Richards, S. H.; Campbell, J. L.; Taylor, R. S.	An exercise intervention to prevent falls in Parkinson's: an economic evaluation	2012	Not relevant to criteria
Flynn, A.; Allen, N. E.; Dennis, S.; Canning, C. G.; Preston, E.	Home-based prescribed exercise improves balance-related activities in people with Parkinson's disease and has benefits similar to centre-based exercise: a systematic review	2019	References reviewed
Fok, P.; Farrell, M.; McMeeken, J.; Kuo, Y. L.	The effects of verbal instructions on gait in people with Parkinson's disease: a systematic review of randomized and non-randomized trials	2011	Systematic review
Follett, K. A.; Torres-Russotto, D.	Deep brain stimulation of globus pallidus interna, subthalamic nucleus, and pedunculopontine nucleus for Parkinson's disease: which target?	2012	Commentary review
Follett, K. A.; Weaver, F. M.; Stern, M.; Hur, K.; Harris, C. L.; Luo, P.; Marks, W. J., Jr.; Rothlind, J.; Sagher, O.; Moy, C.; Pahwa, R.; Burchiel, K.; Hogarth, P.; Lai, E. C.; Duda, J. E.; Holloway, K.; Samii, A.; Horn, S.; Bronstein, J. M.; Stoner, G.; Starr, P. A.; Simpson, R.; Baltuch, G.; De Salles, A.; Huang, G. D.; Reda, D. J.; C. S. P. Study Group	Pallidal versus subthalamic deep-brain stimulation for Parkinson's disease	2010	Doesn't address question of interest
Foster, E. R.; McDaniel, M. A.; Rendell, P. G.	Improving Prospective Memory in Persons With Parkinson Disease: A Randomized Controlled Trial	2017	No PT intervention
Franzen, E.; Johansson, H.; Freidle, M.; Ekman, U.; Wallen, M. B.; Schalling, E.; Lebedev, A.; Lovden, M.; Holmin, S.; Svenningsson, P.; Hagstromer, M.	The EXPANd trial: effects of exercise and exploring neuroplastic changes in people with Parkinson's disease: a study protocol for a double-blinded randomized controlled trial	2019	Study protocol
Freitag, F.; Brucki, S. M. D.; Barbosa, A. F.; Chen, J.; Souza, C. O.; Valente, D. F.; Chien, H. F.; Bedeschi, C.; Voos, M. C.	Is virtual reality beneficial for dual-task gait training in patients with Parkinson's disease? A systematic review	2019	References reviewed
Gage, H.; Storey, L.	Rehabilitation for Parkinson's disease: a systematic review of available evidence	2004	References reviewed

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Authors	Article Title	Year	Reason for Exclusion
Gage, H.; Ting, S.; Williams, P.; Bryan, K.; Kaye, J.; Castleton, B.; Trend, P.; Wade, D.	A comparison of specialist rehabilitation and care assistant support with specialist rehabilitation alone and usual care for people with Parkinson's living in the community: study protocol for a randomised controlled trial	2011	No result sections
Galanaud, J. P.; Elbaz, A.; Clavel, J.; Vidal, J. S.; Correze, J. R.; Alperovitch, A.; Tzourio, C.	Cigarette smoking and Parkinson's disease: a case-control study in a population characterized by a high prevalence of pesticide exposure	2005	Not RCT
Gallagher, R.; Damodaran, H.; Werner, W. G.; Powell, W.; Deutsch, J. E.	Auditory and visual cueing modulate cycling speed of older adults and persons with Parkinson's disease in a Virtual Cycling (V-Cycle) system	2016	Not all patient with PD. Healthy matched group
Galli, M.; Vicidomini, C.; Rozin Kleiner, A. F.; Vacca, L.; Cimolin, V.; Condoluci, C.; Stocchi, F.; De Pandis, M. F.	Peripheral neurostimulation breaks the shuffling steps patterns in Parkinsonian gait: a double blind randomized longitudinal study with automated mechanical peripheral stimulation	2018	Medical device
Galvez, G.; Recuero, M.; Canuet, L.; Del-Pozo, F.	Short-Term Effects of Binaural Beats on EEG Power, Functional Connectivity, Cognition, Gait and Anxiety in Parkinson's Disease	2018	No comparison group
Garcia-Agundez, A.; Folkerts, A. K.; Konrad, R.; Caserman, P.; Tregel, T.; Goosses, M.; Gobel, S.; Kalbe, E.	Recent advances in rehabilitation for Parkinson's Disease with Exergames: A Systematic Review	2019	References reviewed
Garcia-Casares, N.; Martin-Colom, J. E.; Garcia-Arnes, J. A.	Music Therapy in Parkinson's Disease	2018	References reviewed
Ghaffari, B. D.; Kluger, B.	Mechanisms for alternative treatments in Parkinson's disease: acupuncture, tai chi, and other treatments	2014	Commentary review
Ghai, S.; Ghai, I.; Schmitz, G.; Effenberg, A. O.	Effect of rhythmic auditory cueing on parkinsonian gait: A systematic review and meta-analysis	2018	References reviewed
Ghielen, I.; van den Heuvel, O. A.; de Goede, C. J.; Houniet-de Gier, M.; Collette, E. H.; Burgers-Bots, I. A.; Rutten, S.; Kwakkel, G.; Vermunt, K.; van Vliet, B.; Berendse, H. W.; van Wegen, E. E.	BEWARE: Body awareness training in the treatment of wearing-off related anxiety in patients with Parkinson's disease: study protocol for a randomized controlled trial	2015	No result sections
Ghielen, I.; van Wegen, E. E. H.; Rutten, S.; de Goede, C. J. T.; Houniet-de Gier, M.; Collette, E. H.; Burgers-Bots, I. A. L.; Twisk, J. W. R.; Kwakkel, G.; Vermunt, K.; van Vliet, B.; Berendse, H. W.; van den Heuvel, O. A.	Body awareness training in the treatment of wearing-off related anxiety in patients with Parkinson's disease: Results from a pilot randomized controlled trial	2017	Doesn't address question of interest
Giehl, K.; Ophey, A.; Reker, P.; Rehberg, S.; Hammes, J.; Barbe, M. T.; Zokaei, N.; Eggers, C.; Husain, M.; Kalbe, E.; et al.,	Effects of Home-Based Working Memory Training on Visuo-Spatial Working Memory in ParkinsonÃ¢â?¬â?¢s Disease: a Randomized Controlled Trial	2020	No PT intervention
Giehl, K.; Ophey, A.; Reker, P.; Rehberg, S.; Hammes, J.; Barbe, M. T.; Zokaei, N.; Eggers, C.; Husain, M.; Kalbe, E.; van Eimeren, T.	Effects of Home-Based Working Memory Training on Visuo-Spatial Working Memory in Parkinson's Disease: A Randomized Controlled Trial	2020	Repeat of article ID 12673

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Authors	Article Title	Year	Reason for Exclusion
Ginis, P.; Heremans, E.; Ferrari, A.; Dockx, K.; Canning, C. G.; Nieuwboer, A.	Prolonged Walking with a Wearable System Providing Intelligent Auditory Input in People with Parkinson's Disease	2017	Not RCT, not all PD patients
Godinho, C.; Domingos, J.; Cunha, G.; Santos, A. T.; Fernandes, R. M.; Abreu, D.; Goncalves, N.; Matthews, H.; Isaacs, T.; Duffen, J.; Al-Jawad, A.; Larsen, F.; Serrano, A.; Weber, P.; Thoms, A.; Sollinger, S.; Graessner, H.; Maetzler, W.; Ferreira, J. J.	A systematic review of the characteristics and validity of monitoring technologies to assess Parkinson's disease	2016	References reviewed
Goetz, L.; Bhattacharjee, M.; Ferraye, M. U.; Fraix, V.; Maineri, C.; Nosko, D.; Fenoy, A. J.; Piallat, B.; Torres, N.; Krainik, A.; Seigneuret, E.; David, O.; Parent, M.; Parent, A.; Pollak, P.; Benabid, A. L.; Debu, B.; Chabardes, S.	Deep Brain Stimulation of the Pedunculopontine Nucleus Area in Parkinson Disease: MRI-Based Anatomoclinical Correlations and Optimal Target	2019	Fewer than 10 patients per group
Gomez-Gonzalez, J.; Martin-Casas, P.; Cano-de-la-Cuerda, R.	Effects of auditory cues on gait initiation and turning in patients with Parkinson's disease	2019	References reviewed
Goodwin, V. A.; Richards, S. H.; Taylor, R. S.; Taylor, A. H.; Campbell, J. L.	The effectiveness of exercise interventions for people with Parkinson's disease: a systematic review and meta-analysis	2008	Systematic review
Gordt, K.; Gerhardy, T.; Najafi, B.; Schwenk, M.	Effects of Wearable Sensor-Based Balance and Gait Training on Balance, Gait, and Functional Performance in Healthy and Patient Populations: A Systematic Review and Meta-Analysis of Randomized Controlled Trials	2018	Systematic review
Green, E.; Huynh, A.; Broussard, L.; Zunker, B.; Matthews, J.; Hilton, C. L.; Aranha, K.	Systematic Review of Yoga and Balance: Effect on Adults With Neuromuscular Impairment	2019	References reviewed
Guo, Y.; Xu, W.; Liu, F. T.; Li, J. Q.; Cao, X. P.; Tan, L.; Wang, J.; Yu, J. T.	Modifiable risk factors for cognitive impairment in Parkinson's disease: A systematic review and meta-analysis of prospective cohort studies	2019	Systematic review
Hackney, M. E.; Kantorovich, S.; Levin, R.; Earhart, G. M.	Effects of tango on functional mobility in Parkinson's disease: a preliminary study	2007	Fewer than 10 patients per group
Hadian, M.; Abasi, A. A.; Raji, P.; Hoseinabadi, R.; Abbasi, S.	A randomized clinical trial on the evaluation of the effect of vestibular exercises on dizziness and postural control in Parkinson patients	2019	PDF contains abstracts only
Hallisy, K. M.	Tai Chi Beyond Balance and Fall Prevention: Health Benefits and Its Potential Role in Combatting Social Isolation in the Aging Population	2018	References reviewed
Handelzalts, S.; Kenner-Furman, M.; Gray, G.; Soroker, N.; Shani, G.; Melzer, I.	Effects of Perturbation-Based Balance Training in Subacute Persons With Stroke: A Randomized Controlled Trial	2019	Not PD patients
Harro, C. C.; Shoemaker, M. J.; Frey, O.; Gamble, A. C.; Harring, K. B.; Karl, K. L.; McDonald, J. D.; Murray, C. J.; VanDyke, J. M.; Tomassi, E. M.; VanHaitsma, R. J.	The effects of speed-dependent treadmill training and rhythmic auditory-cued overground walking on balance function, fall incidence, and quality of life in individuals with idiopathic Parkinson's disease: a randomized controlled trial	2014	Repeat article

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Authors	Article Title	Year	Reason for Exclusion
Harvey, M.; Weston, K. L.; Gray, W. K.; O'Callaghan, A.; Oates, L. L.; Davidson, R.; Walker, R. W.	High-intensity interval training in people with Parkinson's disease: a randomized, controlled feasibility trial	2019	Fewer than 10 patients in each group
Hashimoto, H.; Nakanishi, H.; Nakamura, M.	The effect of the dance DVD created for the rehabilitation of Parkinson's disease patients	2019	PDF contains abstracts only
Hass, C. J.; Buckley, T. A.; Pitsikoulis, C.; Barthelemy, E. J.	Progressive resistance training improves gait initiation in individuals with Parkinson's disease	2012	Fewer than 10 patients per group
Hass, C. J.; Collins, M. A.; Juncos, J. L.	Resistance training with creatine monohydrate improves upper-body strength in patients with Parkinson disease: a randomized trial	2007	Same res. training protocol in both groups
Hawkins, B. L.; Van Puymbroeck, M.; Walter, A.; Sharp, J.; Woshkolup, K.; Urrea-Mendoza, E.; Revilla, F.; Schmid, A. A.	Perceived Activities and Participation Outcomes of a Yoga Intervention for Individuals with Parkinson's Disease: A Mixed Methods Study	2018	Outcomes not relevant to criteria
Henderson, E. J.; Lord, S. R.; Brodie, M. A.; Gaunt, D. M.; Lawrence, A. D.; Close, J. C.; Whone, A. L.; Ben-Shlomo, Y.	Rivastigmine for gait stability in patients with Parkinson's disease (ReSPonD): a randomised, double-blind, placebo-controlled, phase 2 trial	2016	Not relevant to criteria
Hendy, A. M.; Tillman, A.; Rantalainen, T.; Muthalib, M.; Johnson, L.; Kidgell, D. J.; Wundersitz, D.; Enticott, P. G.; Teo, W. P.	Concurrent transcranial direct current stimulation and progressive resistance training in Parkinson's disease: study protocol for a randomised controlled trial	2016	No result sections
Heremans, E.; Broeder, S.; Nieuwboer, A.; Bekkers, E. M.; Ginis, P.; Janssens, L.; Nackaerts, E.	When motor control gets out of hand: Speeding up triggers freezing in the upper limb in Parkinson's disease	2019	Patient population-not RCT
Hewitt, J.; Goodall, S.; Clemson, L.; Henwood, T.; Refshauge, K.	Progressive Resistance and Balance Training for Falls Prevention in Long-Term Residential Aged Care: A Cluster Randomized Trial of the Sunbeam Program	2018	Study population not specific to PD (n=3 for PD patients)
Hidalgo-Agudo, R. D.; Lucena-Anton, D.; Luque-Moreno, C.; Heredia-Rizo, A. M.; Moral-Munoz, J. A.	Additional Physical Interventions to Conventional Physical Therapy in Parkinson's Disease: A Systematic Review and Meta-Analysis of Randomized Clinical Trials	2020	References reviewed
Hill, K. D.; Hunter, S. W.; Batchelor, F. A.; Cavalheri, V.; Burton, E.	Individualized home-based exercise programs for older people to reduce falls and improve physical performance: A systematic review and meta-analysis	2015	Systematic review
Hirsch, M. A.; Toole, T.; Maitland, C. G.; Rider, R. A.	The effects of balance training and high-intensity resistance training on persons with idiopathic Parkinson's disease	2003	Fewer than 10 patients
Hobson, P.; Holden, A.; Meara, J.	Measuring the impact of Parkinson's disease with the Parkinson's Disease Quality of Life questionnaire	1999	Not RCT; not relevant to PICO
Horiba, M.; Ueki, Y.; Nojima, I.; Shimizu, Y.; Sahashi, K.; Itamoto, S.; Suzuki, A.; Yamada, G.; Matsukawa, N.; Wada, I.	Impaired Motor Skill Acquisition Using Mirror Visual Feedback Improved by Transcranial Direct Current Stimulation (tDCS) in Patients With Parkinson's Disease	2019	Not RCT
Hubble, R. P.; Naughton, G. A.; Silburn, P. A.; Cole, M. H.	Trunk muscle exercises as a means of improving postural stability in people with Parkinson's disease: a protocol for a randomised controlled trial	2014	No result sections

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Authors	Article Title	Year	Reason for Exclusion
Hubble, R. P.; Naughton, G.; Silburn, P. A.; Cole, M. H.	Trunk Exercises Improve Gait Symmetry in Parkinson Disease: A Blind Phase II Randomized Controlled Trial	2018	Fewer than 10 patients in each group
Hubble, R. P.; Silburn, P. A.; Naughton, G. A.; Cole, M. H.	Trunk Exercises Improve Balance in Parkinson Disease: A Phase II Randomized Controlled Trial	2019	Insufficient data
Hulbert, S. M.; Goodwin, V. A.	â??Mind the gapâ?? â?? a scoping review of long term, physical, self-management in Parkinson's	2020	References reviewed
Hulbert, S.; Seymour, K. C.; Ashburn, A.	'PDSAFE'-a multi-dimensional model of falls rehabilitation for people with Parkinson's. A mixed methods analysis of therapists' delivery and experience	2019	PDF contains abstracts only
Islam, A.; Nazarpour, K.; Rochester, L.; Pantall, A.	Effect of transcranial direct current stimulation on cortical activity and muscle activity during gait in Parkinson's disease	2019	PDF contains abstracts only
Jenkinson, C.; Peto, V.; Fitzpatrick, R.; Greenhall, R.; Hyman, N.	Self-reported functioning and well-being in patients with Parkinson's disease: Comparison of the short-form wealth survey (SF-36) and the Parkinson's disease questionnaire (PDQ-39)	1995	Not relevant to criteria
Jia, F.; Zhang, J.; Wang, H.; Liang, Z.; Liu, W.; Wang, X.; Liu, Y.; Guo, Y.; Ling, Z.; Cai, X.; Wu, X.; Wu, J.; Lv, W.; Xu, X.; Zhang, W.; Li, L.	Variable- versus constant-frequency deep-brain stimulation in patients with advanced Parkinson's disease: study protocol for a randomized controlled trial	2019	Study protocol
Jiang, D.; Kong, W.; Jiang, J. J.	Patient Engagement in Randomized Controlled Tai Chi Clinical Trials among the Chronically Ill	2017	Systematic review
Jin, X.; Wang, L.; Liu, S.; Zhu, L.; Loprinzi, P. D.; Fan, X.	The Impact of Mind-body Exercises on Motor Function, Depressive Symptoms, and Quality of Life in Parkinson's Disease: A Systematic Review and Meta-analysis	2019	References reviewed
Jitkritsadakul, O.; Thanawattano, C.; Anan, C.; Bhidayasiri, R.	Tremor's glove-an innovative electrical muscle stimulation therapy for intractable tremor in Parkinson's disease: A randomized sham-controlled trial	2017	Doesn’t address comparison of interest
Johnson, Liam; Putrino, David; James, Ian; Rodrigues, Julian; Stell, Rick; Thickbroom, Gary; Mastaglia, Frank L	The effects of a supervised Pilates training program on balance in Parkinsonâ??s disease	2013	Case series, no comparison group
Joseph, C.; Leavy, B.; Mattsson, S.; Falk, L.; Franzen, E.	Implementation of the HiBalance training program for Parkinson's disease in clinical settings: A feasibility study	2018	Fewer than 10 patients
Juras, G.; Brachman, A.; Michalska, J.; Kamieniarz, A.; Pawlowski, M.; Hadamus, A.; Bialoszewski, D.; Blaszczyk, J.; Slomka, K. J.	Standards of Virtual Reality Application in Balance Training Programs in Clinical Practice: A Systematic Review	2019	Systematic review
Kalyani, H. H. N.; Sullivan, K.; Moyle, G.; Brauer, S.; Jeffrey, E. R.; Roeder, L.; Berndt, S.; Kerr, G.	Effects of Dance on Gait, Cognition, and Dual-Tasking in Parkinson's Disease: A Systematic Review and Meta-Analysis	2019	References reviewed
Kanegusuku, H.; Silva-Batista, C.; Pecanha, T.; Nieuwboer, A.; Silva, N. D., Jr.; Costa, L. A.; de Mello, M. T.; Piemonte, M. E.; Ugrinowitsch, C.; Forjaz, C. L.	Effects of Progressive Resistance Training on Cardiovascular Autonomic Regulation in Patients With Parkinson Disease: A Randomized Controlled Trial	2017	Not relevant outcomes

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Kang, M. G.; Yun, S. J.; Shin, H. I.; Kim, E.; Lee, H. H.; Oh, B. M.; Seo, H. G.	Effects of robot-assisted gait training in patients with Parkinson's disease: study protocol for a randomized controlled trial	2019	No result sections
Kang, M. G.; Yun, S. J.; Shin, H. I.; Kim, E.; Lee, H. H.; Oh, B. M.; Seo, H. G.	Correction to: Effects of robot-assisted gait training in patients with Parkinson's disease: study protocol for a randomized controlled trial	2020	Amendment- study protocol
Karachi, C.; Cormier-Dequaire, F.; Grabli, D.; Lau, B.; Belaid, H.; Navarro, S.; Vidailhet, M.; Bardinet, E.; Fernandez-Vidal, S.; Welter, M. L.	Clinical and anatomical predictors for freezing of gait and falls after subthalamic deep brain stimulation in Parkinson's disease patients	2019	Not RCT
Karl, J. A.; Ouyang, B.; Goetz, S.; Metman, L. V.	A Novel DBS Paradigm for Axial Features in Parkinson's Disease: A Randomized Crossover Study	2020	Doesn't address question of interest
Karpatkin, H.; Babyar, S.; Gayeski, E.; Meredith, L.; Polster, E.; Sheer, P.; Schroeder, D.	The effect of fatigue on balance performance in Parkinson's disease	2020	Fewer than 10 patients per group
Kaski, D.; Dominguez, R. O.; Allum, J. H.; Islam, A. F.; Bronstein, A. M.	Combining physical training with transcranial direct current stimulation to improve gait in Parkinson's disease: a pilot randomized controlled study	2014	16 subjects randomized
Katz, M.; Luciano, M. S.; Carlson, K.; Luo, P.; Marks, W. J., Jr.; Larson, P. S.; Starr, P. A.; Follett, K. A.; Weaver, F. M.; Stern, M. B.; Reda, D. J.; Ostrem, J. L.; C. S. P. study group	Differential effects of deep brain stimulation target on motor subtypes in Parkinson's disease	2015	Doesn't address question of interest
Kaur, R.; Sun, R.; Ziegelman, L.; Sowers, R.; Hernandez, M. E.	Using Virtual Reality to Examine the Neural and Physiological Responses to Height and Perturbations in Quiet Standing	2019	Study population does not have PD
Kearney, E.; Shellikeri, S.; Martino, R.; Yunusova, Y.	Augmented visual feedback-aided interventions for motor rehabilitation in Parkinson's disease: a systematic review	2019	References reviewed
Kedzior, K. K.; Kaplan, I.	Tai Chi and Parkinson's disease (PD): A systematic overview of the scientific quality of the past systematic reviews	2019	References reviewed
Keus, S. H.; Bloem, B. R.; Hendriks, E. J.; Bredero-Cohen, A. B.; Munneke, M.; Practice Recommendations Development, Group	Evidence-based analysis of physical therapy in Parkinson's disease with recommendations for practice and research	2007	System review
Keus, S. H.; Bloem, B. R.; van Hilten, J. J.; Ashburn, A.; Munneke, M.	Effectiveness of physiotherapy in Parkinson's disease: the feasibility of a randomised controlled trial	2007	Doesn't answer question
Khojandi, A.; Shylo, O.; Mannini, L.; Kopell, B. H.; Ramdhani, R. A.	Stratifying Parkinson's Patients With STN-DBS Into High-Frequency or 60 Hz-Frequency Modulation Using a Computational Model	2017	Not RCT
Khuzema, A.; Brammatha, A.; Arul Selvan, V.	Effect of home-based Tai Chi, Yoga or conventional balance exercise on functional balance and mobility among persons with idiopathic Parkinson's disease: An experimental study	2020	Fewer than 10 patients per group
Kim, A.; Darakjian, N.; Finley, J. M.	Walking in fully immersive virtual environments: an evaluation of potential adverse effects in older adults and individuals with Parkinson's disease	2017	Not RCT

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Authors	Article Title	Year	Reason for Exclusion
Kim, R.; Kim, H. J.; Kim, A.; Kim, Y.; Kim, A. R.; Shin, C. W.; Paek, S. H.; Jeon, B.	Depression may negatively affect the change in freezing of gait following subthalamic nucleus stimulation in Parkinson's disease	2017	Not RCT
King, L. A.; Peterson, D. S.; Mancini, M.; Carlson-Kuhta, P.; Fling, B. W.; Smulders, K.; Nutt, J. G.; Dale, M.; Carter, J.; Winters-Stone, K. M.; Horak, F. B.	Do cognitive measures and brain circuitry predict outcomes of exercise in Parkinson Disease: a randomized clinical trial	2015	Not relevant to criteria
King, L.; Jung, S. H.; Mancini, M.; Carlson-Kuhta, P.; Barlow, N.; Morris, R.; Nutt, J.; Horak, F.	Cognitively challenging exercise improved executive function in Parkinson's disease	2019	PDF contains abstracts only
King, L.; Morris, R.; Horak, F.; McBarron, G.; Hidler, J.	Training Responses in Postural Rehabilitation (TRIP) using perturbations while walking	2019	PDF contains abstracts only
Klamroth, S.; Steib, S.; Devan, S.; Pfeifer, K.	Effects of Exercise Therapy on Postural Instability in Parkinson Disease: A Meta-analysis	2016	References reviewed
Kleiner, A. F. R.; Souza Pagnussat, A.; Pinto, C.; Redivo Marchese, R.; Salazar, A. P.; Galli, M.	Automated Mechanical Peripheral Stimulation Effects on Gait Variability in Individuals With Parkinson Disease and Freezing of Gait: A Double-Blind, Randomized Controlled Trial	2018	Medical device
Kluger, B. M.; Brown, R. P.; Aerts, S.; Schenkman, M.	Determinants of objectively measured physical functional performance in early to mid-stage Parkinson disease	2014	Not relevant to criteria
Kompoliti, K.; Goetz, C. G.; Leurgans, S.; Morrissey, M.; Siegel, I. M.	"On" freezing in Parkinson's disease: resistance to visual cue walking devices	2000	Fewer than 10 patients
Kraepelien, M.; Schibbye, R.; MÃ¥nsson, K.; SundstrÃ¶m, C.; Riggare, S.; Andersson, G.; Lindefors, N.; Svenningsson, P.; Kaldo, V.	Individually Tailored Internet-Based Cognitive-Behavioral Therapy for Daily Functioning in Patients with Parkinson's Disease: A Randomized Controlled Trial	2020	Cognitive behavioral therapy- not PT administered
Krishnamurthi, N.; Fleury, J.; Belyea, M.; Shill, H. A.; Abbas, J. J.	ReadySteady intervention to promote physical activity in older adults with Parkinson's disease: Study design and methods	2020	Study protocol
Kuo, Y. C.; Chan, J.; Wu, Y. P.; Bernard, J. R.; Liao, Y. H.	Effect of expiratory muscle strength training intervention on the maximum expiratory pressure and quality of life of patients with Parkinson disease	2017	Patient population size
Kwok, J. Y. Y.; Choi, K. C.; Chan, H. Y. L.	Effects of mindâ??body exercises on the physiological and psychosocial well-being of individuals with Parkinson's disease: A systematic review and meta-analysis	2016	References reviewed
Kwok, J. Y. Y.; Kwan, J. C. Y.; Auyeung, M.; Mok, V. C. T.; Chan, H. Y. L.	The effects of yoga versus stretching and resistance training exercises on psychological distress for people with mild-to-moderate Parkinson's disease: study prxotocol for a randomized controlled trial	2017	No result sections
Kwok, J. Y. Y.; Kwan, J. C. Y.; Auyeung, M.; Mok, V. C. T.; Chow, K. C.; Chan, H. Y. L.	From body, mind, to the integration: a mixed-method, randomized controlled trial of mindfulness yoga on physiopsycho-spiritual well-being of people living with Parkinson's disease	2019	PDF contains abstracts only
Kwok, J. Y.; Choi, K. C.; Chan, H. Y.	Effects of mind-body exercises on the physiological and psychosocial well-being of individuals with Parkinson's disease: A systematic review and meta-analysis	2016	References reviewed

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Authors	Article Title	Year	Reason for Exclusion
Kwon, K. Y.; Lee, H. M.; Kang, S. H.; Pyo, S. J.; Kim, H. J.; Koh, S. B.	Recuperation of slow walking in de novo Parkinson's disease is more closely associated with increased cadence, rather than with expanded stride length	2017	Not RCT
Lakshminarayana, R.; Wang, D.; Burn, D.; Chaudhuri, K. R.; Cummins, G.; Galtrey, C.; Hellman, B.; Pal, S.; Stamford, J.; Steiger, M.; et al.,	Smartphone- and internet-assisted self-management and adherence tools to manage Parkinson's disease (SMART-PD): study protocol for a randomised controlled trial (v7; 15 August 2014)	2014	No result sections
Lakshminarayana, R.; Wang, D.; Burn, D.; Chaudhuri, K. R.; Galtrey, C.; Guzman, N. V.; Hellman, B.; James, B.; Pal, S.; Stamford, J.; Steiger, M.; Stott, R. W.; Teo, J.; Barker, R. A.; Wang, E.; Bloem, B. R.; Van Der Eijk, M.; Rochester, L.; Williams, A.	Using a smartphone-based self-management platform to support medication adherence and clinical consultation in Parkinson's disease	2017	No PT outcomes
Ledger, S.; Galvin, R.; Lynch, D.; Stokes, E. K.	A randomised controlled trial evaluating the effect of an individual auditory cueing device on freezing and gait speed in people with Parkinson's disease	2008	Not a complete study. no result
Lee, H. W.; Ko, P. W.; Kang, K.; Lim, Y. H.	Impairment of static balance in patients with Parkinson's disease using wearable device	2019	PDF contains abstracts only
Lei, C.; Sunzi, K.; Dai, F.; Liu, X.; Wang, Y.; Zhang, B.; He, L.; Ju, M.	Effects of virtual reality rehabilitation training on gait and balance in patients with Parkinson's disease: A systematic review	2019	References reviewed
Li, Z.; Zhuang, J.; Jiang, Y.; Xiao, G.; Jie, K.; Wang, T.; Yin, W.; Zhang, Y.; Wang, Z.	Study protocol for a single-blind randomised controlled trial to evaluate the clinical effects of an Integrated Qigong exercise intervention on freezing of gait in Parkinson's disease	2019	Study protocol
Lim, I.; van Wegen, E.; de Goede, C.; Deutekom, M.; Nieuwboer, A.; Willems, A.; Jones, D.; Rochester, L.; Kwakkel, G.	Effects of external rhythmical cueing on gait in patients with Parkinson's disease: a systematic review	2005	Systematic review
Lima, L. O.; Scianni, A.; Rodrigues-de-Paula, F.	Progressive resistance exercise improves strength and physical performance in people with mild to moderate Parkinson's disease: a systematic review	2013	Systematic review
Lin, F.; Wu, D.; Lin, C.; Cai, H.; Chen, L.; Cai, G.; Ye, Q.; Cai, G.	Pedunculopontine Nucleus Deep Brain Stimulation Improves Gait Disorder in Parkinson's Disease: A Systematic Review and Meta-analysis	2020	References reviewed
Lina, C.; Guoen, C.; Huidan, W.; Yingqing, W.; Ying, C.; Xiaochun, C.; Qinyong, Y.	The Effect of Virtual Reality on the Ability to Perform Activities of Daily Living, Balance During Gait and Motor Function in Parkinson's Disease Patients-- A Systematic Review and Meta-Analysis	2020	References reviewed
Lipsmeier, F.; Taylor, K. I.; Kilchenmann, T.; Wolf, D.; Scotland, A.; Schjodt-Eriksen, J.; Cheng, W. Y.; Fernandez-Garcia, I.; Siebourg-Polster, J.; Jin, L.; Soto, J.; Verselis, L.; Boess, F.; Koller, M.; Grundman, M.; Monsch, A. U.; Postuma, R. B.; Ghosh, A.;	Evaluation of smartphone-based testing to generate exploratory outcome measures in a phase 1 Parkinson's disease clinical trial	2018	Not RCT

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Kremer, T.; Czech, C.; Gossens, C.; Lindemann, M.			
Liu, H. H.; Yeh, N. C.; Wu, Y. F.; Yang, Y. R.; Wang, R. Y.; Cheng, F. Y.	Effects of Tai Chi Exercise on Reducing Falls and Improving Balance Performance in Parkinson's Disease: A Meta-Analysis	2019	References reviewed
Lizarraga, K. J.; Jagid, J. R.; Luca, C. C.	Comparative effects of unilateral and bilateral subthalamic nucleus deep brain stimulation on gait kinematics in Parkinson's disease: a randomized, blinded study	2016	Doesn't address question of interest
Lord, S. R.; Bindels, H.; Ketheeswaran, M.; Brodie, M. A.; Lawrence, A. D.; Close, J. C. T.; Whone, A. L.; Ben-Shlomo, Y.; Henderson, E. J.	Freezing of Gait in People with Parkinson's Disease: Nature, Occurrence, and Risk Factors	2020	Not RCT
Lun, V.; Pullan, N.; Labelle, N.; Adams, C.; Suchowersky, O.	Comparison of the effects of a self-supervised home exercise program with a physiotherapist-supervised exercise program on the motor symptoms of Parkinson's disease	2005	Fewer than 10 patients per group
Luo, L.; Zou, L.; Fang, Q.; Wang, H.; Liu, Y.; Tian, Z.; Han, Y.	Effect of Taichi Softball on Function-Related Outcomes in Older Adults: A Randomized Control Trial	2017	Patient population- mixed population not only PD
Ma, H. I.; Hwang, W. J.; Fang, J. J.; Kuo, J. K.; Wang, C. Y.; Leong, I. F.; Wang, T. Y.	Effects of virtual reality training on functional reaching movements in people with Parkinson's disease: a randomized controlled pilot trial	2011	Doesn't address comparison of interest
Maas, J.; De Vries, N.; Bloem, B.; Kalf, H.	Design of the PERSPECTIVE study: pERsonalized SPEeCh Therapy for actIVE conversation	2019	PDF contains abstracts only
Maggio, M. G.; De Cola, M. C.; Latella, D.; Maresca, G.; Finocchiaro, C.; La Rosa, G.; Cimino, V.; Sorbera, C.; Bramanti, P.; De Luca, R.; Calabro, R. S.	What About the Role of Virtual Reality in Parkinson Disease's Cognitive Rehabilitation? Preliminary Findings From a Randomized Clinical Trial	2018	No PT intervention
Mahmoud, Lse- D.; Shady, Naelra; Hafez, E. S.	Motor imagery training with augmented cues of motor learning on cognitive functions in patients with Parkinsonism	2018	Patients do not have PD- "Parkinsonism"
Maitra, K. K.	Enhancement of reaching performance via self-speech in people with Parkinson's disease	2007	Fewer than 10 patients
Mak, M. K.; Yu, L.; Hui-Chan, C. W.	The immediate effect of a novel audio-visual cueing strategy (simulated traffic lights) on dual-task walking in people with Parkinson's disease	2013	Not RCT- healthy control
Makkos, A.; Pal, E.; Aschermann, Z.; Janszky, J.; Balazs, E.; Takacs, K.; Karadi, K.; Komoly, S.; Kovacs, N.	High-Frequency Repetitive Transcranial Magnetic Stimulation Can Improve Depression in Parkinson's Disease: A Randomized, Double-Blind, Placebo-Controlled Study	2016	No DBS intervention (TMS = noninvasive)
Manor, Y.; Mootanah, R.; Freud, D.; Giladi, N.; Cohen, J. T.	Video-assisted swallowing therapy for patients with Parkinson's disease	2013	No PT intervention

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Authors	Article Title	Year	Reason for Exclusion
Mansfield, A.; Wong, J. S.; Bryce, J.; Knorr, S.; Patterson, K. K.	Does perturbation-based balance training prevent falls? Systematic review and meta-analysis of preliminary randomized controlled trials	2015	Systematic review
Marazzi, S.; Kiper, P.; Palmer, K.; Agostini, M.; Turolla, A.	Effects of vibratory stimulation on balance and gait in Parkinson's disease: a systematic review and meta-analysis	2020	References reviewed
Marotta, N.; Demeco, A.; Indino, A.; de Scorpio, G.; Moggio, L.; Ammendolia, A.	Nintendo WiiTMversus Xbox KinectTM for functional locomotion in people with Parkinson's disease: a systematic review and network meta-analysis	2020	References reviewed
Martignon, C.; Pedrinolla, A.; Ruzzante, F.; Giuriato, G.; Laginestra, F. G.; Bouca-Machado, R.; Ferreira, J. J.; Tinazzi, M.; Schena, F.; Venturelli, M.	Guidelines on exercise testing and prescription for patients at different stages of Parkinson's disease	2020	References reviewed
Maruo, T.; Hosomi, K.; Shimokawa, T.; Kishima, H.; Oshino, S.; Morris, S.; Kageyama, Y.; Yokoe, M.; Yoshimine, T.; Saitoh, Y.	High-frequency repetitive transcranial magnetic stimulation over the primary foot motor area in Parkinson's disease	2013	No DBS intervention (TMS = noninvasive)
Marusiak, J.; Fisher, B. E.; JaskÃ³lska, A.; SÅ?otwiÅ?ski, K.; Budrewicz, S.; Koszewicz, M.; Kisiel-Sajewicz, K.; KamiÅ?ski, B.; JaskÃ³lski, A.	Eight weeks of aerobic interval training improves psychomotor function in patients with parkinsonâ??s diseaseâ??randomized controlled trial	2019	Duplicate citation (ID 165)
Mavrommati, F.; Collett, J.; Franssen, M.; Meaney, A.; Sexton, C.; Dennis-West, A.; Betts, J. F.; Izadi, H.; Bogdanovic, M.; Tims, M.; Farmer, A.; Dawes, H.	Exercise response in Parkinson's disease: insights from a cross-sectional comparison with sedentary controls and a per-protocol analysis of a randomised controlled trial	2017	Not RCT
Mazzarin, C. M.; Valderramas, S. R.; De Paula Ferreira, M.; Tiepolo, E.; GuÃ©rios, L.; Parisotto, D.; Israel, V. L.	Effects of Dance and of Tai Chi on Functional Mobility, Balance, and Agility in Parkinson Disease	2017	References reviewed
McAuley, J. H.; Corcos, D. M.; Rothwell, J. C.; Quinn, N. P.; Marsden, C. D.	Levodopa reversible loss of the Piper frequency oscillation component in Parkinson's disease	2001	Not relevant to criteria
McDonnell, M. N.; Rischbieth, B.; Schammer, T. T.; Seaforth, C.; Shaw, A. J.; Phillips, A. C.	Lee Silverman Voice Treatment (LSVT)-BIG to improve motor function in people with Parkinson's disease: a systematic review and meta-analysis	2018	References reviewed
McNeely, M. E.; Duncan, R. P.; Earhart, G. M.	A comparison of dance interventions in people with Parkinson disease and older adults	2015	References reviewed
McNeely, M. E.; Earhart, G. M.	Lack of Short-Term Effectiveness of Rotating Treadmill Training on Turning in People with Mild-to-Moderate Parkinson's Disease and Healthy Older Adults: A Randomized, Controlled Study	2012	Not RCT
Mehrang, S.; Jauhiainen, M.; Pietil, J.; Puustinen, J.; Ruokolainen, J.; Nieminen, H.	Identification of Parkinson's Disease Utilizing a Single Self-recorded 20-step Walking Test Acquired by Smartphone's Inertial Measurement Unit	2018	Not RCT; non-PD comparison group
Mehrholz, J.; Friis, R.; Kugler, J.; Twork, S.; Storch, A.; Pohl, M.	Treadmill training for patients with Parkinson's disease	2010	Systematic review

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Authors	Article Title	Year	Reason for Exclusion
Mehrholz, J.; Kugler, J.; Storch, A.; Pohl, M.; Elsner, B.; Hirsch, K.	Treadmill training for patients with Parkinson's disease	2015	References reviewed
Mehrholz, J.; Kugler, J.; Storch, A.; Pohl, M.; Hirsch, K.; Elsner, B.	Treadmill training for patients with Parkinson Disease. An abridged version of a Cochrane Review	2016	References reviewed
Memarian, A.; Sanatkaran, A.; Bahari, S. M.	The effect of laughter yoga exercises on anxiety and sleep quality in patients suffering from Parkinsonâ??s disease	2017	Not a RCT
Menza, M.; DeFonzo Dobkin, R.; Marin, H.; Mark, M. H.; Gara, M.; Buyske, S.; Bienfait, K.; Dicke, A.	The impact of treatment of depression on quality of life, disability and relapse in patients with Parkinson's disease	2009	Doesn't address question of interest
Meoni, S.; Debu, B.; Pelissier, P.; Scelzo, E.; Castrioto, A.; Seigneuret, E.; Chabardes, S.; Fraix, V.; Moro, E.	Asymmetric STN DBS for FOG in Parkinson's disease: A pilot trial	2019	Fewer than 10 patients in each group
Merali, S.; Cameron, J. I.; Barclay, R.; Salbach, N. M.	Characterising community exercise programmes delivered by fitness instructors for people with neurological conditions: a scoping review	2016	References reviewed
Mi, T. M.; Garg, S.; Ba, F.; Liu, A. P.; Wu, T.; Gao, L. L.; Dan, X. J.; Chan, P.; McKeown, M. J.	High-frequency rTMS over the supplementary motor area improves freezing of gait in Parkinson's disease: a randomized controlled trial	2019	No DBS intervention (TMS = noninvasive)
Miller, K. J.; Suarez-Iglesias, D.; Seijo-Martinez, M.; Ayan, C.	Physiotherapy for freezing of gait in Parkinson's disease: a systematic review and meta-analysis	2020	References reviewed
Mirelman, A.; Rochester, L.; Maidan, I.; Del Din, S.; Alcock, L.; Nieuwhof, F.; Rikkert, M. O.; Bloem, B. R.; Pelosin, E.; Avanzino, L.; Abbruzzese, G.; Dockx, K.; Bekkers, E.; Giladi, N.; Nieuwboer, A.; Hausdorff, J. M.	Addition of a non-immersive virtual reality component to treadmill training to reduce fall risk in older adults (V-TIME): a randomised controlled trial	2016	Patient population
Miyahara, Y.; Jitkritsadakul, O.; Sringean, J.; Aungkab, N.; Khongprasert, S.; Bhidayasiri, R.	Can therapeutic Thai massage improve upper limb muscle strength in Parkinson's disease? An objective randomized-controlled trial	2018	Does not address comparison of interest
Miyai, I.; Fujimoto, Y.; Yamamoto, H.; Ueda, Y.; Saito, T.; Nozaki, S.; Kang, J.	Long-term effect of body weight-supported treadmill training in Parkinson's disease: a randomized controlled trial	2002	Fewer than 10 patients
Miyasato, R. S.; Silva-Batista, C.; Pecanha, T.; Low, D. A.; de Mello, M. T.; Piemonte, M. E. P.; Ugrinowitsch, C.; Forjaz, C. L. M.; Kanegusuku, H.	Cardiovascular Responses During Resistance Exercise in Patients With Parkinson Disease	2018	Not relevant to criteria
Modugno, N.; Iaconelli, S.; Fiorlli, M.; Lena, F.; Kusch, I.; Mirabella, G.	Active theater as a complementary therapy for Parkinson's disease rehabilitation: a pilot study	2010	Fewer than 10 patients
Moes, E.; Lombardi, K. M.	The relationship between contrast sensitivity, gait, and reading speed in parkinson's disease	2009	Not RCT
Montero Ferro, A.; P. Basso-Vanelli R; Moreira Mello, R. L.; Sanches Garcia-Araujo, A.; Goncalves Mendes, R.; Costa, D.; Gianlorenco, A. C.	Effects of inspiratory muscle training on respiratory muscle strength, lung function, functional capacity and cardiac autonomic function in Parkinson's disease: Randomized controlled clinical trial protocol	2019	No result sections

Authors	Article Title	Year	Reason for Exclusion
Montgomery Jr, E. B.; Lieberman, A.; Singh, G.; Fries, J. F.; Calne, D.; Koller, W.; Muenter, M.; Olanow, C. W.; Stern, M.; Tanner, C.; Tintner, R.; Wasserstein, P.; Watts, R.	Patient education and health promotion can be effective in Parkinson's disease: A randomized controlled trial	1994	Doesn't address question of interest;
Moon, J. H.; Jung, J. H.; Cho, H. Y.	Effects of balance training using a wii fit balance board on balance, gait and activities of daily living in patients with parkinson disease: A pilot, randomized controlled trial	2020	Fewer than 10 patients per group
Moon, S.; Sarmento, C. V. M.; Smirnova, I. V.; Colgrove, Y.; Lyons, K. E.; Lai, S. M.; Liu, W.	Effects of Qigong Exercise on Non-Motor Symptoms and Inflammatory Status in Parkinson's Disease: A Protocol for a Randomized Controlled Trial	2019	No result sections
Morris, M.	Dance as exercise for Parkinson's disease	2019	PDF contains abstracts only
Morris, M. E.; Menz, H. B.; McGinley, J. L.; Huxham, F. E.; Murphy, A. T.; Iansek, R.; Danoudis, M.; Soh, S. E.; Kelly, D.; Watts, J. J.	Falls and mobility in Parkinson's disease: protocol for a randomised controlled clinical trial	2011	No result sections
Morrone, M.; Miccinilli, S.; Bravi, M.; Paolucci, T.; Melgari, J. M.; Salomone, G.; Picelli, A.; Spadini, E.; Ranavolo, A.; Saraceni, V. M.; D. I. Lazzaro V; Sterzi, S.	Perceptive rehabilitation and trunk posture alignment in patients with Parkinson disease: a single blind randomized controlled trial	2016	Doesn't address comparison of interest
Moumdjian, L.; Buhmann, J.; Willems, I.; Feys, P.; Leman, M.	Entrainment and Synchronization to Auditory Stimuli During Walking in Healthy and Neurological Populations: A Methodological Systematic Review	2018	References reviewed
Murdoch, K. C.; Larsen, D.; Edey, W.; Arsenault, C.; Howell, A.; Joyce, A.; Sandham, T.; Miyasaki, J. M.	The efficacy of the Strength, Hope and Resourcefulness Program for people with Parkinson's disease (SHARP-PWP): A mixed methods study	2020	Cognitive behavioral therapy- not PT administered
Murray, D. K.; Sacheli, M. A.; Eng, J. J.; Stoessl, A. J.	The effects of exercise on cognition in Parkinson's disease: a systematic review	2014	Systematic review
Myers, P. S.; McNeely, M. E.; Pickett, K. A.; Duncan, R. P.; Earhart, G. M.	Effects of exercise on gait and motor imagery in people with Parkinson disease and freezing of gait	2018	Doesn't address question of interest
Nackaerts, E.; Broeder, S.; Pereira, M. P.; Swinnen, S. P.; Vandenberghe, W.; Nieuwboer, A.; Heremans, E.	Handwriting training in Parkinson's disease: A trade-off between size, speed and fluency	2017	No PT intervention
Nackaerts, E.; Heremans, E.; Vervoort, G.; Smits-Engelsman, B. C.; Swinnen, S. P.; Vandenberghe, W.; Bergmans, B.; Nieuwboer, A.	Relearning of Writing Skills in Parkinson's Disease After Intensive Amplitude Training	2016	No PT intervention
Nackaerts, E.; Michely, J.; Heremans, E.; Swinnen, S.; Smits-Engelsman, B.; Vandenberghe, W.; Grefkes, C.; Nieuwboer, A.	Being on Target: Visual Information during Writing Affects Effective Connectivity in Parkinson's Disease	2018	Patient population

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Authors	Article Title	Year	Reason for Exclusion
Nascimento, Iapds; Santiago, L. M. M.; de Souza, A. A.; Pegado, C. L.; Ribeiro, T. S.; Lindquist, A. R. R.	Effects of motor imagery training of Parkinson's disease: a protocol for a randomized clinical trial	2019	Study protocol
Nct,	Balance Training in Parkinson's Disease Using Cues	2013	Matching PEER title and PDF under ID 6718
Nct,	Effects of Home Therapeutic Exercises Oriented for Patients With Parkinson's Disease	2015	Doesn't address comparison of interest
Nct,	Biofeedback-based Motor Learning to Ameliorate Freezing of Gait	2010	Not RCT
Nct,	Consolidation of Motor Learning of Writing Skills and Its Related Brain Activity Changes in Parkinson's Disease	2014	Does not address question of interest
Nguyen, H.; Lebel, K.; Boissy, P.; Bogard, S.; Goubault, E.; Duval, C.	Auto detection and segmentation of daily living activities during a Timed Up and Go task in people with Parkinson's disease using multiple inertial sensors	2017	not RCT
Ni, M.; Hazzard, J. B.; Signorile, J. F.; Luca, C.	Exercise Guidelines for Gait Function in Parkinson's Disease: A Systematic Review and Meta-analysis	2018	References reviewed
Ni, X.; Liu, S.; Lu, F.; Shi, X.; Guo, X.	Efficacy and safety of Tai Chi for Parkinson's disease: a systematic review and meta-analysis of randomized controlled trials	2014	Systematic review
Nieuwboer, A.; Rochester, L.; Jones, D.	Cueing gait and gait-related mobility in patients with Parkinson's disease: Developing a therapeutic method based on the international classification of functioning, disability, and health	2008	Commentary review
Nousia, A.; Martzoukou, M.; Tsouris, Z.; Siokas, V.; Aloizou, A. M.; Liampas, I.; Nasios, G.; Dardiotis, E.	The Beneficial Effects of Computer-Based Cognitive Training in Parkinson's Disease: A Systematic Review	2020	References reviewed
Nuic, D.; Vinti, M.; Karachi, C.; Foulon, P.; Van Hamme, A.; Welter, M. L.	The feasibility and positive effects of a customised videogame rehabilitation programme for freezing of gait and falls in Parkinson's disease patients: a pilot study	2018	No comparison group
Odekerken, V. J. J.; van Laar, T.; Staal, M. J.; Mosch, A.; Hoffmann, C. F. E.; Nijssen, P. C. G.; Beute, G. N.; van Vugt, J. P. P.; Lenders, M. W. P. M.; Contarino, M. F.; Mink, M. S. J.; Bour, L. J.; van den Munckhof, P.; Schmand, B. A.; de Haan, R. J.; Schuurman, P. R.; de Bie, R. M. A.	Subthalamic nucleus versus globus pallidus bilateral deep brain stimulation for advanced Parkinson's disease (NSTAPS study): A randomised controlled trial	2013	Doesn't address question of interest
Odekerken, V. J.; Boel, J. A.; Schmand, B. A.; de Haan, R. J.; Figee, M.; van den Munckhof, P.; Schuurman, P. R.; de Bie, R. M.	GPi vs STN deep brain stimulation for Parkinson disease: Three-year follow-up	2016	Doesn't address question of interest
Okamoto, R.; Adachi, K.; Mizukami, K.	Effects of facial rehabilitation exercise on the mood, facial expressions, and facial muscle activities in patients with Parkinson's disease	2019	Foreign language

Authors	Article Title	Year	Reason for Exclusion
Okamoto, R.; Adachi, K.; Mizukami, K.	The effectiveness of facial exercises on the facial expression and the mood in persons with Parkinson's disease	2019	PDF contains abstracts only
Okun, M. S.; Gallo, B. V.; Mandybur, G.; Jagid, J.; Foote, K. D.; Revilla, F. J.; Alterman, R.; Jankovic, J.; Simpson, R.; Junn, F.; Verhagen, L.; Arle, J. E.; Ford, B.; Goodman, R. R.; Stewart, R. M.; Horn, S.; Baltuch, G. H.; Kopell, B. H.; Marshall, F.; Peichel, D.; Pahwa, R.; Lyons, K. E.; Troster, A. I.; Vitek, J. L.; Tagliati, M.; Sjm Dbs Study Group	Subthalamic deep brain stimulation with a constant-current device in Parkinson's disease: an open-label randomised controlled trial	2012	Doesn't address question of interest
Oliveira, R. M.; Gurd, J. M.; Nixon, P.; Marshall, J. C.; Passingham, R. E.	Micrographia in Parkinson's disease: the effect of providing external cues	1997	Patient population- not all PD
Ophey, A.; Giehl, K.; Rehberg, S.; Eggers, C.; Reker, P.; van Eimeren, T.; Kalbe, E.	Effects of working memory training in patients with Parkinson's disease without cognitive impairment: A randomized controlled trial	2020	No PT intervention
Orgeta, V.; McDonald, K. R.; Poliakoff, E.; Hindle, J. V.; Clare, L.; Leroi, I.	Cognitive training interventions for dementia and mild cognitive impairment in Parkinson's disease	2020	References reviewed
Ortelli, P.; Ferrazzoli, D.; Bera, R.; Caremani, L.; Giladi, N.; Maestri, R.; Frazzitta, G.	Effectiveness of a Goal-Based Intensive Rehabilitation in Parkinsonian Patients in Advanced Stages of Disease	2018	Not RCT
Palacios-Navarro, G.; Albiol-Perez, S.; Garcia-Magarino Garcia, I.	Effects of sensory cueing in virtual motor rehabilitation. A review	2016	References reviewed
Palamara, G.; Gotti, F.; Maestri, R.; Bera, R.; Gargantini, R.; Bossio, F.; Zivi, I.; Volpe, D.; Ferrazzoli, D.; Frazzitta, G.	Land Plus Aquatic Therapy Versus Land-Based Rehabilitation Alone for the Treatment of Balance Dysfunction in Parkinson Disease: A Randomized Controlled Study With 6-Month Follow-Up	2017	Not addressing question of interest
Park, H. S.; Yoon, J. W.; Kim, J.; Iseki, K.; Hallett, M.	Development of a VR-based treadmill control interface for gait assessment of patients with Parkinson's disease	2011	Not RCT
Paul, K. C.; Chuang, Y. H.; Shih, I. F.; Keener, A.; Bordelon, Y.; Bronstein, J. M.; Ritz, B.	The association between lifestyle factors and Parkinson's disease progression and mortality	2019	Not RCT
Paul, S. S.; Schaefer, S. Y.; Olivier, G. N.; Walter, C. S.; Lohse, K. R.; Dibble, L. E.	Dopamine Replacement Medication Does Not Influence Implicit Learning of a Stepping Task in People With Parkinson's Disease	2018	Not relevant to criteria
Pazzaglia, C.; Imbimbo, I.; Tranchita, E.; Minganti, C.; Ricciardi, D.; Lo Monaco, R.; Parisi, A.; Padua, L.	Comparison of virtual reality rehabilitation and conventional rehabilitation in Parkinson's disease: a randomised controlled trial	2020	Doesn't address comparison of interest
Pedreira, Glicia; Prazeres, Antonio; Cruz, Danilo; Gomes, IrÃªnio; Monteiro, Larissa; Melo, Ailton	Virtual games and quality of life in Parkinsonâ??s disease: A randomised controlled trial	2013	Doesn't address comparison of interest
Pelosin, E.; Cerulli, C.; Ogliastro, C.; Lagravinese, G.; Mori, L.; Bonassi, G.; Mirelman, A.; Hausdorff, J. M.;	A Multimodal Training Modulates Short Afferent Inhibition and Improves Complex Walking in a Cohort of Faller Older Adults With an Increased Prevalence of Parkinson's Disease	2020	Study population not specific to PD patients

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Authors	Article Title	Year	Reason for Exclusion
Abbruzzese, G.; Marchese, R.; Avanzino, L.			
Pena, J.; Ibarretxe-Bilbao, N.; Garcia-Gorostiaga, I.; Gomez-Beldarrain, M. A.; Diez-Cirarda, M.; Ojeda, N.	Improving functional disability and cognition in Parkinson disease: randomized controlled trial	2014	No PT intervention
Peng, L.; Fu, J.; Ming, Y.; Zeng, S.; He, H.; Chen, L.	The long-term efficacy of STN vs GPi deep brain stimulation for Parkinson disease: A meta-analysis	2018	References reviewed
Penko, A. L.; Barkley, J. E.; Rosenfeldt, A. B.; Alberts, J. L.	Multimodal Training Reduces Fall Frequency as Physical Activity Increases in Individuals With Parkinson's Disease	2019	Fewer than 10 patients per group
Peppe, A.; Paravati, S.; Baldassarre, M. G.; Bakdounes, L.; Spolaor, F.; Guiotto, A.; Pavan, D.; Sawacha, Z.; Bottino, S.; Clerici, D.; Cau, N.; Mauro, A.; Albani, G.; Avenali, M.; Sandrini, G.; Tassorelli, C.; Volpe, D.	Proprioceptive Focal Stimulation (Equistasi R) May Improve the Quality of Gait in Middle-Moderate Parkinson's Disease Patients. Double-Blind, Double-Dummy, Randomized, Crossover, Italian Multicentric Study	2019	Medical device
Peppe, A.; Paravati, S.; Baldassarre, M. G.; Bakdounes, L.; Spolaor, F.; Guiotto, A.; Pavan, D.; Sawacha, Z.; Bottino, S.; Clerici, D.; et al.,	Proprioceptive Focal Stimulation (EquistasiÃ?Â®) May Improve the Quality of Gait in Middle-Moderate Parkinson's Disease Patients. Double-Blind, Double-Dummy, Randomized, Crossover, Italian Multicentric Study	2019	Repeat of article ID 7652
Pereira, A. P. S.; Marinho, V.; Gupta, D.; Magalhaes, F.; Ayres, C.; Teixeira, S.	Music Therapy and Dance as Gait Rehabilitation in Patients With Parkinson Disease: A Review of Evidence	2019	References reviewed
Peters, C.; Currin, M.; Tyson, S.; Rogers, A.; Healy, S.; McPhail, S.; Brauer, S. G.; Heathcote, K.; Comans, T.	A randomized controlled trial of an enhanced interdisciplinary community based group program for people with Parkinson's disease: study rationale and protocol	2012	No result sections
Petrelli, A.; Kaesberg, S.; Barbe, M. T.; Timmermann, L.; Fink, G. R.; Kessler, J.; Kalbe, E.	Effects of cognitive training in Parkinson's disease: a randomized controlled trial	2014	No PT intervention
Pina Fuentes, D.; Oterdoom, D. L. M.; Van Zijl, J. C.; Moes, H. R.; Van Dijk, J. M. C.; Beudel, M.	Adaptive deep brain stimulation in parkinson's disease patients with long-term implanted deep brain stimulation electrodes	2019	PDF contains abstracts only; fewer than 10 pts per group
Pinto, C.; Pagnussat, A. S.; Rozin Kleiner, A. F.; Marchese, R. R.; Salazar, A. P.; Rieder, C. R. M.; Galli, M.	Automated Mechanical Peripheral Stimulation Improves Gait Parameters in Subjects With Parkinson Disease and Freezing of Gait: A Randomized Clinical Trial	2018	Medical device
Pinto, C.; Salazar, A. P.; Marchese, R. R.; Stein, C.; Pagnussat, A. S.	Is hydrotherapy effective to improve balance, functional mobility, motor status, and quality of life in subjects with Parkinson's disease? A systematic review and meta-analysis	2018	Systematic review
Pinto, C.; Salazar, A. P.; Marchese, R. R.; Stein, C.; Pagnussat, A. S.	The Effects of Hydrotherapy on Balance, Functional Mobility, Motor Status, and Quality of Life in Patients with Parkinson Disease: A Systematic Review and Meta-analysis	2019	References reviewed

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Authors	Article Title	Year	Reason for Exclusion
Pohl, M.; Rockstroh, G.; Ruckriem, S.; Mrass, G.; Mehrholz, J.	Immediate effects of speed-dependent treadmill training on gait parameters in early Parkinson's disease	2003	Not relevant to criteria
Pohl, P.; Dizdar, N.; Hallert, E.	The Ronnie Gardiner Rhythm and Music Method - a feasibility study in Parkinson's disease	2013	Fewer than 10 patients in group
Pretzer-Aboff, I.; Galik, E.; Resnick, B.	Feasibility and impact of a function focused care intervention for Parkinson's disease in the community	2011	No comparison group
Protas, E. J.; Mitchell, K.; Williams, A.; Qureshy, H.; Caroline, K.; Lai, E. C.	Gait and step training to reduce falls in Parkinson's disease	2005	Fewer than 10 patients in each group
Prusch, J. S.; Kleiner, A. F. R.; Salazar, A. P.; Pinto, C.; Marchese, R. R.; Galli, M.; Pagnussat, A. S.	Automated mechanical peripheral stimulation and postural control in subjects with Parkinson's disease and freezing of gait: a randomized controlled trial	2018	Medical device
Pupikova, M.; Rektorova, I.	Non-pharmacological management of cognitive impairment in Parkinson's disease	2020	References reviewed
Qi, J.; Kerr, G.; Sullivan, K.; Smith, S.; Meinzer, M.	The effects of non-invasive transcranial brain current stimulation (tDCS) on posture over stable and unstable surfaces in people with Parkinson's: a randomised doubleblind sham-controlled crossover study	2019	PDF contains abstracts only
Qi, J.; Kerr, G.; Sullivan, K.; Smith, S.; Meinzer, M.	Can non-invasive brain stimulation enhance dual-task performance in Parkinson's disease?	2019	PDF contains abstracts only
Qureshi, A. R.; Rana, A. Q.; Malik, S. H.; Rizvi, S. F. H.; Akhter, S.; Vannabouathong, C.; Sarfraz, Z.; Rana, R.	Comprehensive Examination of Therapies for Pain in Parkinson's Disease: A Systematic Review and Meta-Analysis	2018	References reviewed
Qutubuddin, A. A.; Cifu, D. X.; Armistead-Jehle, P.; Carne, W.; McGuirk, T. E.; Baron, M. S.	A comparison of computerized dynamic posturography therapy to standard balance physical therapy in individuals with Parkinson's disease: a pilot study	2007	Fewer than 10 patients
Raffegeau, T. E.; Krehbiel, L. M.; Kang, N.; Thijs, F. J.; Altmann, L. J. P.; Cauraugh, J. H.; Hass, C. J.	A meta-analysis: Parkinson's disease and dual-task walking	2019	References reviewed
Ramazzina, I.; Bernazzoli, B.; Costantino, C.	Systematic review on strength training in Parkinson's disease: an unsolved question	2017	References reviewed
Rawson, K. S.; Cavanaugh, J. T.; Colon-Semenza, C.; DeAngelis, T.; Duncan, R. P.; Fulford, D.; LaValley, M. P.; Mazzoni, P.; Nordahl, T.; Quintiliani, L. M.; Saint-Hilaire, M.; Thomas, C. A.; Earhart, G. M.; Ellis, T. D.	Design of the WHIP-PD study: a phase II, twelve-month, dual-site, randomized controlled trial evaluating the effects of a cognitive-behavioral approach for promoting enhanced walking activity using mobile health technology in people with Parkinson-disease	2020	Study protocol
Reyes, A.; Castillo, A.; Castillo, J.; Cornejo, I.; Cruickshank, T.	The Effects of Respiratory Muscle Training on Phonatory Measures in Individuals with Parkinson's Disease	2019	Fewer than 10 patients
Reynolds, G. O.; Otto, M. W.; Ellis, T. D.; Cronin-Golomb, A.	The Therapeutic Potential of Exercise to Improve Mood, Cognition, and Sleep in Parkinson's Disease	2016	References reviewed
Ricciardi, L.; Ricciardi, D.; Lena, F.; Plotnik, M.; Petracca, M.; Barricella, S.; Bentivoglio, A. R.; Modugno, N.; Bernabei, R.; Fasano, A.	Working on asymmetry in Parkinson's disease: randomized, controlled pilot study	2015	Fewer than 10 patients per group

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Authors	Article Title	Year	Reason for Exclusion
Robinson, A. G.; Dennett, A. M.; Snowdon, D. A.	Treadmill training may be an effective form of task-specific training for improving mobility in people with Parkinson's disease and multiple sclerosis: a systematic review and meta-analysis	2019	References reviewed
Rocchi, L.; Carlson-Kuhta, P.; Chiari, L.; Burchiel, K. J.; Hogarth, P.; Horak, F. B.	Effects of deep brain stimulation in the subthalamic nucleus or globus pallidus internus on step initiation in Parkinson disease: laboratory investigation	2012	Doesn't address question of interest
Rodrigues-Krause, J.; Krause, M.; Reischak-Oliveira, A.	Dancing for Healthy Aging: Functional and Metabolic Perspectives	2019	Systematic review
Rodriguez, M. A.; Crespo, I.; Del Valle, M.; Olmedillas, H.	Should respiratory muscle training be part of the treatment of Parkinson's disease? A systematic review of randomized controlled trials	2020	References reviewed
Rodriguez-Oroz, M. C.; Zamarbide, I.; Guridi, J.; Palmero, M. R.; Obeso, J. A.	Efficacy of deep brain stimulation of the subthalamic nucleus in Parkinson's disease 4 years after surgery: double blind and open label evaluation	2004	Fewer than 10 patients per group
Rogers, M. A.; Bradshaw, J. L.; Phillips, J. G.; Chiu, E.; Vaddadi, K.; Presnel, I.; Mileshkin, C.	Parkinsonian motor characteristics in unipolar major depression	2000	Not RCT
Romann, A. J.; Dornelles, S.; Maineri, N. L.; Rieder, C. R. M.; Olchik, M. R.	Cognitive assessment instruments in Parkinson's disease patients undergoing deep brain stimulation	2012	References reviewed
Roper, J. A.; Kang, N.; Ben, J.; Cauraugh, J. H.; Okun, M. S.; Hass, C. J.	Deep brain stimulation improves gait velocity in Parkinson's disease: a systematic review and meta-analysis	2016	References reviewed
Rosenfeldt, A. B.; Dey, T.; Alberts, J. L.	Aerobic Exercise Preserves Olfaction Function in Individuals with Parkinson's Disease	2016	Not relevant outcome
Rosenfeldt, A. B.; Rasanow, M.; Penko, A. L.; Beall, E. B.; Alberts, J. L.	The cyclical lower extremity exercise for Parkinson's trial (CYCLE): methodology for a randomized controlled trial	2015	No result sections
Rothlind, J. C.; York, M. K.; Carlson, K.; Luo, P.; Marks, W. J., Jr.; Weaver, F. M.; Stern, M.; Follett, K.; Reda, D.; C. S. P. Study Group	Neuropsychological changes following deep brain stimulation surgery for Parkinson's disease: comparisons of treatment at pallidal and subthalamic targets versus best medical therapy	2015	Doesn't address question of interest
Ruszala, S.; Musa, I.	An evaluation of equipment to assist patient sit-to-stand activities in physiotherapy	2005	No separate comparison group
Rutz, D. G.; Benninger, D. H.	Physical Therapy for Freezing of Gait and Gait Impairments in Parkinson Disease: A Systematic Review	2020	References reviewed
Sackley, C. M.; Rick, C.; Au, P.; Brady, M. C.; Beaton, G.; Burton, C.; Caulfield, M.; Dickson, S.; Dowling, F.; Hughes, M.; Ives, N.; Jowett, S.; Masterson-Algar, P.; Nicoll, A.; Patel, S.; Smith, C. H.; Woolley, R.; Clarke, C. E.; Church, A.; Davey, A.; Gallagher, C.; Conroy, A.; Bailey, S.; Done, B.; Davies, D.; Sveinbjornsdottir, S.; Kasti, M.; Allen, K.; Colnet, J.; Riches, J.; Kittridge, L.; Morris, L.; Waszkiewicz, C.; Lyell, V.;	A multicentre, randomised controlled trial to compare the clinical and cost-effectiveness of Lee Silverman Voice Treatment versus standard NHS Speech and Language Therapy versus control in Parkinson's disease: A study protocol for a randomised controlled trial	2020	Study protocol

Authors	Article Title	Year	Reason for Exclusion
Page, V.; Bassford, N.; Rayner, H.; Henderson, E.; Abraham,			
Sackley, C. M.; Smith, C. H.; Rick, C. E.; Brady, M. C.; Ives, N.; Patel, S.; Woolley, R.; Dowling, F.; Patel, R.; Roberts, H.; Jowett, S.; Wheatley, K.; Kelly, D.; Sands, G.; Clarke, C. E.; Molloy, S.; Pavel, C.; Rowbottom, C.; Tweedie, E.; Clarke, P. C.; Nicholl, D.; Siddiqui, F.; Kanakaratna, C.; Bennett, R.; Blachford, K.; Boughey, A.; Harrison, T.; Basso, M. N.; Pooler, J.; Round, J.; Smith, A.; Waszkiewicz, C.; Raw, J.; Vassallo, J.; Ansari, A.; Birtwell, K.; Brooke, J.; Finnigan, K.; Gill	Lee Silverman Voice Treatment versus standard speech and language therapy versus control in Parkinson's disease: A pilot randomised controlled trial (PD COMM pilot)	2018	No PT intervention
Sage, M. D.; Johnston, R. E.; Almeida, Q. J.	Comparison of exercise strategies for motor symptom improvement in Parkinsons disease	2011	Not RCT
Salmanpour, M. R.; Shamsaei, M.; Saberi, A.; Setayeshi, S.; Klyuzhin, I. S.; Sossi, V.; Rahmim, A.	Optimized machine learning methods for prediction of cognitive outcome in Parkinson's disease	2019	Not an RCT
Saltychev, M.; Barlund, E.; Paltamaa, J.; Katajapuu, N.; Laimi, K.	Progressive resistance training in Parkinson's disease: a systematic review and meta-analysis	2016	References reviewed
Santos, L.; Fernandez-Rio, J.; Winge, K.; Barragan-Perez, B.; Rodriguez-Perez, V.; Gonzalez-Diez, V.; Blanco-Traba, M.; Suman, O. E.; Philip Gabel, C.; Rodriguez-Gomez, J.	Effects of supervised slackline training on postural instability, freezing of gait, and falls efficacy in people with Parkinson's disease	2017	No PT intervention
Santos, P.; Machado, T.; Santos, L.; Ribeiro, N.; Melo, A.	Efficacy of the Nintendo Wii combination with Conventional Exercises in the rehabilitation of individuals with Parkinson's disease: A randomized clinical trial	2019	Doesn't address comparison of interest
Schabrun, S. M.; Lamont, R. M.; Brauer, S. G.	Transcranial Direct Current Stimulation to Enhance Dual-Task Gait Training in Parkinson's Disease: A Pilot RCT	2016	Fewer than 10 patients in each group
Schlenstedt, C.; Mancini, M.; Horak, F.; Peterson, D.	Anticipatory Postural Adjustment During Self-Initiated, Cued, and Compensatory Stepping in Healthy Older Adults and Patients With Parkinson Disease	2017	No PD comparison group

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Authors	Article Title	Year	Reason for Exclusion
Schlick, C.; Ernst, A.; Botzel, K.; Plate, A.; Pelykh, O.; Ilmberger, J.	Visual cues combined with treadmill training to improve gait performance in Parkinson's disease: a pilot randomized controlled trial	2016	Patient population size fewer than 10 per group
Seamon, B. A.; Kautz, S. A.; Velozo, C. A.	Rasch Analysis of the Activities-Specific Balance Confidence Scale in Individuals Poststroke	2019	Retrospective; study population not PD
Serrao, M.; Pierelli, F.; Sinibaldi, E.; Chini, G.; Castiglia, S. F.; Priori, M.; Gimma, D.; Sellitto, G.; Ranavolo, A.; Conte, C.; Bartolo, M.; Monari, G.	Progressive Modular Rebalancing System and Visual Cueing for Gait Rehabilitation in Parkinson's Disease: A Pilot, Randomized, Controlled Trial With Crossover	2019	Duplicate of 12303
Shanahan, J.; Morris, M. E.; Bhriain, O. N.; Saunders, J.; Clifford, A. M.	Dance for people with Parkinson disease: what is the evidence telling us?	2015	References reviewed
Sharma, N. K.; Robbins, K.; Wagner, K.; Colgrove, Y. M.	A randomized controlled pilot study of the therapeutic effects of yoga in people with Parkinson's disease	2015	Fewer than 10 in each group
Sharp, K.; Hewitt, J.	Dance as an intervention for people with Parkinson's disease: a systematic review and meta-analysis	2014	Systematic review
Shen, X.; Wong-Yu, I. S. K.; Mak, M. K. Y.	Effects of Exercise on Falls, Balance, and Gait Ability in Parkinson's Disease	2016	References reviewed
Shinmei, I.; Kobayashi, K.; Oe, Y.; Takagishi, Y.; Kanie, A.; Ito, M.; Takebayashi, Y.; Murata, M.; Horikoshi, M.; Dobkin, R. D.	Cognitive behavioral therapy for depression in Japanese Parkinsonâ??s disease patients: A pilot study	2016	Not RCT, no comparison group
Shu, H. F.; Yang, T.; Yu, S. X.; Huang, H. D.; Jiang, L. L.; Gu, J. W.; Kuang, Y. Q.	Aerobic exercise for Parkinson's disease: a systematic review and meta-analysis of randomized controlled trials	2014	Systematic review
Shujaat, F.; Soomro, N.; Khan, M.	The effectiveness of Kayaking exercises as compared to general mobility exercises in reducing axial rigidity and improve bed mobility in early to mid stage of Parkinson's disease	2014	Doesn't address comparison of interest
Siegert, C.; Hauptmann, B.; Jochems, N.; Schrader, A.; Deck, R.	ParkProTrain: an individualized, tablet-based physiotherapy training programme aimed at improving quality of life and participation restrictions in PD patients - a study protocol for a quasi-randomized, longitudinal and sequential multi-method study	2019	No result sections
Sijobert, B.; Azevedo, C.; Andreu, D.; Verna, C.; Geny, C.	Effects of Sensitive Electrical Stimulation-Based Somatosensory Cueing in Parkinson's Disease Gait and Freezing of Gait Assessment	2017	Not RCT
Silva de Lima, A. L.; Evers, L. J. W.; Hahn, T.; Bataille, L.; Hamilton, J. L.; Little, M. A.; Okuma, Y.; Bloem, B. R.; Faber, M. J.	Freezing of gait and fall detection in Parkinson's disease using wearable sensors: a systematic review	2017	References reviewed
Silva, A. Z. D.; Israel, V. L.	Effects of dual-task aquatic exercises on functional mobility, balance and gait of individuals with Parkinson's disease: A randomized clinical trial with a 3-month follow-up	2019	Doesn't address comparison of interest
Silva, K. G.; De Freitas, T. B.; Dona, F.; Gananca, F. F.; Ferraz, H. B.; Torriani-Pasin, C.; Pompeu, J. E.	Effects of virtual rehabilitation versus conventional physical therapy on postural control, gait, and cognition of patients with Parkinson's disease: study protocol for a randomized controlled feasibility trial	2017	No result sections

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Authors	Article Title	Year	Reason for Exclusion
Silva-Batista, C.; de Brito, L. C.; Corcos, D. M.; Roschel, H.; de Mello, M. T.; Piemonte, M. E. P.; Tricoli, V.; Ugrinowitsch, C.	Resistance Training Improves Sleep Quality in Subjects With Moderate Parkinson's Disease	2017	Outcomes not relevant to criteria
Skelly, R.; Brown, L.; Fakis, A.; Kimber, L.; Downes, C.; Lindop, F.; Johnson, C.; Bartliff, C.; Bajaj, N.	Does a specialist unit improve outcomes for hospitalized patients with Parkinson's disease?	2014	Not RCT
Smania, N.; Corato, E.; Tinazzi, M.; Stanzani, C.; Fiaschi, A.; Girardi, P.; Gandolfi, M.	Effect of balance training on postural instability in patients with idiopathic parkinsong's disease	2010	Repeat of article ID 1721
Solla, P.; Cugusi, L.; Bertoli, M.; Cereatti, A.; Della Croce, U.; Pani, D.; Fadda, L.; Cannas, A.; Marrosu, F.; Defazio, G.; Mercuro, G.	Sardinian Folk Dance for Individuals with Parkinson's Disease: A Randomized Controlled Pilot Trial	2019	Fewer than 10 patients in each group
Song, J. H.; Zhou, P. Y.; Cao, Z. H.; Ding, Z. G.; Chen, H. X.; Zhang, G. B.	Rhythmic auditory stimulation with visual stimuli on motor and balance function of patients with Parkinson's disease	2015	Insufficient data
Song, R.; Grabowska, W.; Park, M.; Osypiuk, K.; Vergara-Diaz, G. P.; Bonato, P.; Hausdorff, J. M.; Fox, M.; Sudarsky, L. R.; Macklin, E.; Wayne, P. M.	The impact of Tai Chi and Qigong mind-body exercises on motor and non-motor function and quality of life in Parkinson's disease: A systematic review and meta-analysis	2017	References reviewed
Sparrow, D.; DeAngelis, T. R.; Hendron, K.; Thomas, C. A.; Saint-Hilaire, M.; Ellis, T.	Highly Challenging Balance Program Reduces Fall Rate in Parkinson Disease	2016	Patient population size
Spaulding, S. J.; Barber, B.; Colby, M.; Cormack, B.; Mick, T.; Jenkins, M. E.	Cueing and gait improvement among people with Parkinson's disease: a meta-analysis	2013	References reviewed
St George, R. J.; Carlson-Kuhta, P.; Burchiel, K. J.; Hogarth, P.; Frank, N.; Horak, F. B.	The effects of subthalamic and pallidal deep brain stimulation on postural responses in patients with Parkinson disease	2012	Doesn’t address question of interest
St George, R. J.; Carlson-Kuhta, P.; King, L. A.; Burchiel, K. J.; Horak, F. B.	Compensatory stepping in Parkinson's disease is still a problem after deep brain stimulation randomized to STN or GPi	2015	Doesn’t address question of interest
St George, R. J.; Carlson-Kuhta, P.; Nutt, J. G.; Hogarth, P.; Burchiel, K. J.; Horak, F. B.	The effect of deep brain stimulation randomized by site on balance in Parkinson's disease	2014	Doesn’t address question of interest
Stack, E.; Agarwal, V.; King, R.; Burnett, M.; Tahavori, F.; Janko, B.; Harwin, W.; Ashburn, A.; Kunkel, D.	Identifying balance impairments in people with Parkinson's disease using video and wearable sensors	2018	Not RCT
Stack, E.; Roberts, H.; Ashburn, A.	The PIT: SToPP Trial-A Feasibility Randomised Controlled Trial of Home-Based Physiotherapy for People with Parkinson's Disease Using Video-Based Measures to Preserve Assessor Blinding	2012	Insufficient data
Staiano, A. E.; Flynn, R.	Therapeutic Uses of Active Videogames: A Systematic Review	2014	References reviewed
Stanmore, E.; Stubbs, B.; Vancampfort, D.; de Bruin, E. D.; Firth, J.	The effect of active video games on cognitive functioning in clinical and non-clinical populations: A meta-analysis of randomized controlled trials	2017	Systematic review

Authors	Article Title	Year	Reason for Exclusion
Steffen, T.; Seney, M.	Test-retest reliability and minimal detectable change on balance and ambulation tests, the 36-item short-form health survey, and the unified Parkinson disease rating scale in people with parkinsonism	2008	Mixed patient population-not only Parkinson
Strouwen, C.; Molenaar, E. A.; Keus, S. H.; Munks, L.; Heremans, E.; Vandenberghe, W.; Bloem, B. R.; Nieuwboer, A.	Are factors related to dual-task performance in people with Parkinson's disease dependent on the type of dual task?	2016	Not RCT
Strouwen, C.; Molenaar, E. A.; Keus, S. H.; Munks, L.; Munneke, M.; Vandenberghe, W.; Bloem, B. R.; Nieuwboer, A.	Protocol for a randomized comparison of integrated versus consecutive dual task practice in Parkinson's disease: the DUALITY trial	2014	No result sections
Strouwen, C.; Molenaar, Ealm; Munks, L.; Broeder, S.; Ginis, P.; Bloem, B. R.; Nieuwboer, A.; Heremans, E.	Determinants of Dual-Task Training Effect Size in Parkinson Disease: Who Will Benefit Most?	2019	Does not address question of interest
Stuart, S.; Vitorio, R.; Morris, R.; Martini, D. N.; Fino, P. C.; Mancini, M.	Cortical activity during walking and balance tasks in older adults and in people with Parkinson's disease: A structured review	2018	References reviewed
Stuckenschneider, T.; Askew, C. D.; Meneses, A. L.; Baake, R.; Weber, J.; Schneider, S.	The Effect of Different Exercise Modes on Domain-Specific Cognitive Function in Patients Suffering from Parkinson's Disease: A Systematic Review of Randomized Controlled Trials	2019	References reviewed
Sturkenboom, I. H.; Graff, M. J.; Borm, G. F.; Adang, E. M.; Nijhuis-van der Sanden, M. W.; Bloem, B. R.; Munneke, M.	Effectiveness of occupational therapy in Parkinson's disease: study protocol for a randomized controlled trial	2013	No result sections
Sturkenboom, I. H.; Graff, M. J.; Borm, G. F.; Veenhuizen, Y.; Bloem, B. R.; Munneke, M.; Nijhuis-van der Sanden, M. W.	The impact of occupational therapy in Parkinson's disease: a randomized controlled feasibility study	2013	No PT intervention
Sturkenboom, I. H.; Graff, M. J.; Hendriks, J. C.; Veenhuizen, Y.; Munneke, M.; Bloem, B. R.; Nijhuis-van der Sanden, M. W.; O. TiP study group	Efficacy of occupational therapy for patients with Parkinson's disease: a randomised controlled trial	2014	No PT intervention
Sturkenboom, I. H.; Hendriks, J. C.; Graff, M. J.; Adang, E. M.; Munneke, M.; Nijhuis-van der Sanden, M. W.; Bloem, B. R.	Economic evaluation of occupational therapy in Parkinson's disease: A randomized controlled trial	2015	Cost analysis
Sturkenboom, I. H.; Nijhuis-van der Sanden, M. W.; Graff, M. J.	A process evaluation of a home-based occupational therapy intervention for Parkinson's patients and their caregivers performed alongside a randomized controlled trial	2016	Doesn't include analyses with comparison group
Suarez-Iglesias, D.; Miller, K. J.; Seijo-Martinez, M.; Ayan, C.	Benefits of Pilates in Parkinson's Disease: A Systematic Review and Meta-Analysis	2019	References reviewed
Sun, Y.; Chen, X.	A randomized controlled clinical trial of a core stability exercise program for the intrinsic motivation of Parkinson's patients	2017	Doesn't address question of interest
Svaerke, K.; Niemeijer, M.; LÃ¸kkegaard, A.	The Effects of Computer-Based Cognitive Rehabilitation on Working Memory in Patients with Parkinson's Disease: A Systematic Review	2020	References reviewed
Swank, C.; Shearin, S.; Cleveland, S.; Driver, S.	Auditing the Physical Activity and Parkinson Disease Literature Using the Behavioral Epidemiologic Framework	2017	References reviewed

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Authors	Article Title	Year	Reason for Exclusion
Tambosco, L.; Percebois-Macadre, L.; Rapin, A.; Nicomette-Bardel, J.; Boyer, F. C.	Effort training in Parkinson's disease: a systematic review	2014	Systematic review
Tamplin, J.; Morris, M. E.; Marigliani, C.; Baker, F. A.; Vogel, A. P.	ParkinSong: A Controlled Trial of Singing-Based Therapy for Parkinson's Disease	2019	Not RCT; included atypical PD
Tang, L.; Fang, Y.; Yin, J.	The effects of exercise interventions on Parkinson's disease: A Bayesian network meta-analysis	2019	References reviewed
Terrens, A. F.; Soh, S. E.; Morgan, P. E.	The efficacy and feasibility of aquatic physiotherapy for people with Parkinson's disease: a systematic review	2018	References reviewed
Toh, S. F. M.	A systematic review on the effectiveness of Tai Chi exercise in individuals with Parkinson's disease from 2003 to 2013	2013	Systematic review
Tomlinson, C. L.; Herd, C. P.; Clarke, C. E.; Meek, C.; Patel, S.; Stowe, R.; Deane, K. H.; Shah, L.; Sackley, C. M.; Wheatley, K.; Ives, N.	Physiotherapy for Parkinson's disease: a comparison of techniques	2014	Systematic review
Triegaardt, J.; Han, T. S.; Sada, C.; Sharma, S.; Sharma, P.	The role of virtual reality on outcomes in rehabilitation of Parkinson's disease: meta-analysis and systematic review in 1031 participants	2020	References reviewed
Trigueiro, L. C.; Gama, G. L.; Simao, C. R.; Sousa, A. V.; Godeiro Junior Cde, O.; Lindquist, A. R.	Effects of Treadmill Training with Load on Gait in Parkinson Disease: A Randomized Controlled Clinical Trial	2015	Fewer than 10 patients in each group
Uc, E. Y.; Doerschug, K. C.; Magnotta, V.; Dawson, J. D.; Thomsen, T. R.; Kline, J. N.; Rizzo, M.; Newman, S. R.; Mehta, S.; Grabowski, T. J.; Bruss, J.; Blanchette, D. R.; Anderson, S. W.; Voss, M. W.; Kramer, A. F.; Darling, W. G.	Phase I/II randomized trial of aerobic exercise in Parkinson disease in a community setting	2014	Mixed patient population-Parkinsonisms
Uchitomi, H.; Ogawa, K.; Orimo, S.; Wada, Y.; Miyake, Y.	Effect of Interpersonal Interaction on Festinating Gait Rehabilitation in Patients with Parkinson's Disease	2016	Not RCT
Uhrbrand, A.; Stenager, E.; Pedersen, M. S.; Dalgas, U.	Parkinson's disease and intensive exercise therapy--a systematic review and meta-analysis of randomized controlled trials	2015	Systematic review
Unterreiner, M.; Biedermann, C.; El-Fahem, R.; John, M.; Klose, S.; Haas, C. T.; WÃ¤chter, T.	Comparing computer-aided therapy with conventional physiotherapy in Parkinsonâ??s disease: An equivalence study	2019	Doesn't address comparison of interest
Unterreiner, M.; Biedermann, C.; El-Fahem, R.; John, M.; Klose, S.; Haas, C. T.; Wachter, T.	Comparing computer-aided therapy with conventional physiotherapy in ParkinsonÃ¢â?¬â?¢s disease: an equivalence study	2019	Repeat of article ID 10665
van Balkom, T. D.; Berendse, H. W.; van der Werf, Y. D.; Twisk, J. W. R.; Zijlstra, I.; Hagen, R. H.; Berk, T.; Vriend, C.; van den Heuvel, O. A.	COGTIPS: a double-blind randomized active controlled trial protocol to study the effect of home-based, online cognitive training on cognition and brain networks in Parkinson's disease	2019	Study protocol
van Beek, J. J. W.; van Wegen, E. E. H.; Bohlhalter, S.; Vanbellingen, T.	Exergaming-Based Dexterity Training in Persons With Parkinson Disease: A Pilot Feasibility Study	2019	Not RCT

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Authors	Article Title	Year	Reason for Exclusion
van de Weijer, S. C.; Duits, A. A.; Bloem, B. R.; Kessels, R. P.; Jansen, J. F.; Kohler, S.; Tissingh, G.; Kuijf, M. L.	The Parkin'Play study: protocol of a phase II randomized controlled trial to assess the effects of a health game on cognition in Parkinson's disease	2016	No result sections
van den Heuvel, M. R.; van Wegen, E. E.; de Goede, C. J.; Burgers-Bots, I. A.; Beek, P. J.; Daffertshofer, A.; Kwakkel, G.	The effects of augmented visual feedback during balance training in Parkinson's disease: study design of a randomized clinical trial	2013	No result sections
van der Kolk, N. M.; Overeem, S.; de Vries, N. M.; Kessels, R. P.; Donders, R.; Brouwer, M.; Berg, D.; Post, B.; Bloem, B. R.	Design of the Park-in-Shape study: a phase II double blind randomized controlled trial evaluating the effects of exercise on motor and non-motor symptoms in Parkinson's disease	2015	No result sections
van Nimwegen, M.; Speelman, A. D.; Smulders, K.; Overeem, S.; Borm, G. F.; Backx, F. J.; Bloem, B. R.; Munneke, M.; ParkFit Study, Group	Design and baseline characteristics of the ParkFit study, a randomized controlled trial evaluating the effectiveness of a multifaceted behavioral program to increase physical activity in Parkinson patients	2010	Study protocol; full study ID# 1386
Van Ooteghem, K.; Frank, J. S.; Horak, F. B.	Postural motor learning in Parkinson's disease: The effect of practice on continuous compensatory postural regulation	2017	Not RCT
Van Puymbroeck, M.; Walter, A. A.; Hawkins, B. L.; Sharp, J. L.; Woschkolup, K.; Urrea-Mendoza, E.; Revilla, F.; Adams, E. V.; Schmid, A. A.	Corrigendum to "Functional Improvements in Parkinson's Disease Following a Randomized Trial of Yoga"	2018	Not relevant to criteria
Veazey, C.; Cook, K. F.; Stanley, M.; Lai, E. C.; Kunik, M. E.	Telephone-administered cognitive behavioral therapy: a case study of anxiety and depression in Parkinson's disease	2009	Fewer than 10 patients per group
Vienne, A.; Barrois, R. P.; Buffat, S.; Ricard, D.; Vidal, P. P.	Inertial Sensors to Assess Gait Quality in Patients with Neurological Disorders: A Systematic Review of Technical and Analytical Challenges	2017	References reviewed
Vivas, J.; Arias, P.; Cudeiro, J.	Aquatic therapy versus conventional land-based therapy for Parkinson's disease: an open-label pilot study	2011	Patient population
Volpe, D.; Giantin, M. G.; Manuela, P.; Filippetto, C.; Pelosin, E.; Abbruzzese, G.; Antonini, A.	Water-based vs. non-water-based physiotherapy for rehabilitation of postural deformities in Parkinson's disease: a randomized controlled pilot study	2017	Incorrect population
Vorasoot, N.; Termsarasab, P.; Thadanipon, K.; Pulkes, T.	Effects of handwriting exercise on functional outcome in Parkinson disease: A randomized controlled trial	2020	No PT intervention
Voss, T. S.; Elm, J. J.; Wielinski, C. L.; Aminoff, M. J.; Bandyopadhyay, D.; Chou, K. L.; Sudarsky, L. R.; Tilley, B. C.; Falls Writing Group, Ninds N. E. T. P. D. Investigators	Fall frequency and risk assessment in early Parkinson's disease	2012	Doesn’t address question of interest
Walton, C. C.; Mowszowski, L.; Gilat, M.; Hall, J. M.; O'Callaghan, C.; Muller, A. J.; Georgiades, M.; Szeto, J. Y. Y.; Ehgoetz Martens, K. A.; Shine, J. M.; Naismith, S. L.; Lewis, S. J. G.	Cognitive training for freezing of gait in Parkinson's disease: a randomized controlled trial	2018	No PT intervention

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Authors	Article Title	Year	Reason for Exclusion
Wang, B.; Shen, M.; Wang, Y. X.; He, Z. W.; Chi, S. Q.; Yang, Z. H.	Effect of virtual reality on balance and gait ability in patients with Parkinson's disease: a systematic review and meta-analysis	2019	Systematic review
Wang, J. W.; Zhang, Y. Q.; Zhang, X. H.; Wang, Y. P.; Li, J. P.; Li, Y. J.	Deep Brain Stimulation of Pedunculopontine Nucleus for Postural Instability and Gait Disorder After Parkinson Disease: A Meta-Analysis of Individual Patient Data	2017	References reviewed
Wang, M.; Li, Z.; Lee, E. Y.; Lewis, M. M.; Zhang, L.; Sterling, N. W.; Wagner, D.; Eslinger, P.; Du, G.; Huang, X.	Predicting the multi-domain progression of Parkinson's disease: a Bayesian multivariate generalized linear mixed-effect model	2017	Not RCT
Wang, X. Q.; Pi, Y. L.; Chen, B. L.; Wang, R.; Li, X.; Chen, P. J.	Cognitive motor intervention for gait and balance in Parkinson's disease: systematic review and meta-analysis	2016	References reviewed
Warlop, T.; Detrembleur, C.; Buxes Lopez, M.; Stoquart, G.; Lejeune, T.; Jeanjean, A.	Does Nordic Walking restore the temporal organization of gait variability in Parkinson's disease?	2017	Not RCT, not all PD patients
Watts, J. J.; McGinley, J. L.; Huxham, F.; Menz, H. B.; Iansek, R.; Murphy, A. T.; Waller, E. R.; Morris, M. E.	Cost effectiveness of preventing falls and improving mobility in people with Parkinson disease: protocol for an economic evaluation alongside a clinical trial	2008	Cost analysis
Weaver, F. M.; Follett, K. A.; Stern, M.; Luo, P.; Harris, C. L.; Hur, K.; Marks, W. J., Jr.; Rothlind, J.; Sagher, O.; Moy, C.; Pahwa, R.; Burchiel, K.; Hogarth, P.; Lai, E. C.; Duda, J. E.; Holloway, K.; Samii, A.; Horn, S.; Bronstein, J. M.; Stoner, G.; Starr, P. A.; Simpson, R.; Baltuch, G.; De Salles, A.; Huang, G. D.; Reda, D. J.	Randomized trial of deep brain stimulation for Parkinson disease: thirty- 6-month outcomes	2012	Doesn't address question of interest
Weaver, F. M.; Stroupe, K. T.; Cao, L.; Holloway, R. G.; Vickrey, B. G.; Simuni, T.; Hendricks, A.; Ippolito, D.	Parkinson's disease medication use and costs following deep brain stimulation	2012	Cost analysis
Weiss, D.; Walach, M.; Meisner, C.; Fritz, M.; Scholten, M.; Breit, S.; Plewnia, C.; Bender, B.; Gharabaghi, A.; Wachter, T.; Kruger, R.	Nigral stimulation for resistant axial motor impairment in Parkinson's disease? A randomized controlled trial	2013	Not relevant to criteria treatment
Welman, K.; Atterbury, E.	//Therapist-supervised compared to home-based balance training encourages a 'posture first' strategy during turn-to-sit transitions in individuals with Parkinson's disease	2018	Not a full study
Willems, A. M.; Nieuwboer, A.; Chavret, F.; Desloovere, K.; Dom, R.; Rochester, L.; Jones, D.; Kwakkel, G.; Van Wegen, E.	The use of rhythmic auditory cues to influence gait in patients with Parkinson's disease, the differential effect for freezers and non-freezers, an explorative study	2006	Not RCT
Williams, A.; Gill, S.; Varma, T.; Jenkinson, C.; Quinn, N.; Mitchell, R.; Scott, R.; Ives, N.; Rick, C.; Daniels, J.; Patel, S.; Wheatley, K.	Deep brain stimulation plus best medical therapy versus best medical therapy alone for advanced Parkinson's disease (PD SURG trial): a randomised, open-label trial	2010	Doesn't address question of interest

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Authors	Article Title	Year	Reason for Exclusion
Wills, A. M.; Li, R.; Perez, A.; Ren, X.; Boyd, J.; Ninds Net-Pd Investigators	Predictors of weight loss in early treated Parkinson's disease from the NET-PD LS-1 cohort	2017	Doesn't address question of interest
Winser, S. J.; Paul, L. F.; Magnus, L. K. L.; Yan, S.; Shenug, T. P.; Sing, Y. M.; Cheing, G.	Economic Evaluation of Exercise-Based Fall Prevention Programs for People with Parkinson's Disease: A Systematic Review	2019	References reviewed
Wittwer, J. E.; Webster, K. E.; Hill, K.	Rhythmic auditory cueing to improve walking in patients with neurological conditions other than Parkinson's disease--what is the evidence?	2013	Systematic review
Wu, B.; Han, L.; Sun, B. M.; Hu, X. W.; Wang, X. P.	Influence of deep brain stimulation of the subthalamic nucleus on cognitive function in patients with Parkinson's disease	2014	References reviewed
Wu, P. L.; Lee, M.; Huang, T. T.	Effectiveness of physical activity on patients with depression and Parkinson's disease: A systematic review	2017	References reviewed
Xie, T.; Padmanaban, M.; Bloom, L.; MacCracken, E.; Bertacchi, B.; Dachman, A.; Warnke, P.	Effect of low versus high frequency stimulation on freezing of gait and other axial symptoms in Parkinson patients with bilateral STN DBS: a mini-review	2017	Systematic review
Xie, Y. J.; Gao, Q.; He, C. Q.; Bian, R.	Effect of Repetitive Transcranial Magnetic Stimulation on Gait and Freezing of Gait in Parkinson Disease: A Systematic Review and Meta-analysis	2020	References reviewed
Yang, L.; Lam, F. M. H.; Liao, L. R.; Huang, M. Z.; He, C. Q.; Pang, M. Y. C.	Psychometric properties of dual-task balance and walking assessments for individuals with neurological conditions: A systematic review	2017	References reviewed
Yang, Y.; Hao, Y. L.; Tian, W. J.; Gong, L.; Zhang, K.; Shi, Q. G.; Sun, D. F.; Li, C. L.; Zhao, Z. L.	The effectiveness of Tai Chi for patients with Parkinson's disease: study protocol for a randomized controlled trial	2015	No result sections
Yang, Y.; Li, X. Y.; Gong, L.; Zhu, Y. L.; Hao, Y. L.	Tai Chi for improvement of motor function, balance and gait in Parkinson's disease: a systematic review and meta-analysis	2014	Systematic review
Yitayeh, A.; Teshome, A.	The effectiveness of physiotherapy treatment on balance dysfunction and postural instability in persons with Parkinson's disease: a systematic review and meta-analysis	2016	References reviewed
Yotnuengnit, P.; Bhidayasiri, R.; Donkhan, R.; Chaluaysrimuang, J.; Piravej, K.	Effects of Transcranial Direct Current Stimulation Plus Physical Therapy on Gait in Patients With Parkinson Disease: A Randomized Controlled Trial	2018	Patients do not receive DBS (tDCS = noninvasive)
Yuen, C.; Chua, K.; Lau, W.; Zhuang, Z.; Chow, H.; Li, M.	The effect of conduction exercise and self-acupressure in treatment of Parkinson's disease: Protocol for a pilot study	2019	Study protocol
Zeng, W.; Kao, P. J.; Lee, Y. Y.; Wu, R. M.; Luh, J. J.; Lin, S. Y.	Effects of combined auditory cues and treadmill training on cortical excitability and gait performance in Parkinson's disease	2019	Only contains abstract, fewer than 10 patients per group
Zhan, A.; Mohan, S.; Tarolli, C.; Schneider, R. B.; Adams, J. L.; Sharma, S.; Elson, M. J.; Spear, K. L.; Glidden, A. M.; Little, M. A.; Terzis, A.; Dorsey, E. R.; Saria, S.	Using Smartphones and Machine Learning to Quantify Parkinson Disease Severity: The Mobile Parkinson Disease Score	2018	Not RCT

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Authors	Article Title	Year	Reason for Exclusion
Zhang, Q.; Hu, J.; Wei, L.; Jia, Y.; Jin, Y.	Effects of dance therapy on cognitive and mood symptoms in people with Parkinson's disease: A systematic review and meta-analysis	2019	References reviewed
Zhang, S.; Liu, D.; Ye, D.; Li, H.; Chen, F.	Can music-based movement therapy improve motor dysfunction in patients with Parkinson's disease? Systematic review and meta-analysis	2017	References reviewed

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Guideline Development Group Disclosures

Prior to the development of this clinical practice guideline, clinical practice guideline development group members disclosed conflicts of interest (COI). They disclosed COIs in writing to the American Academy of Orthopaedic Surgeons via a private online reporting database and verbally at the recommendation approval meeting.

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Appendix 3

PICO Questions Used to Define Literature Search

1. In patients with Parkinson's, are aerobic interventions more effective than no/other treatments in affecting patient outcomes?
2. In patients with Parkinson's, are resistance interventions more effective than no/other treatments in affecting patient outcomes?
3. In patients with Parkinson's, are balance interventions more effective than no/other treatments in affecting patient outcomes?
4. In patients with Parkinson's, are stretching/flexibility interventions more effective than no/other treatments in affecting patient outcomes?
5. In patients with Parkinson's, does cueing affect outcomes?
6. In patients with Parkinson's, do PD community exercise programs affect outcomes?
7. In patients with Parkinson's, does gait training improve patient outcomes?
8. In patients with Parkinson's, does task specific training improve functional outcomes?
9. In patients with Parkinson's, which prognostic factors affect outcomes?
10. In patients with Parkinson's, does physical therapy using a behavioral change approach improve physical therapy or exercise outcomes?
11. In patients with Parkinson's, does interdisciplinary care improve outcomes?
12. In patients with Parkinson's with DBS, does pre- and/or post-physical therapy improve outcomes?
13. In patients with Parkinson's, which specific motor learning strategies/interventions improve patient outcomes?
14. In patients with Parkinson's, does receiving care from an expert physical therapist, improve outcomes?
15. In patients with Parkinson's, does physical therapist management, augmented with mobile health technology, improve patient outcomes?

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Literature Search Strategy

Database: MEDLINE (Ovid MEDLINE® and Epub Ahead of Print, In-Process and Other Non-Indexed Citations, Daily and Versions®, version 1946 to July 17, 2019)
Interface: Ovid
Dates Searched: 7/18/2019; 6/16/2020

Line	Query
1	(exp "Animals"/ NOT Humans/) OR exp "Cadaver"/ OR (animal? OR dog OR dogs OR canine OR horse OR horses OR equine OR mouse OR mice OR rat OR rats OR rabbit OR rabbits OR sheep OR porcine OR pig OR pigs OR rodent?).ti. OR (cadaver* OR in vitro).ti,ab.
2	(((comment or editorial or letter or historical article) not clinical trial) or address or news or newspaper article or case reports).pt. or (case report? OR abstracts OR editorial OR reply OR commentary).ti.
3	exp "Parkinson Disease"/ or ("parkinson disease" or "parkinson's disease").ti,ab.
4	exp "Exercise"/ or exp "Exercise Therapy"/ or (aerobic or aerobics).ti,ab.
5	exp "Resistance Training"/ or (strength or strengthening or resistance).ti,ab.
6	exp "Postural Balance"/ or (balance or postural or posture).ti,ab.
7	exp "Muscle Stretching Exercises"/ or exp "Exercise Movement Techniques"/ or (stretching or flexibility or yoga or "tai chi" or qigong or dance or dancing or boxing or training).ti,ab. or "Dance Therapy"/
8	exp "Cues"/ or (cues or cueing).ti,ab.
9	exp "Gait"/ or exp "Gait Analysis"/ or (gait).ti,ab.
10	exp "Physical Therapy Modalities"/ or "Rehabilitation"/ or "Occupational Therapy"/ or "Deep Brain Stimulation"/ OR "Transcranial Direct Current Stimulation"/ or "Transcranial Magnetic Stimulation"/ or ("physical therapy" or "physical therapies" or "physical therapist" or physiotherapy or physiotherapies or physiotherapist).ti,ab.
11	exp "Patient Care Team"/ or (multidisciplinary or interdisciplinary or "team based").ti,ab.
12	1 or 2
13	(3 and (4 or 5 or 6 or 7 or 8 or 9 or 10 or 11)) not 12
14	limit 13 to (english language and yr="1994-Current")
15	clinical trial.mp. OR clinical trial.pt. OR random:.mp. OR tu.xs.
16	(MEDLINE OR (systematic* AND review*) OR "meta analys*").ti,ab. OR (meta analysis OR systematic review).pt.
17	**14 and 15**
18	14 and (15 or 16)

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Database: Embase
Interface: Elsevier (https://embase.com)
Dates Searched: 7/18/2019; 6/16/2020

Line	Query
1	cadaver'/de OR 'in vitro study'/exp OR 'abstract report'/de OR abstracts:ti OR 'book'/de OR 'editorial'/de OR editorial:ti OR 'note'/de OR 'letter'/it OR reply:ti OR commentary:ti OR 'case study'/de OR 'case report'/de OR 'conference abstract'/it OR 'chapter'/it OR 'conference paper'/it OR 'conference review'/it OR (cadever* OR 'in vitro'):ti,ab OR 'animal experiment'/exp OR (animal$ OR dog OR dogs OR canine OR horse OR horses OR equine OR mouse OR mice OR rat OR rats OR rabbit OR rabbits OR sheep OR p$ediatric$ OR porcine OR pig OR pigs OR rodent$):ti
2	parkinson disease'/de OR 'parkinson disease':ti,ab OR 'parkinson s disease':ti,ab
3	exercise'/de or 'kinesiotherapy'/exp or 'aerobic exercise'/de or (aerobic or aerobics):ti,ab
4	resistance training'/exp or (strength or strengthening or resistance):ti,ab
5	body equilibrium'/exp or (balance or postural or posture):ti,ab
6	stretching exercise'/exp OR 'muscle stretching'/exp OR 'dance therapy'/exp or (stretching or flexibility or yoga or 'tai chi' or qigong or dance or dancing or boxing or training):ti,ab
7	association'/exp AND (cues:ti,ab OR cueing:ti,ab)
8	gait'/exp or gait:ti,ab
9	physiotherapy'/exp OR 'rehabilitation'/exp or ('physical therapy' or 'physical therapies' or 'physical therapist' or physiotherapy or physiotherapist or physiotherapies):ti,ab
10	collaborative care team'/exp or (multidisciplinary or interdisciplinary or 'team based'):ti,ab
11	#2 NOT #1 AND [english]/lim AND [1994-2019]/py
~~12~~	#11 AND #3
~~13~~	#11 AND #4
~~14~~	#11 AND #5
~~15~~	#11 AND #6
~~16~~	#11 AND #7
~~17~~	#11 AND #8
~~18~~	#11 AND #9
~~19~~	#11 AND #10
12	#11 AND (#3 OR #4 OR #5 OR #6 OR #7 OR #8 OR #9 OR #10)
13	crossover procedure':de OR 'double-blind procedure':de OR 'randomized controlled trial':de OR 'single-blind procedure':de OR (random* OR factorial* OR crossover* OR cross NEXT/1 over* OR placebo* OR doubl* NEAR/1 blind* OR singl* NEAR/1 blind* OR assign* OR allocat* OR volunteer*):de,ab,ti
14	systematic review'/exp OR 'meta analysis'/exp OR ((systematic* NEAR/2 review*):ti,ab,kw) OR 'meta analys*':ti,ab,kw
15	**#12 AND # 13**
16	#12 AND (#13 OR #14)

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Database: Cochrane Central Register of Controlled Trials (CENTRAL)
Interface: Wiley (https://www.cochranelibrary.com/central)
Dates Searched: 7/18/2019; 6/16/2020

Line	Query
1	[mh "parkinson disease"] or "parkinson disease" or "parkinson's disease"
2	[mh "exercise"] or [mh "exercise therapy"] or aerobic:ti,ab or aerobics:ti,ab
3	[mh "resistance training"] or (strength or strengthening or resistance):ti,ab
4	[mh "postural balance"] or (balance or posture or postural):ti,ab
5	[mh "muscle stretching exercises"] or [mh "exercise movement techniques"] or (stretching or flexibility or yoga or "tai chi" or qigong or dance or dancing or boxing or training):ti,ab
6	[mh "cues"] or (cues or cueing):ti,ab
7	[mh "gait"] or [mh "gait analysis"] OR gait:ti,ab
8	[mh "physical therapy modalities"] or [mh rehabilitation] or [mh "occupational therapy"] or ("physical therapy" or "physical therapies" or "physical therapist" or physiotherapy or physiotherapies or physiotherapist):ti,ab
9	[mh "Patient Care Team"] or (multidisciplinary or interdisciplinary or "team based"):ti,ab
10	#1 and (#2 or #3 or #4 or #5 or #6 or #7 or #8 or #9)
	with Publication Year from 1994 to 2019, in Trials
11	#10 not "conference abstract":pt
12	"conference abstract":pt OR abstracts:ti OR editorial:ti OR reply:ti OR commentary:ti OR cadaver*:ti,ab 'in vitro':ti,ab OR animal*:ti OR dog:ti OR dogs:ti OR canine:ti OR horse:ti OR horses:ti OR equine:ti OR mouse:ti OR mice:ti OR rat:ti OR rats:ti OR rabbit:ti OR rabbits:ti OR sheep:ti OR porcine:ti OR pig:ti OR pigs:ti OR rodent*:ti
13	(#1 and #2) not #12
14	(#1 and #3) not #12
15	(#1 and #4) not #12
16	(#1 and #5) not #12
17	(#1 and #6) not #12
18	(#1 and #7) not #12
19	(#1 and #8) not #12
20	(#1 and #9) not #12
21	#10 not #12

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Inclusion Criteria

Standard Inclusion Criteria

- Articles must be a full article report of a clinical study (studies using registry data can be included in a guideline if they are published in a peer-reviewed journal and meets all other inclusion criteria/quality standards).
- Noncomparative case series/incidence/prevalence studies, meeting abstracts, historical articles, editorials, letters, and commentaries are excluded.
- Confounded studies (i.e., studies that give patients the treatment of interest AND another treatment without appropriate sub-analysis or statistical adjustment) are excluded.
- Case series studies that have nonconsecutive enrollment of patients are excluded.
- Controlled trials in which patients were not stochastically assigned to groups AND in which there was either a difference in patient characteristics or outcomes at baseline AND where the authors did not statistically adjust for these differences when analyzing the results are excluded.
- All studies of "Very Low" quality of evidence (e.g., Level V) are excluded.
- Studies not appearing in a peer-reviewed publication are excluded.
- For any included study that uses "paper-and-pencil" outcome measures (e.g., Composite measures, SF36, etc.), only outcome measures that have been validated are included.
- For any given follow-up time point in any included study, there must be ≥ 50% patient follow-up (if the follow-up is >50% but <80%, the study quality will be downgraded).
- Studies must be of humans.
- Studies must be published in English.
- Studies results must be quantitatively presented.
- In vitro studies are excluded.
- Biomechanical studies are excluded.
- Studies performed on cadavers are excluded.

We will only evaluate surrogate outcomes when no patient-oriented outcomes are available.

Customized Inclusion Criteria

- Study must be of "individuals with Parkinson disease."
    - Do NOT include atypical PD, Parkinson plus syndromes, Parkinsonism.
- Study must be published in or after 1994.
- Studies should have "10" or more patients per group.
- Patient outcome follow-up times should be "no restriction."
- Study must be a randomized controlled trial.

Best Available Evidence

When examining primary studies, we will analyze the best available evidence regardless of study design. We will first consider randomized controlled trials identified by the search strategy. In the absence of 2 or more RCTs, we will sequentially search for prospective controlled trials, prospective comparative studies, retrospective comparative studies, and prospective case-series studies. Only studies of the highest level of available evidence are included, assuming that there were 2 or more studies of that higher level. For example, if there are 2 high-quality studies that address the recommendation, moderate and low studies addressing the same procedure and outcomes are not included.

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