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## Evidence-based analysis of physiotherapy in Parkinson's disease with recommendations for practice and research

Based on: Keus SHJ, Bloem BR, Hendriks EJ, Bredero-Cohen AB and Munneke M, on behalf of the Practice Recommendations Development Group. *Mov Disord* 2007; 22(4):451-460.

### Summary

Physiotherapy is often prescribed in Parkinson's disease (PD). To facilitate the uniformity and efficacy of this intervention, we analysed current evidence and developed practice recommendations. Therefore, we carried out an evidence-based literature review. The results were supplemented with clinical expertise and patient values and translated into practice recommendations, developed according to international standards of guideline development. A systematic literature search yielded six systematic reviews and 23 randomised controlled trials of moderate methodological quality with sufficient data. Six specific core areas for physiotherapy in PD were identified: transfers, posture, reaching and grasping, balance, gait and physical capacity. We extracted four specific treatment recommendations that were based on evidence from at least two controlled trials: cueing strategies to improve gait; cognitive movement strategies to improve transfers; exercises to improve balance; and training of joint mobility and muscle power to improve physical capacity. These practice recommendations provide a basis for current physiotherapy in PD in everyday clinical practice, as well as for future research in this field.



## Introduction

In the course of their disease, most patients with Parkinson's disease (PD) face mounting mobility deficits, including difficulties with transfers, posture, balance and walking. This frequently leads to loss of independence, (fear of) falls, injuries and inactivity, resulting in social isolation and an increased risk of osteoporosis or cardiovascular disease.<sup>35;153</sup> Consequently, costs increase and quality of life decreases.<sup>5;6</sup> These mobility deficits are difficult to treat with drugs or neurosurgery.<sup>89;154</sup>

Physiotherapy is often prescribed next to medical treatment.<sup>155</sup> However, there are presently no guidelines for physiotherapy in PD with practical recommendations graded according to scientific evidence. Prior research was hampered by this lack of uniform treatment recommendations.<sup>138;147;156</sup> Therefore, we developed evidence-based practice recommendations according to international criteria for guideline development.<sup>157;158</sup>

With these recommendations we aim to facilitate the uniformity and efficacy of physiotherapy in PD. Furthermore, the recommendations will provide referring physicians insight into the possibilities and limitations of physiotherapy in PD, thereby promoting the quality of referrals. Finally, the recommendations can provide a firm basis for future research in this field.

Here, we describe the systematic analysis of evidence and the key recommendations. For detailed recommendations on referral indications and treatment options we refer to a comprehensive description that is available online: [www.cebp.nl](http://www.cebp.nl) or [www.kngf.nl](http://www.kngf.nl).

## Methods

### Evidence-based literature review

#### *Search strategy and selection criteria*

First, in May 2002, we carried out a systematic literature search for guidelines, systematic reviews, trials and expert opinions was performed in the electronic databases of MEDLINE, CINAHL, Embase and the Cochrane register of controlled trials. As insights may evolve over time, expert opinions were only included when published after May 1997. Randomised controlled trials (RCTs), controlled clinical trials (CCTs) and pre-experimental studies were identified using combinations of the following [MeSH] headings and free texts: 'Parkinson disease', 'physical therapy', 'physical therapy techniques', 'exercise movement techniques', 'exercise', 'exercise therapy', 'physiotherapy' and 'training'. To identify clinical measurements for baseline assessment and treatment evaluation purposes, combinations of the following [MeSH] headings and free texts were

used: 'Parkinson disease', 'sensitivity and specificity', 'exercise test', 'physical examination', 'outcome assessment' and 'treatment outcome'. Furthermore, cross-references and expert recommended references were evaluated. To be selected, publications had to address physiotherapy in PD and be published in English, Dutch, or German. Trials were only selected if sufficient data were reported.

### Levels of evidence

The selected literature was critically appraised by assessing the quality of the study design. When evidence was not available in published studies, recommendations were formulated based on consensus among the members of the Practice Recommendations Development Group. Evidence was graded according to EBRO recommendations (*Table 1*). EBRO is an initiative of the Dutch Cochrane Center and the Dutch Institute for Healthcare Improvement (CBO, [www.cbo.nl](http://www.cbo.nl)), a member of the Guidelines International Network (GIN). Consensus was gained via informative meetings; Delphi rounds; web-based discussions; and consensus-meetings. Finally, practice recommendations were graded based on their levels of evidence (*Table 2*).

**Table 1. EBRO-classification of study results according to the level of evidence**

Level	Level of the evidence
A1	Meta-analyses (systematic reviews), which include at least some, randomised clinical trials at quality level A2 that show consistent results between studies;
A2	Randomised clinical trials of a good methodological quality (randomised double-blind controlled studies) with sufficient power and consistency;
B	Randomised clinical trials of a moderate methodological quality or with insufficient power, or other non-randomised, cohort or patient-control group study designs that involve inter-group comparisons;
C	Patient series;
D	Expert opinion.

**Table 2. EBRO-grading of recommendations according to the level of evidence**

Level	Level of the evidence
1	Supported by one systematic review at quality level A1 or at least two independent trials at quality level A2;
2	Supported by at least two independent trials at quality level B;
3	Supported by one trial at quality level A2 or B, or research at quality level C;
4	Based on the expert opinion (e.g. published in peer-reviewed medical journals or by the members of the Practice Recommendations Development Group).

### *Identified literature*

The literature searches yielded six systematic reviews<sup>138;139;147;150;156;159</sup> controlled (level B) studies with sufficient data on the effectiveness of physiotherapy in PD.<sup>38;84-86;102-104;110;117;120-123;160-170</sup> One of these studies was covered in two publications.<sup>84;104</sup> Another six controlled studies could not be included, due to insufficient data.<sup>171-176</sup>

### **Extracting Practice Recommendations**

A national Practice Recommendations Development Group of nine expert physiotherapists and one expert neurologist, as well as a Steering Committee that guarded the development process, were installed in December 2001. On the basis of the systematic literature search practice recommendations were deduced according to international standards for guideline development.<sup>157;158</sup>

### *Clinical expertise and patient values*

An independent, international Review Panel of 16 professionals with specific expertise in movement disorders (e.g. neurologist, general practitioner, physiotherapist and occupational therapist), reviewed a draft of the practice recommendations. Finally, a Patient Panel of the Dutch Parkinson's Disease Association reviewed a draft of the practice recommendations. The key question to the patient was 'Would your physiotherapist be able to optimally treat you and the problems you experience due to your Parkinson's disease, if he had a copy of this manuscript?'. The Practice Recommendations Development Group discussed the collected drawbacks and strengths of the recommendations until consensus was reached. Finally, the literature search was updated in October 2003. Newly found evidence was graded according to the EBRO-criteria and, after consensus was reached, incorporated into the recommendations.

## **Results**

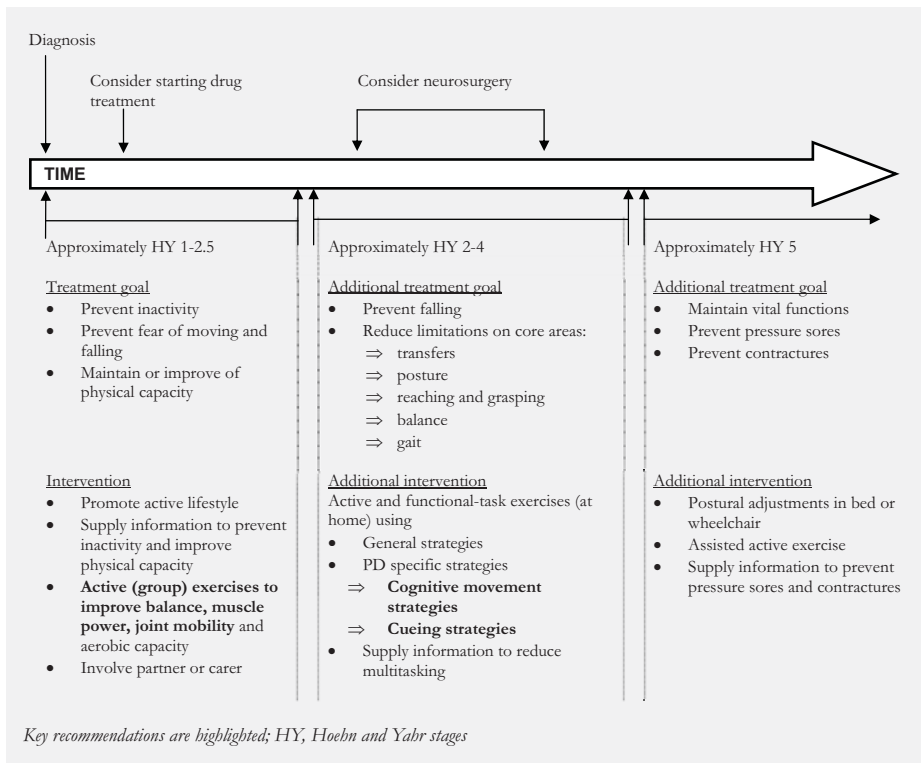
### **Core areas**

Physiotherapy is unlikely to influence the disease process itself, but can improve daily functioning by teaching PD patients in the use of (compensatory) movement strategies. Furthermore, physiotherapy may influence, or even prevent, secondary health problems such as cardiovascular diseases due to an inactive lifestyle.

Six specific core areas for physiotherapy in PD were identified (in random order):

1. Transfers (e.g. turning in bed or rising from a chair);
2. Posture (including neck and back problems);
3. Reaching and grasping;
4. Balance and falls (including fear of falling);
5. Gait;
6. Physical capacity and (in)activity.

**Figure 1. Phases in the course of PD: goals and possible interventions for physiotherapy**



### History taking and physical examination

The practice recommendations contain a quick reference card for history taking and physical examination. During history taking, the physiotherapist should systematically assess health problems on all levels of the International Classification of Functioning, Disability and Health (ICF): impairments, activity limitations and participation restrictions (*Chapter 1*). The outcome of the history taking and physical assessment determines the core area(s) for treatment. Finally, the therapist should examine the patient's expectations regarding treatment, particularly whether these are realistic. Based on the results of the

history taking and physical examination, the therapist determines whether physiotherapy is indicated and, if so, draws a treatment plan. The Practice Recommendations Development Group has identified three phases in the course of the disease: early, middle, late (*Figure 1*). These phases are based on the model of Kamsma.<sup>39</sup> Each phase is characterised by specific physiotherapy goals and interventions within the six core areas. In the successive phases, the goals and interventions of the foregoing phase(s) might valid.

### **Clinical measurements**

We selected clinical measurements (both quantitative and qualitative) for baseline assessment and treatment evaluation purposes. In physiotherapy, the most suitable instruments are linked to the ICF-domain of level of limitations (in activities).<sup>19;177</sup> Instruments were selected based on ICF-domain, feasibility and clinimetric properties: reliability; validity; and responsiveness.

Three instruments are recommended for use in all patients: the Patient Specific Index (PSI), a patient preference disability questionnaire to identify patient-specific complaints (for baseline assessment and treatment evaluation)<sup>178;179</sup>, a structured falls history questionnaire (for baseline assessment)<sup>65</sup> and the global perceived effect (for treatment evaluation).

PD patients with more than one fall in the previous year are likely to fall again within the next three months. This can lead to fractures or other physical injury and to (more) fear to move, resulting in decreased activities and an increased liability to renewed falls. Most falls in PD occur during transfers (e.g. rising from a chair) and during (freezing of) gait.<sup>60;65</sup> Therefore, fall circumstances should be adequately screened to guarantee that interventions are tailored to the patient's specific fall circumstances.

Repeated clinical evaluations should always be performed while the patient is in a comparable clinical state (e.g. always at the same time after medication intake, or standardised for on- and off-periods). Depending on the patient-specific treatment goals and the patient's motivation, treatment should be finished when the goals are reached, or when the therapist concludes that physiotherapy no longer has additional value (e.g. the goals are unreachable, or the patient can achieve the goals unsupervised).

### **Key recommendations**

Of all practice recommendations for physiotherapy in PD, four are based on evidence from two or more controlled trials (*Tables 3 to 5*). Therefore, they reach 'level 2'-recommendation (*Table 2*):

- I. Application of cueing strategies to improve gait;
- II. Application of cognitive movement strategies to improve transfers;
- III. Specific exercises to improve balance;
- IV. Training of joint mobility and muscle power to improve physical capacity.

### *I. Cueing strategies*

It is plausible that in patients with PD, gait is improved by applying visual or auditory cues, which have been trained during active gait training.<sup>85;186</sup>

Cues are stimuli from the environment or generated by the patient. The patient uses these cues, consciously or not, to facilitate (automatic and repetitive) movements. It is not yet clear exactly how cues improve movement. Perhaps they provide an external rhythm that can compensate for the improperly supplied internal rhythm of the basal ganglia, correct the motor set deficiency, or (in case of visual cues) generate optical flow that activates a cerebellar visual–motor pathway.<sup>150</sup> Not all patients benefit equally from using cues.

A distinction is made between rhythmical cues and ‘one-off’ cues. Rhythmical cues are given as a continuous, serial set of stimuli, which can serve as a control mechanism to pace walking. The frequency of rhythmical cues required is situation-specific. In most situations, a comfortable walking speed is required. Then, the cueing frequency is based on the patient’s comfortable walking speed as measured with the Ten-meter Walk Test.<sup>103</sup> One-off cues are used as a focusing point to maintain balance and for initiating activities of daily living (e.g. start walking after a period of freezing, or rising from a chair).

Cues can be divided into four groups:

- Auditory cues, e.g. the use of a walkman with rhythmic music, a metronome or counting (by the patient, partner or carer)<sup>84-86;121;165;180-182</sup>;
- Visual cues, e.g. stepping over stripes on the floor or over the grip of an inverted walking stick, or focusing on an object (e.g. a clock) in the environment<sup>84;85;165;181;183-186</sup>;
- Tactile cues, e.g. tapping on the hip or the leg<sup>84;165</sup>;
- Cognitive cues, e.g. a mental image of the appropriate step length.<sup>121;186</sup>

### *II. Cognitive movement strategies*

It is plausible that in patients with PD applying cognitive movement strategies improves the performance of transfers.<sup>38;85</sup>

In this strategy, complex automated movements are transformed into a series of sub-movements that have to be executed in a fixed order. All elements consist of relatively simple movement components. The course of the movement is thereby reorganised in such a way that the activity can be performed consciously. The fundamental problem of disturbed internal control (in particular the inability of the basal ganglia to automatically program sequential movements) is thus by-passed. Before execution, the movement should be prepared mentally. The newly learned movement sequence explicitly does not become automated, but performance remains under conscious control and can be guided



by the application of cues for initiation.<sup>84;85;104</sup>

### *III. Balance*

In PD-specific balance training, patients are taught to employ visual and vestibular feedback and train lower limb strength. It is plausible that this balance training is effective in improving balance in patients with PD and more effective than balance exercises alone.<sup>163;169</sup>

### *IV Physical capacity*

It is plausible that an exercise program aimed at improving range of motion, combined with activity-related (e.g. gait or balance) exercises, improves activities of daily living (ADL).<sup>120;122;123;165;167</sup> Furthermore, it is plausible that a strength training program increases muscle power in PD patients.<sup>161;163;168</sup>

### **Additional recommendations**

A broad range of 'level 3' and 'level 4' recommendations is provided, including specific recommendations (i.e. tailored to the core areas) and more general recommendations. The patient-specific treatment goals, as determined with a patients-preference outcome measure, determine which recommendations are best addressed. Examples of general recommendations are: involve the partner or carer, recognise on- and off-periods, preferentially select functional exercises, avoid dual tasking and evaluate treatment outcome every four weeks, in order to decide whether the intervention needs to be continued, adjusted or terminated.

### **Format**

The practice recommendations manuscript has been transformed into a formal guideline for physiotherapy in PD.<sup>187</sup> The guideline informs neurologists about the indication for referral to physiotherapy and informs therapists about possibilities and limitations of physiotherapy in PD.

This guideline consists of brief practice recommendations (nine pages), a detailed review of the evidence (34 pages, excluding references and supplements) and four quick reference cards concisely describing the history taking, physical examination, instruments for baseline assessment and treatment evaluation purposes and the disease-specific treatment strategies. Furthermore, a patient information leaflet is provided. The manuscript will be scrutinised within five years and updated if necessary.

### **Formal approval**

The practice recommendations were formally approved and disseminated by the Royal Dutch Society for Physical Therapy as their official guideline. The full practice recom-

Table 3. Randomised controlled trials (EBRO B-level): physiotherapy compared with 'no intervention'

First author (yr of publication)	N* (E,C)	Design (Hochm & Yähr)	Experimental Intervention	Duration	Nr of sessions	Group effect
Bergen <sup>160</sup> (2002)	8 (4,4)	Parallel (2)	Exercises to improve physical capacity	16 wks, (22 hrs)	48	VO2-max and leg strength
Comella <sup>20</sup> (1994)	18 (na)	Cross-over (2-3)	Exercises for ROM, gait, balance, dexterity and physical capacity (proprioceptive neuromuscular facilitation); Additional: OT	4 wks (12 hrs)	12	UPDRS (total, ADL and motor domains)
Gauthier <sup>121</sup> (1987)	64 (33,31)	Parallel (2-4)	Exercises for ROM, dexterity, ADL, balance, posture and gait (visual and auditory cues); Education; Additional: OT, dietician, SW, psychologist.	5 wks (20hrs)	10	ADL (BI)
Patti <sup>102</sup> (1996)	20 (12,8)	Parallel (2-3)	Active and passive exercises for ROM, balance, gait (e.g auditory cues) and anti rigidity. Additional: OT for self-care; Speech therapy for swallowing.	4 wks		ADL (BI, FIM), gait (speed, step length) and UPDRS (total)
Schenkman <sup>103</sup> (1998)	51 (27,24)	Parallel (2-3)	Active exercises for (axial) ROM and coordinated movement incorporated in ADL.	10 wks (22.5 to 30 hrs)	30	Functional axial rotation, functional reach (balance)
Toole <sup>164</sup> (2000)	11 (6,5)	Parallel (1-4)	Active exercises for strength of knee (fitness equipment) and ankle (resistive elastic bands) and balance (pro- and retro-pulsion tests, balance on foam)	10 wks (30 hrs)	30	Leg strength and balance (sway)

E=experimental group; C=control group; ROM=range of motion; ADL= activities of daily living; OT=occupational therapy; SW=social work; UPDRS= Unified Parkinson's Disease Rating Scale; BI=Barthel Index; FIM=Functional Independence Measure; \* Drop-outs included

Table 4. Non-randomised controlled trials: physiotherapy compared with 'no intervention'

First author (yr of publication)	N* (E,C)	Design (Hochm & Yahr)	Experimental Intervention	Duration	Nr of sessions	Group effect
Bridgewater <sup>61</sup> (1997)	26 (13, 13)	Parallel (1-3)	Exercises for strength trunk muscles (respiration, posture) in different positions (prone, back and on hands and knees).	12 wks (14 hrs)	24	Rotational strength trunk and ADL (NUDS, HAP)
Formisano <sup>123</sup> (1992)	33 (16,17)	Parallel (2-3)	Passive exercises for ROM, active exercises for posture, balance, coordination, gait, dexterity and respiration.	17 wks (51 hrs) 6 wks (9 hrs)	51	Gait (speed) and ADL (NUDS)
Nieuwboer <sup>85</sup> (2001)	33 (na)	Within subject (2-3)	Active home-based exercises strategies for transfers (cognitive movement strategies) and gait (visual and auditory cues).		18	ADL (PAS) and gait (step length)

E=experimental group; C=control group; ROM=range of motion; ADL= activities of daily living; UPDRS= Unified Parkinson's Disease Rating Scale; NUDS=Northwestern University Disability Scale; HAP=Human Activity Profile; PAS=Parkinson Activity Scale, \* Drop-outs included.

Table 5. Randomised controlled trials: physiotherapy compared with 'placebo controlled'

First author (yr of publication)	N* (E,C)	Design, Hoehn & Yahr	Experimental Intervention	Control Intervention	Duration	Nr of sessions	Group effect
Hirsch <sup>163</sup> (2003)	15 (6,9)	Parallel, (E1.9± 0.6; C1.8±0.3) <sup>#</sup>	Active exercises for ankle and knee strength (fitness equipment, resistive elastic bands) and balance (pro and retropulsion tests, balance and weight shifting on foam).	Exercises for balance (see E)	10 wks (22.5hrs)	30	Balance, leg strength, instru- mental ADL (eg housekeeping) Memory, eating, incontinence
Hurwitz <sup>164</sup> (1989)	30 (15,15)	Parallel (1-3)	Exercises for ROM, mobility and self-care.	Weekly assessment, no exercise	32 wks (16 hrs)	32	Memory, eating, incontinence
Kamsma <sup>38</sup> (1995)	38 (25,13)	Parallel (2-4)	Exercises (cognitive movement strategies) for gait and transfers (e.g. rising from a chair, bed mobility)	Exercises for physical capac- ity and ROM.	1 year (8 + 2-9 hrs)	1 <sup>st</sup> : 8 2 <sup>nd</sup> : 2-9	ADL, physical functioning coping, UPDRS (bed, chair mobility)
Marchese <sup>88</sup> (2000)	20 (10,10)	Parallel (1.5 -3)	Exercises for (axial) ROM, posture and gait (visual and auditory cues).	Equal, without cues	6 wks (18 hrs)	18	UPDRS (motor)
Mohr <sup>104</sup> (1996)	41 (20,21)	Parallel (1.5-4)	Group exercises (external cues and cognitive movement strategies) for gait, transfers and relaxation.	Group exercises for respiration, disease specific information.	10 wks (30 hrs)	20	UPDRS (motor), gait (initiation), postural stability and dexterity
Stallibrass <sup>168</sup> (2003)	93 (32,31/30)	Parallel (?)	Alexander Technique	Manual contact to the skin and personal attention (C1); none (C2)	12 wks (16hrs)	24	ADL (SPDDS) vs. C2, depression (BDI) vs. C2
Thaut <sup>86</sup> (1996)	26 (15,11/11)	Parallel (2.5) <sup>#</sup>	Gait training with weekly increased rhythm (auditory cues).	Self-paced gait training (C1); 3 wks (10.5hrs) none (C2)	3 wks (10.5hrs)	21	Gait (speed and stride length vs. C2, cadence vs. C1

E=experimental group; C=control group; ROM=range of motion; ADL= activities of daily living; UPDRS= Unified Parkinson's Disease Rating Scale; BDI=Beck Depression Inventory; SPDDS,  
Self-assessment Parkinson's Disease Disability Scale; #, mean; \* Drop-outs included.

mentations are available free of charge, in Dutch and, as of January 2006, in English ([www.kngf.nl](http://www.kngf.nl); [www.cebp.nl](http://www.cebp.nl)). The Association of Physiotherapists in Parkinson's Disease Europe (APPDE, [www.appde.eu](http://www.appde.eu)) endorses the practice recommendations and supports their international implementation and evaluation.

### **Field test**

The practice recommendations were field tested for four months by 70 physiotherapists who were not involved in the development process. In this field test, therapists thoroughly studied the practice recommendations and subsequently applied it in ongoing or newly started treatments of PD patients. Therapists completed a questionnaire on the overall comprehensibility of the practice recommendations, on the applicability in everyday clinical practice, on the feasibility of the recommended measuring instruments and on any discrepancies between the recommendations and everyday clinical practice. Physiotherapists could also provide additional comments to improve the practice recommendations. Simultaneously, a draft of the practice recommendations was evaluated in a feasibility study (*Chapter 5*).<sup>207</sup> The Practice Recommendations Development Group discussed the collected drawbacks and strengths of the recommendations until consensus was reached and the guideline could be finalised.

### **Update of Latest Evidence**

For our guideline (published in 2004), literature published until October 2003 was reviewed. We have repeated the literature search for all studies published until June 2006. Several papers have appeared since the publication of the guideline.<sup>189-207</sup> An analysis of these studies demonstrates that the level of evidence of the recommendations provided in our guideline is not altered by the results of these studies.

## **Conclusion and future directions**

### **Evidence-based healthcare**

There are indications that physiotherapy might be effective in PD.<sup>208</sup> However, the evidence is inconclusive. This is due to the small number of patients enrolled in the studies, the methodological flaws in many studies and the possibility of publication bias. Three systematic reviews had reasonable quality<sup>138;147;156</sup>, the others had moderate<sup>139;159</sup> or poor<sup>150</sup> quality. Furthermore, the specific physiotherapy interventions that were evaluated in different studies varied widely. This finding is not surprising, because evidence-based practice guidelines were unavailable until now. An important step was made by expert physiotherapists in the UK who developed a guideline of physiotherapy in PD.<sup>88</sup> Although this guideline provides an extensive overview of the field, it was not systematically developed

according to international standards for guideline development. For example, referring physicians and patients were not involved in the development process.

The current practice recommendations were systematically developed according to accepted international criteria and are reproducible.<sup>157,158</sup> By integrating the best available research evidence with clinical expertise and patient values, we have developed clinical practice recommendations that facilitate evidence-based health care for physiotherapy in PD. These recommendations provide a firm basis for current physiotherapy in PD, as well as for future research in this field. Our suggestion is that future research should further address the use of cues and movement strategies. For instance, we need to know for which subgroups of PD patients cues and movement strategies are most effective. In addition, we need to further clarify how cues and movement strategies might prevent freezing and falls in PD. Another research topic is the safety problems (e.g. falls) caused by executing dual tasks in relation to physiotherapy interventions. For instance, can the performance of dual tasks be trained and, if so, how? Pain and fatigue are also issues of common clinical concern. Evidence concerning physiotherapy interventions dealing with these issues is limited and should be enlarged. Finally, there is a need to evaluate how physiotherapy guidelines can be implemented effectively into everyday clinical practice. Do PD patients benefit from implementation of guidelines?

Future research requires appropriate methods to optimise the scientific value. An important methodological issue that needs to be addressed is the use of appropriate outcome measures with particular relevance to patients, their carers, physiotherapists and physicians. Furthermore, prospective intervention studies should include a sufficient number of participants and these patients need to be followed for at least six months to determine the duration of any improvement.

### **Implementation of practice recommendations**

We have developed a multifaceted implementation strategy: creation of regional networks of expert physiotherapists with specific training in PD (ParkinsonNet), who are offered continuous education, improved communication with referring physicians and a PD-specific electronic patient record; quick reference referral cards are provided for referring physicians (e.g. neurologists or geriatricians). Currently, a large cluster RCT (the ParkinsonNet Trial) is performed in the Netherlands to evaluate the implementation of these practice recommendations (*Chapter 8*).<sup>209</sup>

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## Appendix

The following are members of the Practice Recommendations Development Group: BR Bloem PhD (neurologist, RUNMC), CJT de Goede MSc (physiotherapist, human movement scientist, VU University Medical Center), Ms M van Haaren (physiotherapist, Rehabilitation Centre Breda), HJM Hendriks PhD (physiotherapist, health scientist, clinical epidemiologist, Dutch Institute of Allied Health Care, Centre for Evidence Based Physiotherapy), Ms M Jaspers (Mensendieck exercise therapist, Fysio Ludinge), YPT Kamsma PhD (physiotherapist, human movement scientist, Center for Human Movement Sciences), Ms SHJ Keus MSc (physiotherapist, human movement scientist, LUMC), M Munneke PhD (physiotherapist, human movement scientist, clinical epidemiologist, RUNMC), Ms J Westra (physiotherapist, Nursing home Maartenshof), BY de Wolff MSc (Cesar exercise therapist, Medical Center De Vecht).

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