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Person-centered home-based rehabilitation for persons with Parkinson's disease: A scoping review

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ABSTRACT

Background: Due to vague, initial symptoms, persons with Parkinson's disease (PD) usually receive a definitive diagnosis after a prolonged period of time. At the time of diagnosis, they have already experienced limitations in activities of daily living and quality of life and are thus in need of immediate rehabilitation.

Objective: To describe the existing knowledge on the rehabilitation of persons with PD suitable to a home environment and to describe the person-centeredness, interprofessionality and clinical effectiveness of existing rehabilitation activities.

Sources of evidence: 67 full-text papers from the EBSCO, CINAHL, Medline, Google and Google Scholar databases, published in English, Swedish or Finnish between January 2010 and October 2018, were charted (type of rehabilitation, sample, instrumentation, reported effects) and summarized.

Results: Rehabilitation through physical activities still appears to be the most common form of rehabilitation, varying from walking to individually tailored exercise programs. The majority of physical rehabilitation activities were conducted outside the home even though they were suitable for a home setting. Physical activities not only improved several physical outcomes but also quality of life, well-being and activities of daily living functions, especially when digital devices were used. Cognitive and psychosocial rehabilitation were much less researched but seen to be an emerging area of research. The focus of rehabilitation seems to lie on persons with PD, not their near-ones. The majority of interventions were planned without discussing in advance with the persons with PD about their preferences, needs or values. Very few interventions were individually tailored or conducted in a home setting, and many studies included patient-recorded outcome measures, but only as secondary to clinical measures. Only a few studies focused on an interprofessional approach to PD rehabilitation, despite the approach being found effective in regard to quality of life for persons with PD.

Conclusions: There appears to be a focus on physical outcomes and symptom management in the rehabilitation of persons with PD, even though cognitive and psychosocial well-being are often explored as secondary outcomes. Very few rehabilitation interventions were planned with persons or conducted in a home setting, and no interventions were seen that included near-ones. The majority of interventions were planned without the involvement of persons with PD. Still, many of the studies included patient-recorded outcome measures. Digital devices that assist in physical rehabilitation and an interprofessional approach to rehabilitation yield positive clinical outcomes, which in turn promotes a person-centered and holistic approach to rehabilitation.

What is already known about the topic?

- Persons with PD can achieve the same QoL as persons without PD at the same age, if they receive and engage in systematic, holistic, person-centered, interprofessional care and rehabilitation.
- An interprofessional, collaborative and cooperative approach to PD rehabilitation is important.

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- Home-based rehabilitation is considered favorable for many persons with PD, due to the familiar environment and the convenience for near-ones to provide support. Training near-ones is also of paramount importance in the maintenance of a safe environment.

What this paper adds

- There appears to be a focus on physical outcomes and symptom management in the rehabilitation of persons with PD, even though cognitive and psychosocial well-being are often explored as secondary outcomes.
- Very few rehabilitation interventions were planned with patients or conducted in a home setting, and no interventions were seen that included near-ones. The majority of interventions were planned without the involvement of persons with PD. Still, many of the studies included patient-recorded outcome measures, but only as secondary to clinical measures.
- Digital devices that assist in physical rehabilitation and an interprofessional approach to rehabilitation yield positive clinical outcomes, which in turn promotes a person-centered and holistic approach to rehabilitation.

1. Introduction

Approximately ten million people in the world today have been diagnosed with Parkinson's disease (PD), and the prevalence of the disease is increasing, most likely related to an increasing population of older people. The mean age of initial PD diagnosis is about 55–65, but also young-onset PD can occur. There is no one known cause of this chronic disorder, but some genetic and environmental factors have been identified (Rizek et al., 2016). PD is a multifaceted neurodegenerative disorder affecting both motoric and voluntary movements, such as dual-task performance or gait, and nonmotoric functions such as task initiation and accomplishment, cognition, emotions, sleep, etc. The cardinal signs of the disease - tremors, rigidity, bradykinesia and postural instability - are caused by a loss of dopamine in the substantia nigra and associated nigrostriatal denervation. PD is divided into two subtypes, tremor dominant (TD) and postural instability gait difficulty (PIGD) (Current Care Guidelines, 2018). However, the presentation of symptoms and onset of the disorder is highly individual, as is perceived quality of life (QoL). Persons with PD can achieve the same QoL as persons without PD at the same age, if they receive and engage in systematic, holistic, person-centered, interprofessional care and rehabilitation (Ebben, 2018). The aim of this study was to describe the existing knowledge on the rehabilitation of persons with PD suitable to a home environment and to describe the person-centeredness, interprofessionality and clinical effectiveness of existing rehabilitation activities.

2. Background

Due to an initial asymptomatic phase, followed by a phase with non-specific prodromal symptoms, persons with PD usually receive their diagnosis after an extended period of time. They can consequently already be experiencing severe limitations in activities of daily living (ADL) and a decrease in QoL when diagnosed (Hariz and Forsgren, 2011) and therefore need immediate physiological, psychosocial and cognitive rehabilitation. For older people, meaning in everyday life is more important than ability or disability per se (Hedman et al., 2015). Hoehn & Yahr developed a system (the Hoehn & Yahr (H&Y) scale) for grading the severity of PD, using a scale of 1–5 to evaluate patients' clinical disability. In the H&Y scale, persons whose symptoms are in stages 1–2 are considered minimally disabled and still able to lead independent lives, persons in stage 3 are considered to be experiencing a transition to major disability, and persons in stages 4–5 are considered severely disabled (Shulman et al., 2008; Hoehn and Yahr, 2001).

Even though the so-called dopamine medication refractory axial motor impairments, such as postural instability, freezing of gait, dysphagia, and dysarthria, are often explicit in PD, the non-motoric symptoms also significantly impact a person's psychological well-being (Nicoletti et al., 2017), perceived disability and health-related QoL (Dogan et al., 2015). Ylikoski et al. (2016) found that persons with PD (n = 684) perceived poor self-rated health (44,4%) and poor QoL (43.3%) due to sleep difficulties and fatigue: occurrence of short sleep was found in 32.5% of persons with PD, poor sleep in 21.2%, sleep deprivation in 33.8%, disrupted sleep in 47.4%, difficulties falling asleep in 12.2% and long sleep in 26.2%, respectively. In another study, Dogan et al. (2015) found that fatigue was the most important factor ($p < 0.001$) affecting health-related QoL among persons with PD.

It is not only the persons with PD but also their near-ones (i.e., spouses, other family members) who can experience poor QoL. Balash et al. (2017) examined the answers that persons with PD and their caregivers (often near-ones) gave on questionnaires related to QoL. Using the PDQoL Questionnaire (PDQ-39), the Scale of Quality of Life Care-Givers (SQLC) and the Multidimensional Caregiver Strain Index (MCSI), Balash et al. found strong and comparable agreement for the total scores: PDQ-39 revealed that about 75.4% $\pm$ 14% of persons with PD had low QoL scores; SQLC revealed that about 78.1% $\pm$ 14.1% of caregivers had low QoL scores; MCSI revealed that about 78.2%$\pm$14.3% of caregivers experienced caregiver strain. In another study, Kelly et al. (2012) found a significant correlation between the health-related QoL (HRQoL) of persons with PD and caregiver strain (rho 0.43, $p < .001$), but no significant relationships between caregiver and care-recipient HRQoL or caregiver HRQoL and caregiver strain.

Given these somewhat conflicting research results and the highly individual onset of PD, health care providers should not make assumptions but instead always ask the person with PD and her/his near-ones what their actual life experiences are, including their resources and preferences – i.e., act in a person-centered manner. Person centeredness can be defined as providing care that is respectful of and responsive to individual patient preferences, needs, and values, which entails ensuring that each patient's values guide all clinical decisions (Institute of Medicine, 2016). Person centeredness also encompasses respect for the person's narratives that reflect said person's sense of self, lived experiences and relationships (i.e., personal knowledge) and showing such respect by safeguarding the partnership that exists in care through shared decision-making and meaningful activities in a personalized environment (Ekman et al., 2011; McCormack and McCance, 2006; Kitwood, 1997). In research activities, such as the identification of research priorities, participation in data collection, analysis of or commenting on research reports, the terms public and patient involvement are used (INVOLVE, 2019).

For older persons, an illness such as PD can give rise to emotional considerations of the lived experience of having a chronic disease, in relation to the meaning of autonomy and participation; this involves living a life apart, yet remaining a person who is able, trustworthy, and given responsibility, i.e., still seen and acknowledged (Hedman et al., 2015). Since PD is a progressive condition, both the short-term and long-term benefits of rehabilitation are important. Still, the true benefits of rehabilitation are only realized if the person with PD develops the skills and strategies for long-term adherence to activity. In PD rehabilitation, the optimal mix of interventions varies according to each person's preferred form of activity, capacity for learning, age and stage of disease (Gisbert and Schenkman, 2015; Moldovan and Dogaru, 2014). Adherence to an activity regimen is more likely if a person is doing something he/she enjoys (Gisbert and Schenkman, 2015).

For the past few decades, the medical management of PD (pharmacological interventions, deep brain stimulation) has been accompanied with physical rehabilitation, including different exercises, and such an approach has been found useful, especially for persons with early- or mid-stage PD. Such a treatment combination yields longer periods of functional capacity before the inevitable decline caused by the neurodegenerative disease (Gisbert and Schenkman, 2015). The amalgamation of physical and psychosocial rehabilitation not only fulfills the idea of holistic care and rehabilitation (cf. Ebben, 2018), it also leads to better outcomes, even in relation to the non-motoric symptoms of PD. Subsequently, an interprofessional, collaborative and cooperative approach to PD rehabilitation is important (Earhart and Williams, 2012). Furthermore, the entire rehabilitation program should be carried out in a peaceful, relaxing environment and the person's near-ones should be encouraged to play a decisive role in the continuous encouragement of and support for the person with PD (Moldovan and Dogaru, 2014). Training near-ones is also of paramount importance in the maintenance of a safe environment (Gisbert and Schenkman, 2015). Home-based rehabilitation is considered favorable for many persons with PD, due to the familiar environment and the convenience whereby near-ones can provide support. A range of digital devices that can facilitate home-based PD rehabilitation already exist, for example the NIRVANA bracelet (http://www.btsbioengineering.com/products/nirvana/), the Parkinson bracelet (https://parkinsonranneke.fi/), Virtual Reality (VR) devices, Balance Retraining Therapy (BRT), Active Balance Rehabilitation (ABR) and so on (Albiol-Perez et al., 2012). Given that patient-reported outcome measures have become more and more important in measurements of outcome, it is important to take all of the issues mentioned above into consideration (Bindemann, 2010).

The systematic, holistic, person-centered, and interprofessional rehabilitation of persons with PD and their near-ones in the home setting (using digital devices, if so desired) could improve the effectiveness of rehabilitation and patient-recorded outcomes in the long run. The aim of this study was to describe the existing knowledge on the rehabilitation of persons with PD suitable to a home environment and which can involve the use of digital devices, if so desired. The research questions were:

- What types of rehabilitation are there for persons with PD or their near-ones, suitable to a home environment and which can involve the use of digital devices, if so desired?
- How person-centered, interprofessional and clinically effective are the currently existing rehabilitation activities?

This study is part of a research project with the aim to develop quality criteria for person-centered, safe, competent and effective advanced care at home.

3. Material and methods

To describe the existing knowledge (Tricco et al., 2018) on the rehabilitation of persons with PD suitable to a home environment and which can involve the use of digital devices, a scoping review methodology was chosen. Previously known as integrative reviews, scoping reviews are a method used to map evidence in complex research areas. Arksey and O'Malley (2005) found that while systematic reviews tend to focus on a strictly defined research question and studies with a randomized, controlled research design, scoping reviews address a broader research question and include studies that reflect a greater variety of research designs as well as gray literature, i.e., statement papers and practice-oriented development reports. The scoping review process starts with the identification of a research question, followed by the identification of relevant studies, selection of studies, charting of data, and summarization and reporting of results (Arksey and O'Malley, 2005). For the reporting in this review, the PRISMA-ScR checklist has served as a guideline (Tricco et al., 2018).

3.1. Search strategy and information sources

Following the identification of this study's research questions, the next step was the identification of relevant studies and grey literature. Between August 7 and October 16, 2018, searches of the EBSCO, CINAHL and Medline databases were conducted. The search terms included "Parkinson(s) Disease" OR "PD" OR "Parkinson" AND "rehabilitation". In addition, a general internet search (Google and Google Scholar) was conducted to identify grey literature.

3.2. Eligibility criteria

The eligibility criteria included full-text published or to-be-published, peer-reviewed studies and grey literature focused on rehabilitation in the context of PD between January 2010 and October 2018, in English, Swedish or Finnish. To be included, the studies (quantitative, qualitative, mixed methods, or study protocols) had to focus on rehabilitation at home, and to apply a valid instrument through which the measurement of the clinical effects of rehabilitation occurred. Systematic reviews were also considered eligible sources of information (Peters et al., 2015). The grey literature accepted for review had to be either a statement paper or a practice-oriented development report, not an advertisement of rehabilitation services.

3.3. Data charting and analysis

Following the development and implementation of the search strategy, the screening of potentially relevant papers for inclusion occurred. Overall, 154 references were identified through the electronic database searches and general internet search (Fig. 1). Duplicates were removed (n = 29). Level one testing included title and abstract screening, after which relevant papers were retained for full text review in level two testing (data charting: research method/s, sample size, type of rehabilitation intervention, instrumentation, results and/or conclusions) by the first author. Additionally, the reference lists of retrieved articles were manually reviewed. A second reviewer acted as "tiebreaker". Conference abstracts with no research results (n = 6), intervention studies without control groups (n = 4), material with a focus on rehabilitation that cannot be arranged in a home setting (e.g., deep brain stimulation, biomechanical muscle stimulation, pressure threshold, whole body vibration, different perceptual surfaces, n = 42), and websites marketing private or national PD rehabilitation centers (n = 6) were excluded. Following data charting and extraction, the data were summarized to answer the research questions (Peters et al., 2015; Arksey and O'Malley, 2005).

4. Results

The material for the review consisted of 67 papers, of which the majority were published in medical journals (37%). The others were published in journals with a focus on rehabilitation (25%), physiotherapy (15%), speech or language issues (9%), quality of life (5%), or nursing (3%). In addition, five papers (6%) were published in an open-access ("pay to publish") journal that accepts

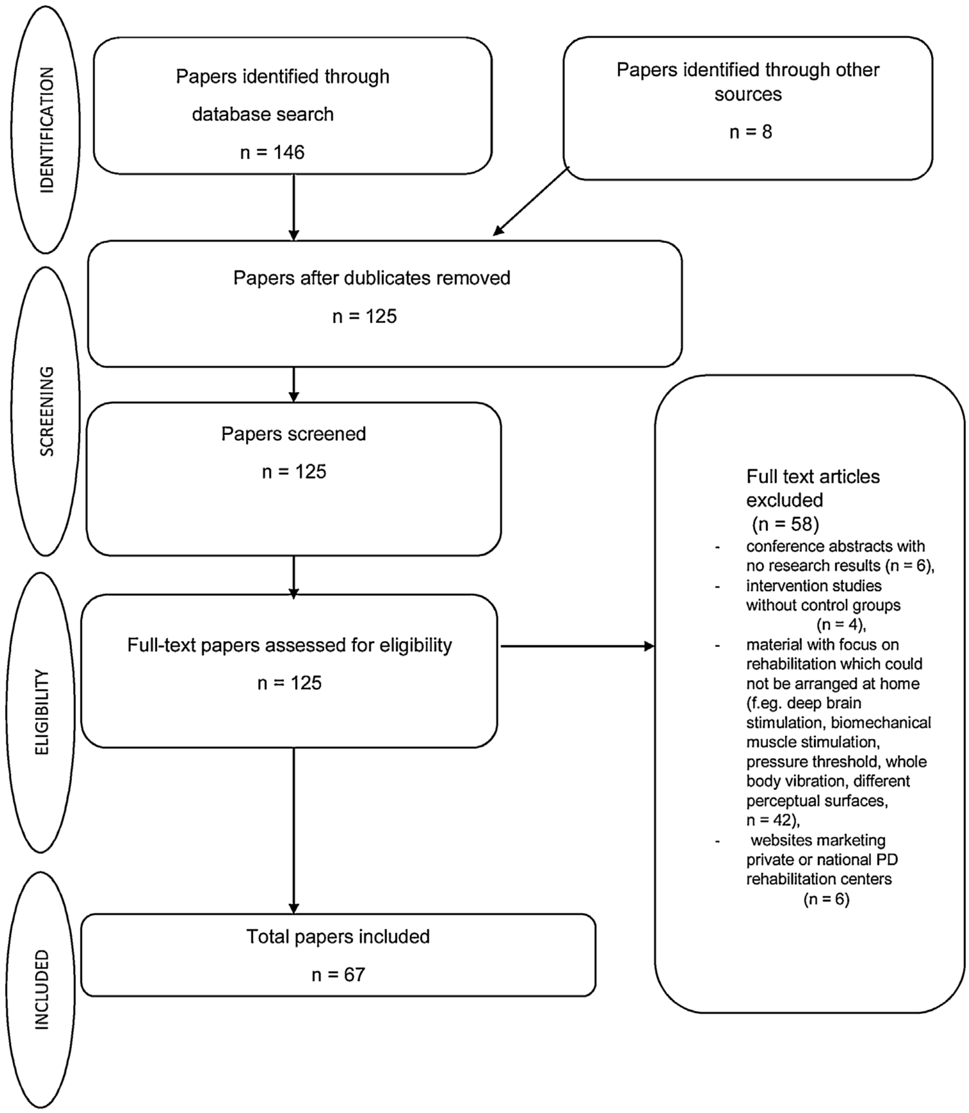

Fig. 1. Flow diagram of paper selection.

manuscripts "from all science and medicine" for a fee of 3000 USD, i.e., a possibly predatory source but still accepted into databases.

Rehabilitation for persons with PD appears to be of continuous professional interest: 34 papers were published between 2010–2014, and 33 between 2015-2018. The majority were randomized intervention studies (n = 30, 45%), but cross-sectional empirical studies on a descriptive level (n = 16, 24%), systematic reviews (n = 5, 7%), instrument development or testing studies (n = 9, 13%), intervention study protocols (n = 4, 6%) and theoretical papers (n = 3, 5%) were also seen. Due to the number of papers included in this review, results concerning aims and detailed research methods were not described. Instead, the focus was on the types and effects of rehabilitation.

In the majority of papers, a focus on rehabilitation through physical activities and the effect of such on the motoric and non-motoric symptoms of PD (Table 1) was seen. While the relationship between physical activity, Parkinsonism and quality of life is still somewhat tentative, Archer et al. (2011) maintain that, in view of the particular responsiveness of the dopaminergic neurons to exercise, the principle of "use it or lose it" may be especially applicable for persons with PD. According to Cavanaugh et al. (2015), as a result of physical inactivity, persons with PD demonstrate 1- and 2-year declines in ambulatory activity and recommend further investigation of sustained daily physical activity. The physical exercise forms seen varied from walking, Nordic-walking or dancing to individually tailored exercise programs with or without digital devices that provided immediate feedback (Table 1). Of the interventions related to rehabilitation through physical activities (Table 1), some presupposed special devices such as an exercise bike (Uygur et al., 2015; Ridgel et al., 2012), a treadmill (Paker et al., 2013; Earhart and Williams, 2012), boxing equipment (Combs et al., 2013, Combs et al., 2011), a pool (Ayán and Cancela, 2012) or a body positive pressure support system (Lander and Moran, 2017). All other physical rehabilitation activities (walking, dancing, Qigong/Tai-chi, individual combinations) were suitable for the home environment. To facilitate the measurement of individual outcomes, a range of digital devices that measure different parameters such as heart rate, muscle strength, gait velocity, stride length, dynamic balance (four square step test), reaction time, walking speed (10 m walk test), rotation and swing time, or cadence and instruments that measure swallowing sequences were seen in the papers reviewed here. There were also digital assistive devices such as VR goggles/headsets/glasses (Dockx et al., 2016; Yen et al., 2011), yoked prisms (Padula et al., 2015), a closed-loop augmented-reality cueing device (Espay et al., 2010), a wearable sensor-based biofeedback

Table 1
Included studies with physical rehabilitation in focus.

Physical activities: *Physical exercise form*	Intervention	Sample	Instrumentation used in data collection	Effects	Authors, per exercise form, in chronological order
Nordic walking	A tailored exercise program including Nordic Walking: two sessions per week, during 12 weeks	RCT, random sample, persons with PD (n = 10) and without PD (n = 10)	Resting heart rate Walking distance Muscle strength Parkinson's disease rating scale UPDRS-III, Hoehn & Yahr scale, PD Fatigue Scale-16, Beck Depression Inventory I-II, Starkstein Apathy Scale, Non-Motor Symptom Scale	Significant changes in resting HR, in walked distance ($p < 0.05$), and in lower limbs muscle strength ($p < 0.005$) were observed in Nordic Walking group. Both balance abilities and safety with mobility were increased ($p < 0.005$). Finally, a significant improvement in motor and non-motor symptoms was detected.	Cugusi et al., 2015
Walking	Obstacle crossing with concurrent music, total of 12 trials per person	Stratified sample, persons with PD (n = 10) with mild or moderate disease severity according to Hoehn & Yahr scale; and age-matched persons without PD (n = 10),	Step length (SL), toe-obstacle distance (TO), heel-obstacle distance (HO), step height of lead foot (SHLead) and trail foot (SHTrail), crossing velocity of the lead limb (CVLead), crossing velocity of trail limb (CVTrail), whole-body center of mass (CVCOM)	Subjects with PD further decreased obstacle-crossing velocities and maintained spatial parameters in the music condition. In contrast, CTRL subjects maintained all spatiotemporal parameters of obstacle crossing with music. The alterations to crossing behaviors observed among the subjects with PD support our previous suggestion that listening to music while walking may be an attentionally demanding task.	Brown et al., 2010
	Talking while walking, total eight walks across the GAITRite (C) system	Stratified sample of persons with PD (n = 25): 18 of them in stage H & Y II, four at stage III and four at stage IV	GAITRite (C) portable walkway system with sensor pads, Dementia Rating Scale, Beck Depression Inventory	The results indicated that cognitive-linguistic demand had an impact on gait. One finding, altered double-support time, distinguished the Parkinson group from the control participants (p 0.04).	Lapointe et al., 2010
	Adding mental practice to physical practice: experimental group was submitted to a single session of mental practice and physical practice gait, and the control group only to physical practice gait	RCT, random sample of persons with PD (n = 20) at stage II-III H & Y were randomized to intervention group and control group	Stride length, total stance and swing time, hip range of motion, velocity and mobility at baseline, 10 min, 1 day and 7 days after the session	There was no statistically significant difference between the groups. An intragroup difference was observed in velocity, stride length, hip range of motion, and mobility, as well as total stance and swing time. These results were also observed on follow-ups. Mental practice did not have a greater effect on the gait of individuals with IPD than physical practice, after a single session	deMelo De Melo Santiago et al., 2015
Cycling	Forty minutes of Active Assisted Cycling (motorized cycle)	Persons with PD (n = 10) in stage I-III according to H & Y	Heart rate, pedaling power, and rating of perceived exertion were recorded before, during, and after a bout of AAC. Functional assessments included tremor score during resting, postural, and kinetic tremor	Most participants showed improvements in tremor and bradykinesia immediately after a single bout of cycling.	Ridgel et al., 2012
	High speed low resistance cycling intervals : familiarization session and three 30 min test sessions with 15 second intervals of high-speed low resistance cycling	Persons with PD (n = 10) in H & Y stages I-II	Four square step test (4SST), 10 m walk test (10 mW), Timed-up-and-go (TUG), Simple reaction time (SRT), Choice reaction time (CRT)	Despite the relatively low dose of speed-based exercise, high speed cycling elicited significant ($p < 0.05$) improvements in the four square step test and 10 m walk test. Excepting reaction times, there was high reliability and adequate sensitivity to detect moderate and small differences. The present results suggest that brief intervals of HS-LR bicycling are promising and should be examined in a longer duration exercise program	Uygur et al., 2015
Dance with or without music	Dance therapy: dance 60 min twice a week, i.e., 20 sessions during 10 weeks	RCT, Persons with PD (n = 16) were divided into dance therapy group (n = 9) and traditional therapy group (n = 7)	Berg balance scale (BBS), Gait dynamic index (GDI), Four square step test (4SST), Timed-up-and-go (TUG), 6 min walking test (6MWT), Frontal assessment battery (FAB), Trail making test (TMT-A&B) at baseline, after treatment and 8 week follow-up	In the DT group, motor and cognitive outcomes significantly improved after treatment and were retained after follow-up. Significant changes were found for 6MWT ($p = 0.028$), TUG ($p = 0.007$), TMT-A ($p = 0.014$) and TMT-B ($p = 0.036$).	De Natale et al., 2017
	Dance class for 1 h twice a week during 10 weeks or usual care	RCT, randomized sample of person with mild to moderate PD, intervention group (n = 15) and control group (n = 12)	Standing start 180 grade turn test (SS180)	Significant 4-way interactions between the groups, over time and turn style, with longer latency of the head ($p = 0.008$) and greater rotation in the pelvis ($p = 0.036$), alongside a trend of slower movement of the first ($p = 0.063$) and second ($p = 0.081$) foot in controls were shown, with minimal change in dancers. Those who danced were better able to coordinate their axial and perpendicular segments and surprisingly became more 'en bloc' in their turning behavior.	Hulbert et al., 2017

Table 1 (*Continued*)

Physical activities: *Physical exercise form*	Intervention	Sample	Instrumentation used in data collection	Effects	Authors, per exercise form, in chronological order
Qigong/Tai-chi	Review	n = 15 RCT or non-RCT trials from seven databases	Berg balance scale (BBS), Timed-up-and-go test (TUG), Quality of life (QoL)	Tai Chi plus medication showed greater improvements in motor function (standardized mean difference, SMD,-0.57; 95% confidence intervals,CI,-1.11to-0.04), Berg balance scale (BBS,SMD,-1.22;95%CI -1.65to-0.80), and time up and go test (SMD,-1.06;95%CI-1.44to-0.68). Compared with other therapy plus medication, TaiChi plus medication also showed greater gains in motor function (SMD,-0.78;95%CI-1.46to-0.10), BBS(SMD,-0.99;95%CI-1.44to-0.54), and functional reach test (SMD,-0.77;95%CI-1.51to-0.03). However, TaiChi plus medication did not show better improvements in gait or q uality of life. There was not sufficient evidence to support or refute the effect of Qigong plus medication for PD	Yang et al., 2015
	Six-weeks Qigong intervention for 15-20 min twice per day at home plus a weekly group discussion	n = 7 persons with PD	The unified Parkinson's disease rating scale (UPDRS), Parkinson's disease sleeping scale (PDSS-2), Parkinson fatigue scale (PFS-16), Mini-mental state examination (MMSE), Trail making test (TMT-A&B)	Following Qigong, subjects showed improvement in some aspects of sleep quality. Fatigue remained unchanged. Gait function was improved by a significant reduction of stride time and a slight increase in stride length. Together these changes resulted in significant improvements to gait velocity	Wassom et al., 2015
	Review	n = 11 RCT or quasi-experimental studies from six databases	Berg balance scale (BBS), tandem stance, functional reach, balance platform test, stride length, velocity, mobility, aerobic endurance, fall rates	Participants enrolled in Tai Chi had better balance and one or more aspect of well-being, though mixed results were reported. Further research is needed with more rigorous study designs, larger sample sizes, adequate Tai Chi exercise doses, and carefully chosen outcome measures that assess the mechanisms as well as the effects of Tai Chi, before widespread recommendations can be made	Cwiekala-Lewis et al., 2017
Treadmill training	Theoretical paper			Treadmill training is also thought to provide an external cue to improve gait function in those with PD, although exact mechanisms are debated (e.g., somatosensory cue versus visual cue). In addition to Mehrholz and colleagues' Cochrane review, 14 other reviews have reported treadmill training as an effective intervention for those with PD. One advantage of treadmill training is that it is generally accessible, as many physical therapy clinics have at least one treadmill and local fitness centers often have several treadmills. Although it has been reported that treadmill training improves gait function, it is important to consider the safety of treadmill training for those with PD	Earhart and Williams, 2012
	Two 20 min sessions robotic treadmill training per week during 10 weeks	n = 12 persons with PD at stage I-III at H & Y scale	TUG test, 10MWT, UPDRS motor subscale scores, PDQ-39, Mini-mental state examination (MMSE), hospital anxiety and depression scale (HADS) at baseline, five and 12 weeks after intervention	TUG test, 10MWT and UPDRS motor subscale scores showed statistically significant improvement after robotic treadmill training ($p = 0.02$, $p = 0.001$, $p = 0.016$). PDQ-39 scores improved significantly after robotic treadmill training ($p = 0.03$), however, the scores turned back to the baseline level at the 12 week control.	Paker et al., 2013
	Progressive, interval-based locomotor training 30 min per week for 6 weeks	n = 20 persons with PD at stage I-III at H & Y scale were randomized into intervention group (n = 10) and control group (n = 10)	Berg balance scale (BBS), rapid step up test (RST), Parkinson's disease questionnaire (PDQ-39), sensory organization test (SOT), limits of stability (LOS) at baseline, directly after and three months after intervention	Significant gains in balance measures were observed post-training in BBS, RST and SOT for the RAC group and in RST, SOT and LOS for the SDTT group. Gains were retained at 3 months post-training in all measures for RAC group, but only the RST for the SDTT group. No clear trend in reduction in fall frequency was evident.	Harro et al., 2014
	a single progressive body weight-supported treadmill training 10 min	n = 10 person with PD and 10 healthy persons	video capture and analysis of 10 min BWSTT, step length SL, cadence, velocity at baseline, and at 5 min, 10 min and 15 min after training	During positive pressure BWSTT there was a significant effect of BW support on step length(SL) increase ($p < 0.01$) and cadence decrease ($p < 0.001$) in the healthy group but not in the PD group ($p = 0.45$ SL, $p = 0.21$ cadence). In post-intervention assessments there was a significant effect of time on velocity ($p < 0.002$non-PD,$p < 0.001$PD) and	Lander and Moran, 2017

				cadence ($p < 0.05$ non-PD, $p < 0.01$ PD) in both groups. There appears to be a generalized effect of TT on overground gait mechanics after a single session of positive pressure BWSTT regardless of PD impairment.	
Boxing	24-36 boxing sessions a 90 min for 12 weeks	convenience sample of n = 6 persons with PD	Functional reach test, Berg balance scale BBS, timed-up-to go TUG, six-minute walking test 6MWT, gait speed, cadence, stride length, unified Parkinson disease rating scale UPDRS, Parkinson disease quality of life scale (PDQL) at baseline and 12, 24 and 36 weeks after intervention	Six patients completed all phases of the case series, showed improvements on at least 5 of the 12 outcome measures over the baseline at the 12-week test, and showed continued improvements at the 24- and 36-week tests. Patients with mild PD typically showed improvements earlier than those with moderate to severe PD.	Combs et al., 2011
	24-36 boxing sessions for 90 min over 12 weeks	convenience sample of persons with PD (n = 31) were randomly assigned to boxing-intervention (n = 17) and traditional exercise group (n = 14)	Berg balance scale (BBS), activities-specific balance confidence test ABC, timed-up-and-go (TUG), dual-task timed up and go (dTUG), gait velocity, 6 min walking test 6MWT, Parkinson disease quality of life scale (PDQL) at baseline, one and 12 weeks after intervention	The traditional exercise group demonstrated significantly greater gains in balance confidence than the boxing group ($p < 0.025$). Only the boxing group demonstrated significant improvements in gait velocity and endurance over time with a medium between-group effect size for the gait endurance ($d = 0.65$). Both groups demonstrated significant improvements with the balance, mobility, and quality of life with large within-group effect sizes ($d \geq 0.80$).	Combs et al., 2013
Water-based exercise	A low intensity water exercise program (group 1) or a muscle resistance water exercise intervention (group 2) twice a week 60 min sessions for 12 weeks	n = 21 persons with PD at stage I-III at H & Y scale	Five times to sit-to-stand test, unified Parkinson disease rating scale (UPDRS), Parkinson disease questionnaire (PDQ-39)	Once the intervention ended, the participants' QOL improved significantly, regardless of the program undertaken ($P = .02$ for group 1; $P = .005$ for group 2). Only participants in group 2 showed a significant change in functional mobility ($P = .001$) and Parkinsonian motor symptoms ($P = .012$).	Ayan & Cancela 2012
Individual exercise program	A tailored exercise program (exercise therapy and movement strategy training) biweekly 90 min	n = 15 persons with PD	self-reported number of falls, freezing gait questionnaire, Tinetti falls assessment tool, Parkinson's disease questionnaire (PDQ-39) at baseline and 1- and 2-year	At 1-year, a significant improvement was identified in gait freezing and Tinetti scores, as well as a statistically significant reduction in the number of falls and falls risk. Several aspects of the PDQ-39 have also improved. Some of the effects continued to exist through year two, but the improvement has not been consistent compared to year one.	Georgy et al., 2012
	16 months exercise intervention: flexibility/ balance/function exercise, supervised aerobic exercise, and control group with home-based exercise	RCT, n = 121 persons with PD at stages I-III at H & Y scale were randomized into three groups: flexibility/balance/function exercise, supervised aerobic exercise, and control group with home-based exercise	continuous scale physical function (CS-PFP), functional reach test (FRT), oxygen uptake ml/kg/min, unified Parkinson disease rating scale (UPDRS), ADL, Parkinson's disease quality of life scale (PDQ-39D) at baseline and 4, 10 and 16 months after intervention	Of the 121 participants, 86.8%, 82.6%, and 79.3% completed 4, 10, and 16 months, respectively, of the intervention. At 4 months, improvement in CS-PFP scores was greater in the FBF group than in the control group (mean difference = 4.3, 95% confidence interval [CI] = 1.2 to 7.3) and the AE group (mean difference = 3.1, 95% CI = 0.0 to 6.2**)**. Balance was not different among groups at any time point.	Schenkman et al., 2012
	Adapted physical activity program 3 sessions for 60-70 min per week for 9 weeks: balance, walking, strength and functional activities	n = 9 persons with PD at stage I-III at H & Y scale	six minute walking test (6MWT), five time sit-to-stand test (FTSST), Berg balance scale (BBS), sit and reach test, timed up and go-test (TUG), unified Parkinson disease rating scale (UPDRS III), PD fatigue scale (BFS), Beck depression inventory (BDI), PD quality of life scale (PDQ-8) at baseline and end of intervention	A significant decrease in resting HR (67.55 ± 10.85 vs. 70.22 ± 12.34 bpm, $p < 0.05$) and a significant increase in walked distance ($p < 0.0005$) were observed. A significant impairment of the muscle's strength was noted (FTSST, $p < 0.05$). BBS showed a significant increase in balance abilities ($p < 0.0005$) and safety with mobility (TUG, $p < 0.005$) was enhanced. Finally, a significant improvement in motor and non-motor symptoms was detected: UPDRS-III ($p < 0.00,005$), PFS ($p < 0.005$), BDI-II ($p < 0.05$) and PDQ-8 ($p < 0.05$). A tailored exercise program in PD patients could be effective as an adjunct to conventional therapy on improving daily activities, motor and non-motor symptoms, with better QoL.	Cugusi et al., 2014
	Expiratory muscle strength (EMS) training for 10 months	n = 10 persons with PD	maximal expiratory pressure (MEP), swallowing safety at baseline, at the end of intervention and 3 months after	Participants demonstrated, on average, a 19% improvement in MEP from pre- to post-EMST. Following the 3 mo detraining period, MEP declined by 2% yet remained 17% above the baseline value. No statistically significant changes were found in swallowing safety from post-EMST to postdetraining period. Following the 3 mo detraining period, seven participants demonstrated no change in swallowing safety, one worsened, and two had improvements.	Troche et al., 2014

Table 1 (*Continued*)

Physical activities: *Physical exercise form*	Intervention	Sample	Instrumentation used in data collection	Effects	Authors, per exercise form, in chronological order
	Crossover versus stabilometric platform 4 weeks for the treatment of balance	n = 60 persons with PD were randomly assigned to two groups	unified Parkinson disease rating scale (UPDRS), Berg balance scale (BBS), timed up and go-test (TUG), six minute walking test (6MWT)	Walking economy improved in the AE group compared with the FBF group at 4 months (mean difference =-1.2, 95% CI=-1.9 to -0.5), 10 months (mean difference=-1.2, 95% CI=-1.9 to -0.5), and 16 months (mean difference=-1.7, 95% CI = - 2.5 to -1.0). The only secondary outcome that showed significant differences was UPDRS ADL subscale scores: the FBF group performed better than the control group at 4 months (mean difference = - 1.47, 95% CI=-2.79 to -0.15) and 16 months (mean difference=-1.95, 95% CI=-3.84 to -0.08).	Frazzitta et al., 2015
	Expiratory muscle strength (EMS) training for 3 to 5 times per day during 4 weeks	n = 14 persons with PD	maximal expiratory pressure (MEP), Parkinson's disease questionnaire (PDQ-39)	The posttest PEmax of the 5DE was significantly higher than that of the 3DC ($P < 0.05$). Moreover, 5DE and 3DE but not 3DC significantly increased PEmax after training. There were no differences in the overall quality of life in PD patients measured by PDQ-39 among three groups, but the 5DE group significantly improved the mobility constructs of PDQ-39 compared with 3DC ($P < 0.05$).	Kuo et al., 2017
Digital device assisted exercise	A telerehabilitation application for the dysarthric speech disorder	stratified sample, n = 61 persons with PD and hypokinetic dysarthria at stage I-IV at H & Y scale	speech intelligibility, acoustic measures, sound pressure levels and duration of vowel prolongation, pitch range, participant satisfaction	The telerehabilitation application described in this study provides evidence for the delivery of online assessment for the dysarthric speech disorder associated with Parkinson's disease	Constantinescu et al., 2010
	At-home training twice per day, 30 min per session, with closed-loop wearable visual-auditory cueing device for improving gait	n = 13 persons with PD	gait velocity, stride length, cadence, freezing of gait questionnaire (FOGQ) at baseline and after 2 weeks	Devices using closed-loop sensory feedback appear to be effective and desirable nonpharmacologic interventions to improve walking in selected individuals with PD.	Espay et al., 2010
	Altered auditory feedback in improving speech rate and intelligibility	n = 10 persons with PD had both altered auditory feedback and traditional rate reduction once a week for six weeks	speech rate, intelligibility at baseline and six weeks	As a group, there was no significant change in either speech rate or intelligibility resulting from either treatment type. However, individual speakers showed improvements in speech performance as a result of each therapy technique. In most cases, these benefits persisted for at least 6 months post-treatment.	Lowit et al., 2010
	Virtual reality augmented balance training versus traditional balance training for six weeks	RCT, n = 42 persons with PD at stage II-III at H & Y scale were randomized to intervention group (n = 14), traditional balance training group (n = 14) and control group (n = 14)	sensory organization tests (SOTs), equilibrium scores, sensory ratios and verbal reaction times (VRTs) at baseline, after training and at four week follow-up	There were no significant differences in equilibrium scores or VRTs between the VR and CB groups. However, the equilibrium scores in SOT-6 (i.e., unreliable vision and somatosensation) of the VR group increased significantly more than that of the control group after training. The equilibrium scores in SOT-5 (i.e., unreliable somatosensation with eyes closed) of the CB group also increased significantly more than that of the control group after training. Both VR and CB training improved sensory integration for postural control in people with PD, especially when they were deprived of sensory redundancy.	Yen et al., 2011
	Externally cued training 3 times per week for 4 weeks: persons with PD received either to intervention group and to control group, and healthy elderly persons were an external control group	n = 21 persons with PD and 12 healthy elderly persons	center-of-mass position, center-of-mass velocity, stability against either backward or forward balance loss at baseline and after 4 weeks training	Task-specific training with preparatory audiovisual cues resulted in improved overall dynamic stability against both forward and backward balance loss.	Bhatt et al., 2013
	Intervention with yoked prisms and a pressure sensitive mat	n = 36 persons with PD	anterior-posterior and medial-lateral axes	T-tests for each measure comparing the difference-of-differences to a zero change at baseline returned statistically significant reductions in both AP ($p < 0.0001$;95%CI:1.368–2.976) and ML ($p = 0.0002$;95% CI:1.472–4.173) imbalances using specifically directed yoked prisms to correct the visual midline deviation. These	Padula et al., 2015

			findings demonstrate that yoked prisms have the potential to provide a cost-effective means to restore the visual midline thereby improving balance, reduce Risk of Falls and subsequent injury.	
Review	Database search at six databases, randomised and quasi-randomised controlled trials of VR exercise interventions in people with PD	sample size, intervention length, step and stride length, balance, quality of life	VR interventions may lead to greater improvements in step and stride length compared with physiotherapy interventions. Limited evidence that improvements in gait, balance, and quality of life were similar to those found in active control interventions.	Dockx et al., 2016
Speech treatment delivered to the home via telerehabilitation, metropolitan online and face-to-face treatment groups	RCT, n = 31 persons with PD from a metropolitan area were randomly assigned into face-to-face or online Lee Silverman Voice Treatment group, and 21 persons with PD from a nonmetropolitan area were treated online	acoustic, perceptual, and dysarthria impact profile (DIP) at baseline and two times after intervention	Significant improvements posttreatment were achieved for several acoustic, perceptual, and quality of life measures across the groups. No significant effect of online treatment location was identified.	Theodoros et al., 2016
Wearable sensor-based biofeedback gamepad training for balance and gait 20 sessions of training for balance and gait	RCT, n = 42 persons with PD were randomized into experimental (tailored functional tasks using Gamepad) and physiotherapy without biofeedback groups	Berg Balance Scale (BBS) and 10-m walk test (10MWT), instrumental stabilometric indexes, Tele-healthcare Satisfaction Questionnaire at baseline, postintervention, and at 1-month follow-up	Statistically significant between-group differences in BBS scores suggested better balance performances of the experimental group compared with the physiotherapy without biofeedback group both posttraining (experimental group – physiotherapy without biofeedback group: mean, 2.3 ± 3.4 points; P = .047) and at follow-up (experimental group – physiotherapy without biofeedback group: mean, 2.7 ± 3.3 points; P = .018). Posttraining stabilometric indexes showed that mediolateral body sway during upright stance was significantly reduced in the experimental group compared with the physiotherapy without biofeedback group (experimental group – physiotherapy without biofeedback group: -1.6 ± 1.5 mm; P = .003). No significant between-group differences were found in the other outcomes.	Carpinella et al., 2017
One session of game-based augmented visual feedback via articulatory kinematics	n = 9 persons with PD and dysarthria	articulatory working space (AWS) at baseline and 48 h after training session	Eight of nine participants benefited from training, increasing their sentence AWS to a greater degree following feedback as compared with the baseline in loud and clear conditions. The majority of participants were able to demonstrate the learned skill at the retention session.	Yunusova et al., 2017

system (GAMing Experience in Parkinson's Disease, Gamepad) (Carpinella et al., 2017), a game-based visual feedback system (Yunusova et al., 2017) and telerehabilitation equipment (Theodoros et al., 2016; Constantinescu et al., 2010).

A focus on cognitive rehabilitation was seen in only a few papers. In an intervention study by De Natale et al. (2017), dance therapy was found to significantly improve ($p = 0.007$, 0.014) the motor and cognitive outcomes of persons with PD ($n = 9$) but not the control group ($n = 7$). Cruise et al. (2011) found that exercise as such improved frontal lobe based executive function, but not mood or disease-specific QoL. In a systematic review and meta-analysis of the effectiveness of exercise intervention programs on cognition in people suffering from multiple sclerosis, stroke or PD, Kalron and Zeilig (2015) found in nine of the 12 studies they reviewed that exercise led to statistically significant improvements in cognition but that the total effect size was non-significant (0.18) for changes in executive functions. Kalron and Zeilig also noted that due to the lack of commonality between the measures of cognition, training sequences and intervention periods seen in their study, it was unclear whether exercise training can be considered effective in improving the cognitive functions of neurological patients (Kalron and Zeilig, 2015). Cognition in relation to brain plasticity and increase of grey matter density was referred to in two papers. In a report, Mirabella (2015) questioned whether art therapy could promote some form of brain plasticity or compensate for the brain damage caused by PD. In a systematic review, McLean et al. (2017) sought information on the effectiveness of mindfulness-based stress reduction but found limited and inconclusive evidence of its effectiveness for persons with PD. In another systematic review, Alzahrani and Venneri (2018) looked at the effectiveness of cognitive rehabilitation in PD, concluding that longitudinal studies to investigate the possible long-term benefits of cognitive training and an investigation of whether disease characteristics (e.g., disease stage, degree of cognitive impairment, dominant side (right/left), specific motor symptoms (rigidity/tremor) influence the effectiveness of treatment were needed.

In only a few papers was a focus on psychosocial rehabilitation seen. In a study protocol for a 3-year prospective cohort study, Tickle-Degnen et al. (2014) sought to understand the social self-management of persons with PD: the degree to which expressive nonverbal capacity can predict the trajectory of social self-management and whether gender has a moderating effect on the association between expressive capacity and change in social self-management. One paper emerged from that cohort study, a preliminary analysis by Ma et al. (2016) in which significant correlations were found between QoL and gender ($r = .26$), disease severity ($r = .38$), depression ($r = .65$), motor difficulties of daily living ($r = .71$), and stigma ($r = .83$). Ma et al. also found that perceived stigma made a significant and unique contribution to the explanation of QoL by 13.7% ($p < 0.001$) and, using a final hierarchical multiple regression with stigma and 4 covariates, presented an overall model that explained 77.8% of the total variance of QoL ($F\,[5, 63] = 48.79$, p 0.001). Navarta-Sánchez et al. (2018) presented a study protocol in which a quasi-experimental study was used to evaluate the effects of a multidisciplinary psychosocial intervention that focused on improving coping skills for persons with PD, their adjustment to PD and QoL for both persons with PD and their family caregivers. All of the interventions seen in this category were developed for and implemented with persons with PD individually or in groups; near-ones were not included.

Regarding person-centeredness, the majority of cross-sectional studies ($n = 46$) were planned without patient involvement, and the patients' preferences, needs, and values were not considered prior to implementation of interventions. Also, the recruitment of participants and subsequent division into intervention and control group appears to have been based on clinical status (motoric and non-motoric symptoms). Only some interventions were individually tailored (Cugusi et al., 2015, Cugusi et al., 2014) and only some interventions were conducted at a patient's home (Bhatt et al., 2013; Espay et al., 2010; Constantinescu et al., 2010). However, many interventions included patient-recorded outcome measures such as assessment of ADL function (Kuo et al., 2017; Cugusi et al., 2014; Paker et al., 2013; Georgy et al., 2012), QoL (Ferrazzoli et al., 2018; Dockx et al., 2016; Theodoros et al., 2016; Yang et al., 2015; Connor et al., 2015; Cugusi et al., 2014; Combs et al., 2013; Ayán and Cancela, 2012), mood or disease-specific QoL (Cruise et al., 2011), well-being (Cwiekala-Lewis et al., 2017), or motor and non-motor symptoms (Connor et al., 2015; Cugusi et al., 2015, Cugusi et al., 2014).

The effectiveness of rehabilitation through physical activities was difficult to synthetize due to differences in the papers' focus, research design and sample criteria. However, it appears that physical exercise improved physical outcomes, e.g., resting heart rate (Cugusi et al., 2015), lower limb muscle strength (Cugusi et al., 2015, Cugusi et al., 2014), balance (Cwiekala-Lewis et al., 2017; Cugusi et al., 2015; Frazzitta et al., 2015; Cugusi et al., 2014; Yang et al., 2015; Harro et al., 2014; Combs et al., 2013), coordination (Hulbert et al., 2017), gait (Lander and Moran, 2017; Wassom et al., 2015; Earhart and Williams, 2012; Georgy et al., 2012), and walking capacity (Cugusi et al., 2015; Uygur et al., 2015; Cugusi et al., 2014; Paker et al., 2013; Combs et al., 2013; Schenkman et al., 2012). Additionally, physical exercise improved well-being or QoL (Cwiekala-Lewis et al., 2017; Combs et al., 2013; Ayán and Cancela, 2012), physical exercise improved ADL functions (Cugusi et al., 2014; Schenkman et al., 2012; Georgy et al., 2012), and physical exercise decreased non-motoric symptoms (Cugusi et al., 2015) such as tremors or bradykinesia (Ridgel et al., 2012). It is worth noting, however, that the addition of further tasks during physical exercise appeared to have a negative impact on task performance (Lapointe et al., 2010; Brown et al., 2010) but that such was not seen when measured during a single combined mental and physical exercise session (De Melo Santiago et al., 2015). Lastly, virtual devices and applications used during physical exercise, such as VR goggles/headsets/glasses, closed-loop sensory feedback systems, systems-yoked prisms or gamepads, or telerehabilitation with visual feedback seem to improve walking (Dockx et al., 2016; Espay et al., 2010), balance (Carpinella et al., 2017; Padula et al., 2015; Bhatt et al., 2013; Yen et al., 2011), speech (Yunusova et al., 2017; Theodoros et al., 2016; Constantinescu et al., 2010; Lowit et al., 2010), and QoL (Theodoros et al., 2016).

The effectiveness of cognitive or social rehabilitation could not be explored here due to the small number of papers included in this review that referenced those subjects. Rehabilitative programs for persons with PD should be "goal-based" (targeted to practicing and learning-specific activities from core areas), a number of practice variables (intensity, specificity, complexity) should still be identified and programs should be tailored to each individual patient's characteristics (Abbruzzese et al., 2016).

An interprofessional approach to PD rehabilitation was found to be effective in regard to QoL by Ferrazzoli et al. (2018), both immediately and three months after intensive multidisciplinary rehabilitation. In a mixed-methods study, Connor et al. (2015) used a randomized controlled trial design to test their newly developed multidisciplinary implementation program, Care Coordination for Health Promotion and Activities in Parkinson's Disease (CHAPS), investigating whether it improves performance in 38 quality measures categorized into overarching areas: communication, education, and continuity; regulatory reporting; diagnosis; periodic assessment; medication use; management of motor and non-motor symptoms; use of non-pharmacological approaches and therapies; palliative care; and health maintenance. The secondary outcomes measured with CHAPS are patient HRQoL, self-efficacy, and perceptions of care quality (Connor et al., 2015). To date, there are no published results from that study yet. Tan et al. (2014) conducted a systematic review and found inconclusive evidence to quantify the positive and sustained effects of multidisciplinary interventions in regard to improving QoL for persons with PD. Tan et al. also noted that the studies included in their review varied and lacked long-term follow-up that could quantify retention of the interventions addressed.

Seen here, the overall purpose of the instruments in the included papers was to measure physical outcomes (see Table 1) or perceived ADL capacity or QoL, and all of the instruments were especially developed or validated for persons with PD. The PDQ-39, a 39-item Parkinson Disease Questionnaire that measures perceived health-related QoL and ADL capacity (Jenkinson et al., 1997), was the instrument most often seen in the included papers. Used to measure patient-recorded outcomes, the PDQ-39 has been validated in several studies (Tu et al., 2017a, Tu et al., 2017b; Morley et al., 2015; Lawrence et al., 2014). The Unified Parkinson's Disease Rating Scale (UPDRS), which measures perceived ADL capacity and QoL, was also often seen and validated in several studies (Lee et al., 2016; Lawrence et al., 2014). The 36-item Short-Form Health Survey (SF-36) was used to measure perceived clinical symptoms and validated (Tu et al., 2017a, Tu et al., 2017b; Raggi et al., 2012). The 36-item WHO-DAS II, used to measure disability, was used alongside the SF-36 to group patients (i.e., perceived ADL capacity and HRQoL) (Raggi et al., 2012). The Satisfaction With Life Scale (SWLS) was used to assess life satisfaction (Rosengren et al., 2015). The Patient-Reported Outcome tool for Advanced Parkinson's disease (PRO-APD) was developed with the aim to assess patient's perceptions of symptom severity and expectations of therapy (Reddy et al., 2014).

5. Discussion and conclusions

The aim of this study was to describe the existing knowledge on the rehabilitation of persons with PD suitable to a home environment and which can involve the use of digital devices, if so desired. In this scoping review (n = 67 papers), the majority of papers had a focus on rehabilitation through physical activities and the effect that such has on the motoric and non-motoric symptoms of PD (cf. Gisbert and Schenkman, 2015). There were very few papers or studies exploring cognitive or psychosocial rehabilitation, even though PD is known to negatively affect autonomy (Hedman et al., 2015), self-image (cf. Ma et al., 2016), ADL-functions and QoL (cf. Hariz and Forsgren, 2011). Due to the fact that most persons receive a late diagnosis, immediate holistic rehabilitation is needed once a diagnosis has been made (cf. Ebben, 2018), including an individual plan for physical activities (cf. Kalron and Zeilig, 2015) such as walking, dancing, cycling or qigong alongside art therapy (cf. Mirabella, 2015) and mindfulness-related stress reduction (cf. McLean et al., 2017).

Still, research on cognitive and psychosocial rehabilitation is lacking, and there is an overall gap in the knowledge and application of interventions for persons with PD or their near-ones (cf. Navarta-Sánchez et al., 2018; Ma et al., 2016; Tickle-Degnen et al., 2014). The rehabilitation interventions presented in the papers reviewed were developed for and implemented with persons with PD individually or in groups; their near-ones were not included even though they may also experience changes in everyday QoL (cf. Balash et al., 2017; Gisbert and Schenkman, 2015; Kelly et al., 2012). This occurred despite the fact that the majority of physical rehabilitation activities were suitable for the home environment and thus also for patients' near-ones (cf. Gisbert and Schenkman, 2015; Moldovan and Dogaru, 2014). Only some activities required special devices such as a treadmill or boxing equipment, which can be purchased or rented. While a range of digital devices used to measure different physical outcome parameters was also seen in the papers reviewed, these are not necessary for home rehabilitation, unless individual, "motivating" feedback is needed. However, there were some digital exercise devices (e.g., a wearable sensor-based biofeedback gamepad, closed-loop wearable visual-auditory cueing device) that appeared to improve motoric outcomes (cf. Carpinella et al., 2017; Yunusova et al., 2017; Dockx et al., 2016; Espay et al., 2010) and QoL (cf. Theodoros et al., 2016) to some degree. Most important is that continuity and person-centeredness is integrated into at-home physical exercise sessions for persons with PD. Digital devices can facilitate such and thus should be further developed so as to provide both personal guidance and immediate feedback, thereby increasing the safety of home rehabilitation.

The effectiveness of rehabilitation through physical activities was difficult to synthetize; research focus, designs and sample criteria differed. However, it appears that physical exercise decreased non-motoric symptoms and improved physical outcomes, ADL functions, well-being and/or QoL. Digital devices such as VR goggles/headsets/glasses, closed-loop sensory feedback, systems-yoked prisms or gamepads, or telerehabilitation with visual feedback, when used in conjunction with physical exercise, appear to improve clinical outcomes (cf. Albiol-Perez et al., 2012), possibly due to the individualized, person-centered feedback they can provide (cf. Gisbert and Schenkman, 2015). Given that such devices support both continuity and individuality in rehabilitation, these results are promising. We note that due to the small number of papers related to the effectiveness of cognitive or psychosocial rehabilitation, no conclusions can be drawn about these aspects in this review.

While the majority of interventions investigated in the studies reviewed (n = 46) were planned for persons with PD, such occurred without discussing with the persons themselves in advance about their preferences, needs, or values, i.e., in direct contradiction to the principles of person-centeredness (cf. Ekman et al., 2011; McCormack and McCance, 2006; Kitwood, 1997). The recruitment of participants was based on clinical status, mainly motoric and non-motoric symptoms – not the persons' preferred form of rehabilitation activity, capacity for learning or age (cf. Gisbert and Schenkman, 2015; Moldovan and Dogaru, 2014). In some studies, it was stated that the interventions were individually tailored, but how or why they were considered so was not explained. Some rehabilitation was conducted in persons' homes with the help of telecommunication or digital devices, and many studies included patient-recorded outcome measures (cf. Bindemann, 2010). Nevertheless, these often seemed secondary in relation to clinical measures.

As previously mentioned, the majority of papers were from non-nursing journals: medical journals (37%) or journals with a focus on rehabilitation (25%) or physiotherapy (15%). This may partially explain why the interventions primarily had a physical or clinical outcome focus. For some decades, a multidisciplinary or interprofessional perspective has been considered a key factor in evidence-based, effective and continuous care. Yet there were few papers with a multidisciplinary approach to PD rehabilitation (cf. Earhart and Williams, 2012). Still, Ferrazzoli et al. (2018) found an interprofessional approach to be effective in regard to the QoL of persons with PD, both immediately and three months after intensive interprofessional rehabilitation. Given that two ongoing studies investigating such an approach were seen in this review, we conclude that this approach is starting to emerge.

The focus of rehabilitation in the context of PD still appears to lie on physiological symptoms and functional capacity, not cognitive or psychosocial well-being as such. However, research into such aspects of rehabilitation seems to be growing, and person-centeredness is already somewhat embedded in rehabilitation interventions in the form of individually tailored physical interventions with or without digital device feedback, patient-recorded outcome measurements and home rehabilitation experiments. We maintain that the majority of physical rehabilitation activities described in this review are suitable for a home setting and, consequently, not only persons with PD but also their near-ones, whose rehabilitation currently appears to be non-existent, can benefit from such an arrangement. We saw that digital devices used to assist physical rehabilitation and an interprofessional approach to rehabilitation yield positive clinical outcomes, which in turn promotes a person-centered and holistic approach to rehabilitation.

This review has some limitations. The data search was conducted by one author only, and while there is a manual documentation of the search process there is no registered review protocol. Still, the data charting form was developed by all three authors, and two authors independently performed the data extraction. The participants' type of PD, stage of illness, adverse events or reasons for study dropout were not always explicitly reported in the data reviewed. In the intervention studies the sample sizes were quite small (20–120, mean 20), the availability of follow-up data on the long-term effects of a rehabilitation intervention was limited, and significant outcomes were often contradicted by other results. Furthermore, effectiveness was most often considered in relation to clinical outcomes and there was no reporting on the costs/benefits of interventions and/or how they affected health service utilization.

Further trials with larger sample sizes, control groups, randomization, standardized outcome measures and longer follow-ups are needed. We recommend that truly person-centered interventions and study designs should be developed, analyzed and reported together with persons with PD and their near-ones. Furthermore, studies and interventions should more often focus on the cognitive and psychosocial rehabilitation, and include patients´ near-ones. The outcome measurement should also be person-centered: in addition to clinical measures and objective observations such as physiological parameters, the different patient-recorded outcome measures and experiences with focus on self-efficacy, medication use, ADL, QoL – in form of diaries or interviews - should be embedded into all trials. This speaks for interprofessional research groups and interprofessional interventions. After all these improvements are made, we recommend implementation science studies in order to evaluate the context before moving into home rehabilitation studies.

Declaration of Competing Interest

No conflicts of interest to state.

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