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Chapter

# Current Rehabilitation Therapies in Parkinson's Disease

*Qing Zhao, Lingjing Jin, Lin Ma, Tingting Sun and Mengdie Zhou*

## Abstract

Rehabilitation is one of the important non-pharmacological interventions for Parkinson's disease (PD). At the time of diagnosis, an appropriate exercise regimen can be prescribed based on the patient's symptoms. Rehabilitative therapies should be continued throughout the disease course. This chapter summarized the standard specifications and research progression on PD from perspectives of assessment and treatment of rehabilitation. The physical therapy, occupational therapy, speech-language therapy, and neuromodulation therapy are the focus of the introduction. Accurate and comprehensive functional assessment is the premise of rehabilitation plan. Various approaches are used individually or in combined targeted at one or more dysfunction. Although there is still no consensus about the optimal approach about intensity, the frequency of treatment sessions, and complexity, rehabilitation is proved to be able to induce short-term, but clinically important benefits, particularly for gait and balance. The rehabilitative program for PD should be targeted to practicing and learning specific activities in the core areas and be tailored to the individual patients' characteristics. In addition to improving patient's performance, environmental modification and alleviation of caregivers are also included in rehabilitation intervention. Innovative techniques have been recently proposed: virtual reality and exergaming, motor imagery and action observation, robot-assisted physiotherapy, and nonconventional therapies.

**Keywords:** Parkinson's disease, rehabilitation, physical therapy, occupational therapy, speech-language therapy, self-management

## 1. Introduction

Rehabilitative therapy is very important across Parkinson's disease (PD) stages, which is considered as an adjuvant to pharmacological and surgical treatments for PD to maintain functional ability, minimize secondary complications, and improve quality of life. In a broad sense, rehabilitation includes exercise, physiotherapy, occupational therapy, speech-language therapy, psychological and cognitive therapy, nursing and care, dietetic intervention, as well as neuromodulation. Telemedicine and artificial intelligence are also boosting the development of PD rehabilitation. The evidence of these interventions is growing rapidly, and the following contents mainly refer to
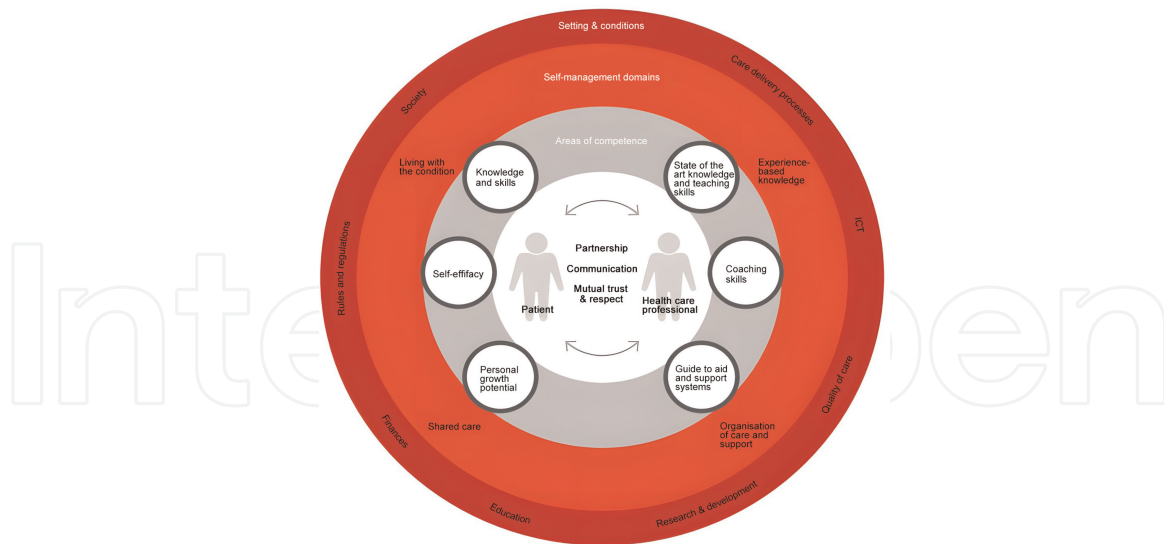
**Figure 1.**
*Generic model of self-management [1].*

authoritative guidelines as well as findings from relatively high-quality randomized clinical trial studies. No matter what kind of rehabilitation, self-management, and long-term adherence should be emphasized. Experts recommend using *5As* model (Assess, Advice, Agree, Assist, and Arrange) to foster motivation of people with PD (Pwp) (**Figure 1**).

## 2. Mechanisms underline benefits of physical therapy in PD
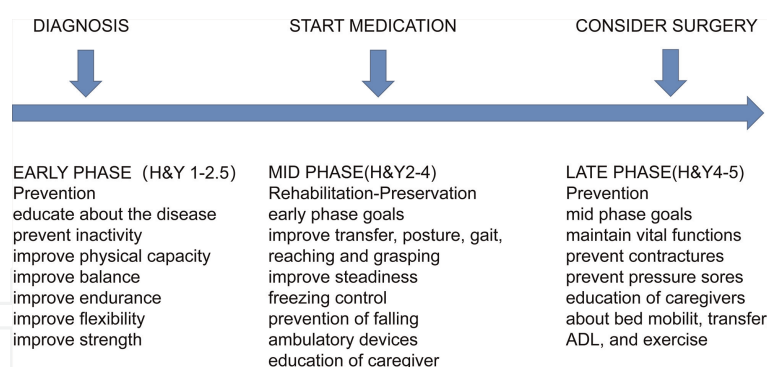
Animal experiments have shown that exercise and learning are able to induce a dynamic interplay between degenerative and regenerative mechanisms, influence dopaminergic and glutamatergic neurotransmission, increase synaptic strength and potentiate functional circuitry and induce the brain plasticity which is likely to represent neural basis of rehabilitation for PD. In addition, increasing evidence suggests that physical exercise alleviates chronic oxidative stress through increasing mitochondria biogenesis and up-regulating autophagy, stimulates the synthesis of neurotransmitters and trophic factors. All of these molecular biological changes probably contribute to neuroplasticity.

On the other hand, a combination of physical therapy and neuromodulation techniques (DBS, rTMS, tDCs) may improve retention of motor learning by modulating excitability of certain cortical areas.

So, it may be explained to some extent, exercise and physiotherapy could help not only motor and non-motor symptoms or complications but also show disease-modified potential.

## 3. Physical therapy (PT)

In European physiotherapy guidelines for PD, the five core areas of PT are physical capacity, transfers, manual activities, balance, and gait. Additional areas include pain and respiratory problems. Physical capacity is expressed by exercise tolerance, joint mobility plus muscle tone, power, and endurance, which is precondition for activities

DIAGNOSIS  START MEDICATION  CONSIDER SURGERY

EARLY PHASE  (H&Y 1-2.5)
Prevention
educate about the disease
prevent inactivity
improve physical capacity
improve balance
improve endurance
improve flexibility
improve strength

MID PHASE(H&Y2-4)
Rehabilitation-Preservation
early phase goals
improve transfer, posture, gait,
reaching and grasping
improve steadiness
freezing control
prevention of falling
ambulatory devices
education of caregiver

LATE PHASE(H&Y4-5)
Prevention
mid phase goals
maintain vital functions
prevent contractures
prevent pressure sores
education of caregivers
about bed mobilit, transfer,
ADL, and exercise

**Figure 2.**
*Main goals in each stages of PD [2].*

of daily life and participation in society. As the disease progresses, transfer and manual activities are often diminished as complex motor sequences and associated with tremor sometimes. The main hazard of balance disorders are fallen. Other associated factors of falls include freezing, reduced step height, bradykinesia, impaired postural reflexes, sedative drugs, and fear. It is recommended to establish rehabilitation goals and specific programs according to the individual differences in Pwp and stages of disease, including early, mid, and late phase corresponding to Hoehn-Yahr classification (**Figure 2**). All physiotherapists are advised to describe *SMART* goals:

- Specific: avoid broad goals and identify specific problems.

- Measurable: using one or more of the recommended measurement tools.

- Attainable: where both the Pwp and physiotherapist expect its feasibility as well as practicable.

- Relevant: to this individual Pwp and within the scope of physiotherapy

- Time-based: by when it is expected, these goals should be achieved.

The goal attainment scaling (GAS) provides a method to score the extent to which Pwp goal is achieved in the course of intervention.

## 3.1 Measurement tools

Evaluation is necessary and critical for rehabilitation of PD because it contributes to identify impairments, set goal to meet the patient's needs, develop the appropriate treatment plan, and even motivate patients in adherence to the therapy. Due to the medication intake impairments and activity limitations for Pwp can vary greatly during a day, most questionnaires and measurement tools are used at time of the day and tiredness of patients after medication intake. But for balance or applicable for specific patients who report differences in ability, it is recommended to assess in both on and off stages. Although it could be assessed for the severity of disease comprehensively by means of MDS-UPDRS from four perspectives, more detailed and targeted rehabilitative evaluations are still needed. Recommended measurement tools for physical therapy of PD are summarized in **Table 1.** And the most common ones are described below:

| Physical capacity | Transfer | Manual activity | Balance | Gait | Flexibility | Fall | Quality of life |
|---|---|---|---|---|---|---|---|
| Endurance: 6MWT,GXT Borg Scale (RPE) | Bed related: M-PAS Bed | STEF | Push & Release Test, RPT FRT,SLST | 10 MW 6MWT | ROM (Goniometer) | ABC | PDQ-39 EQ-5D PDQL |
| Aerobotic: TMST | | NHPT | Stationary: BBS | Rapid Turns | | FES-I | ADL |
| Resistance: MMT, ACT Isokinetic dynamometer | Chair related: M-PAS Chair FTSTS | | Transfer related: M-PAS Chair FTSTS | M-PAS gait &TUG | SRT Bach scratch | | CGI PSI-PD |
| FTSTS | TUG | | Gait related: M-PAS gait &TUG Rapid Turns DGI FGA Mini-BESTest | FOG-Q | | | |

6MWT: 6 Minutes' Walk Test; GXT: Graded Exercise Test; TMST: 2 Minutes Step Test; ACT: Arm Curled Test; FTSTS: 5 Times Sit To Stand; M-PAS: Modified Parkinson Activity Scale; TUG: Timed Up&Go; STEF: Simple Test for Evaluating Hand Function; NHPT: Nine-Hole Peg Test; RPT: Retropulsion Test; FRT: Functional Reach Test; SLST: Single Leg Stand Test; BBS: Berg Balance Scale; DGI: Dynamic Gait Index; FGA: Functional Gait Assessment; FOG: Freezing Of Gait; SRT: Sit and Reach Test; ABC: Activities Balance Confidence Scale; FES-I: Falls Efficacy Scale International.

**Table 1.**
*Measurement tools for PD.*

### 3.1.1 Modified Parkinson activity scale (M-PAS)

The M-PAS was developed as an objective evaluation tool for activity limitations within the core areas of motor rehabilitation. The M-PAS was introduced as the only rating scale recommended in the physical and occupational therapy guidelines for Pwp. It consists of 14 items divided into three domains that describe core activities related to functional mobility for Pwp: chair transfer (two items), gait akinesia (six items), and bed mobility (six items). Each item is scored on a 5-point scale (0–4), with higher scores indicating greater independence. This assessment takes into account whether to use hands when transfer, whether there is a dual task (motor or cognitive) and so on more accurately so that it can break the ceiling effects of PAS.

### 3.1.2 Berg balance scale (BBS)

The BBS has been the main instrument used to evaluate balance impairment in different populations and disorders. It is a 14-item scale that objectively measures static and dynamic activities of varying difficulty. Each item is scored on a 5-point ordinal scale ranging from 0 (unable to perform) to 4 (normal performance). The total score range is 0–56, and higher scores denote better balance. Scores of 0–20 refer to those patients restricted to a wheelchair; 21–40 refer to assistance during the gait; and 41–56 points correspond to independence. Scoring is based on the individual's ability to perform each task independently and/or meet certain time or distance requirements. But it is not suitable for Pwp in Hoehn-Yahr 4—5 stage, and for patients with vestibular dysfunction.

### 3.1.3 Six minute walk test (6MWT)

The 6MWT is a sub-maximal exercise test used to assess aerobic capacity and endurance, which provides valuable information regarding all the systems during physical activity, including pulmonary and cardiovascular systems, blood circulation, neuromuscular units, body metabolism, and peripheral circulation. Turning difficulty is frequently reported in Pwp and affects ability of movement combined with hypokinesia. Locomotor assessment of straight-line walking and turning are widely clinically used when considered together rather than when assessed independently. The 6MWT is conducive to such an assessment because it generally combines numerous turns and straight-line walking within 6 minutes. It is important to standardize the track for both clinical and research purposes and it is recommended that a 30-meter or 100-foot walkway with the length of corridor be marked every 3 meters while turn-around points are to be marked by a cone [3].

### 3.1.4 10 meter walk (10 MW)

The 10 MWT is a performance measure used to assess walking speed in meters per second over a short distance. It can be employed to determine functional mobility, gait, and vestibular function. The individual walks without assistance for 10 meters, with the time measured for the intermediate 6 meters to allow for acceleration. It has demonstrated excellent reliability in many conditions, including PD, so it was updated by American Physical Therapy Association (APTA) in 2013. The test can be performed at preferred walking speed or fastest speed possible. The average walking speed for persons in $60-69$ is $1.34-1.24$ m/s, while Pwp is much slower than that.

### 3.1.5 Timed up and go (TUG)

The TUG test is a clinical tool widely used to determine fall risk and measure the progress of balance, sit-to-stand and walking. During the test, the patient stands up upon therapist's command, walks 3 meters, turns around, walks back to the chair, and sits down. For Pwp, some changes usually are observed such as slow tentative pace, loss of balance, short strides, little or no arm swing, and shuffling. The sensitivity and specificity have been reported to be 87%. But it demonstrates less reliability among patients suffering from cognitive impairment (**Figure 3**).



Simple Test for Evaluating Hand Function(STEF)     Nine-Hole Peg Test(NHPT)
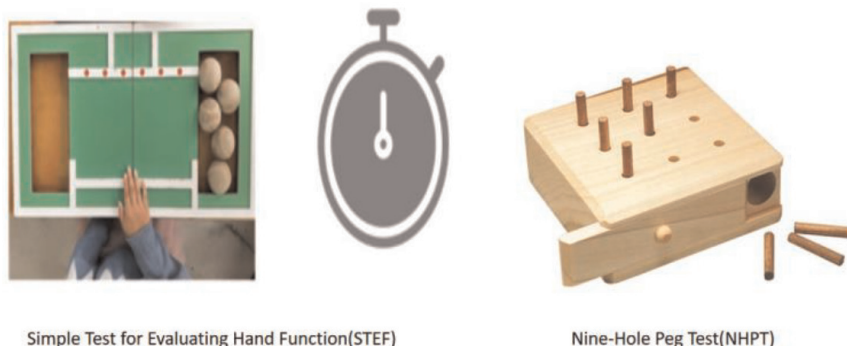
**Figure 3.**
*Assessment tests for manual activity.*

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### 3.1.6 Mini-BESTest

The Mini-BESTest is both a clinical tool and a research outcome measure that examines postural control systems through the performance of dynamic balance tasks. Four items of it include anticipatory, reactive postural control, sensory orientation, and dynamic gait. Recent clinical study has shown that the Mini-BESTest was the strongest individual predictor of falls in individuals with PD compared with other balance scales, highlighting the importance of evaluating dynamic balance ability during fall risk assessment.

### 3.1.7 Five times sit to stand (FTSTS)

The FTSTS is a quick and easy test for functional lower extremity strength, ability to transition movements, balance, and fall risk. Its scoring is based on the amount of time (to the nearest decimal in seconds) a patient is able to transfer from a seated to a standing position and back to sitting five times, which was more sensitive for younger population(<60 years). The shorter the time to complete the test, the better the outcome of it. It has a moderate responsiveness to change over time and was moderately related to measures of gait and dynamic balance in vestibular and balance disorders participants.

### 3.1.8 New freezing of gait questionnaire (NFOG-Q)

NFOG-Q is a widely used tool to quantify freezing of gait severity. It is a self-reported questionnaire consisting of nine items that measure freezing of gait (FOG). But its reliability is influenced by the patients' difficulties with self-perceived ratings of FOG and it is currently questioned as an outcome indicator for clinical trials [4]. So, the automated video system and wearable sensor techniques are developed for Pwp to provide more objective and accurate information about FOG. For example, the Kin-FOG system uses an RGB-D sensor based on Microsoft Kinect V2 for capturing data [5]. Wearable sensor-based devices can detect freezes in progress and provide a cue to help the Pwp resume walking.

### 3.1.9 Borg scale 6–20

Borg rating of perceived exertion (RPE) is a tool to measure person's perception of effort and exertion, breathlessness, and fatigue during activity. It can be used in monitoring the progress and intensity of exercise for Pwp undergoing rehabilitation and endurance training. Borg's original version is a 15-point scale ranging from 6 to 20 (no exertion at all to absolutely maximum). Effort is graded using number or words. It is a significant predictor of heart rate and workload, which is not affected by age, gender, or disease severity. So, it is used in Pwp in which formal exercise testing may not be available [6].

## 3.2 Approaches of physiotherapy

The contents of physical therapy include three parts: exercise, practice, and movement strategy training. Functional exercise aiming to induce motor learning is called "Practice." Conventional physiotherapy is categorized as all physiotherapist-supervised active exercise interventions targeting the core areas above. To gain insight

into the barriers and preferences regarding exercise of Pwp is the foundation and one of main goals of PT is encouraging Pwp strives for normal physical activity under supervision or not.

Exercise, as a subset of physical activity, is planned, structured, repetitive, and has a defined endpoint with the goal of improving physical fitness. Exercise is a universal prescription for PD. Moreover, exercise is a broad term that incorporates various activities, such as aerobic exercise, resistance training, flexibility training, and other types. Recommendations for valid exercise are shown in **Table 2** according to the APTA guideline 2022 [7].

| Intervention | Quality of Evidence | Strength of Recommendation | Recommendation |
|---|---|---|---|
| Aerobic exercise | High | ◆◆◆◆ | Physical therapists should implement moderate- to high-intensity aerobic exercise to improve $VO_2$, reduce motor disease severity and improve functional outcomes in individuals with Parkinson disease |
| Resistance training | High | ◆◆◆◆ | Physical therapists should implement resistance training to reduce motor disease severity and improve strength, power, nonmotor symptoms, functional outcomes, and quality of life in individuals with Parkinson disease |
| Balance training | High | ◆◆◆◆ | Physical therapists should implement balance training intervention programs to reduce postural control impairments and improve balance and gait outcomes, mobility, balance confidence, and quality of life in individuals with Parkinson disease |
| Flexibility exercises | Low | ◆◆◇◇ | Physical therapists may implement flexibility exercises to improve ROM in individuals with Parkinson disease |
| External cueing | High | ◆◆◆◆ | Physical therapists should implement external cueing to reduce motor disease severity and freezing of gait and to improve gait outcomes in individuals with Parkinson disease |
| Community-based exercise | High | ◆◆◆◆ | Physical therapists should recommend community-based exercise to reduce motor disease severity and improve nonmotor symptoms, functional outcomes, and quality of life in individuals with Parkinson disease |
| Gait training | High | ◆◆◆◆ | Physical therapists should implement gait training to reduce motor disease severity and improve stride length, gait speed, mobility, and balance in individuals with Parkinson disease |
| Task-specific training | High | ◆◆◆◆ | Physical therapists should implement task-specific training to improve task-specific impairment levels and functional outcomes for individuals with Parkinson disease |
| Behavior-change approach | High | ◆◆◆◇ | Physical therapists should implement behavior-change approaches to improve physical activity and quality of life in individuals with Parkinson disease |

| Intervention | Quality of Evidence | Strength of Recommendation | Recommendation |
|---|---|---|---|
| Integrated care | High | ◆◆◆◆ | Physical therapist services should be delivered within an integrated care approach to reduce motor disease severity and improve quality of life in individuals with Parkinson disease |
| Telerehabilitation | Moderate | ◆◆◇◇ | Physical therapist services may be delivered via telerehabilitation to improve balance in individuals with Parkinson disease |

**Table 2.**
*Recommendations of American Physical Therapy Association (APTA) [7].*

### 3.2.1 Aerobic exercise

Several high-quality clinical trials confirmed that moderate to high-intensity aerobic exercise can improve oxygen consumption (VO2), motor and non-motor impairments, be a benefit for improving functional activities (gait, balance) and quality of life in Pwp. As for modes of exercise walking on a treadmill or stationary cycling are frequently used but there is no evidence single form of aerobic exercise is superior to another. It should be chosen to ensure safety of Pwp, especially for those who are at high risk of falling and/or with FOG. Gradually progressing the duration and intensity of the aerobic exercise is recommended to reduce risk of injury. In Parkinson's exercise guidelines in American College of Sports Medicine (ACSM) there are elaborate introduction on the frequency, intensity and progression, time and volume, type of exercises, and even disease-related considerations for Pwp (**Table 3**), [8]. In addition, regular, long-term engagement in aerobic exercise is needed to sustain a benefit.

### 3.2.2 Resistance training

A progressive resistance training program was shown to be more effective than a nonprogressive exercise intervention (modified from the fitness counts booklet, Parkinson's foundation). Resistance training with instability (RTI) was favored and specific modes include free weights, weighted vests, weight machines, closed vs. open-chain activities, body weight resistance, etc.

Either alone or as a part of multimodal intervention resistance training can improve muscle power or strength, non-motor (depression, anxiety, and cognition), activities (gait speed, balance, mobility, and stability), quality of life, and reduce fall rate of Pwp.

### 3.2.3 Balance training

The intervention approaches used to target balance are mainly multimodal balance training that incorporated elements of strengthening, sensory integration, anticipatory postural adjustments, compensatory postural adjustments, gait, and functional task training. Its benefits are reflected in improvement of postural control, balance and confidence, mobility, gait outcomes, quality of life as well as non-motor

| F.I.T.T.-V.P. | Aerobic | Strength | Balance, agility, & multi-Tasking | Flexibility |
|---|---|---|---|---|
| Frequency | At least 3 days per week. | 2−3 days per week, challenging all major muscle groups on nonconsecutive days. | 2−3 days per week focused workout, with daily integration as possible. | ≥ 2−3 days/week, with dally being most effective. |
| Intensity & Progression | Moderate Intensity: 40% - 60% HRR (or VO$_2$R), RPE of 12−13/20 or 3−4/10. **Progress** to vigorous intensity: 60−85% HRR; RPE 14−17/20 or 5−7/10), when physiologically appropriate and safe. Teach client to self-assess. | 40−50% of 1-RM for beginners. 60−70% 1-RM for more advanced exercisers. **Progress** number of repetitions and resistance, working muscles to fatigue. | Appropriate challenge delivered in a safe manner given the setting (individual vs. group). **Progress** motor and cognitive challenges as patient improves and can tolerate. | Full extension, flexion, or rotation stretch to the point of slight discomfort. **Progress** as patient can tolerate |
| Time & Volume | ≥30 min of continuous or intermittent exercise per session.<br><br>Build to at least 150 minutes/week. | 10−15 repetitions starting an exercise program. ≥1 set of 8−12 repetitions (∼60% 1-RM) and progress to 3 sets of 8−10 to fatigue. Build to 2−3 hours/week. | 30−60 minutes per workout.<br><br>Build to 2−3 hours/week. | Static Stretching: 15–60 seconds per muscle; 2–4 repetitions of each stretch.<br><br>Dynamic Stretching: 8−10 movements in each direction. |
| Type | Prolonged, rhythmic activities using large muscle groups. | Major muscle groups of the upper and lower body using weight machines, resistance bands, or body weight. Focus on extensors. Could use resistance training with instability. | Multi-directional stepping, weight shifting, reaching, large amplitude movements, functional agility (steps, turning, obstacles, backwards, floor activities, sit-to-stand). Multi-task training (motor, cognitive, distractions). Static and dynamic balance with varied surfaces, limb support, perturbations. | Static Stretching: All major muscle groups after exercise, first thing in the morning or before bed. Dynamic stretching/active range of motion: Prior to intense aerobic and strengthening exercise. Include diaphragmatic breathing and meditation. |
| Disease-Related Considerations | Prioritize safety (ambulatory status, physical assistance, equipment). Risk of freezing of gait. Consider comorbidities (*e.g.*, musculoskeletal, cardio-respiratory). Risk of autonomic | Posture and body mechanics. Estimate 1-RM safely. Progressive with high repetitions. Timed for ON periods of optimal functioning. For safety, avoid heavy free weights. | Consider varied ability levels related to cognitive engagement and attention. Allow upper extremity support when needed. Consider comorbidities (*e.g.*, peripheral | Consider dystonia (tonic or activity-induced) and general worsening of flexed posture with disease progression. Consider comorbidities (*e.g.*, |

| F.I.T.T.-V.P. | Aerobic | Strength | Balance, agility, & multi-Tasking | Flexibility |
|---|---|---|---|---|
| | dysfunction, including orthostatic hypotension, blunted heart rate response to exercise, arrhythmias associated with PD or medications. | Consider comorbidities (*e.g.*, spinal stenosis, osteoporosis, osteopenia). | neuropathy, cognitive decline). Risk of freezing of gait. Use of gait belt for safety. | osteoporosis, pain, dystonia). |
| | Consider collaborating with a licensed physical therapist specializing in Parkinson's disease to assist with full functional evaluation and Individually-tailored exercise recommendations taking into account complex medical history. | | | 2021 |

**Table 3.**
*Parkinson's exercise guidelines (Parkinson's foundation) from ACSM [8].*

symptoms. What should be concerned the benefits of using technology-required equipment not yet commercially available, such as wearable sensors, research-grade force plates, rotational treadmills, exergaming systems [9]' and so on.

### 3.2.4 Gait training

The schemes of gait training are varied, including forward treadmill, downhill treadmill, curved walking rotating treadmill, robot-assisted gait training (RAGT) [10], treadmill with virtual reality (VR). Aggregate evidence demonstrates that gait training could improve severity of disease, step length and cadence, walking speed and capacity, functional mobility, and balance. But individuals who are at H&Y stages 4–5 of PD and high risk for falls should be considered more for safety and need more supervision.

### 3.2.5 External cueing

This is one of movement strategy training approaches that compensates for the deficits with the internal (automatic) generation of behavior. External cueing was defined as an external temporal or spatial stimulus, including rhythmic auditory cueing, visual cues, verbal cues, or attentional cues. Above cues or feedback often combined with gait and balance training, for example, rhythmic auditory stimuli (RAS) provided during balance training or treadmill are more effective and sustain longer than the general program without RAS [11]. No matter which kind of cue, combined overground or treadmill training, it has an immediate and positive impact on spatio-temporal parameters of gait and improves functional outcomes of gait and FOG. In future, optimal modes of delivery leveraging advances in technology should be further examined.

### 3.2.6 Task-specific training

This is an upgrade from exercise to practice. The tasks trained for PD include mental imagery, upper extremity training, turning training, fall prevention training,

dual-task training, bladder training, and multimodal training. Mental imagery training with sufficient repetition uses dynamic neurocognitive imagery, with the goal of developing an individual's imagery skills, kinesthetic and proprioceptive sense, and motor self-awareness, to improve mental imagery ability. Upper extremities training may improve strength, manual dexterity, sensation, and goal attainment. Dual-task training may utilize cognitive challenge tasks during gait training to improve balance impairment and perception of FOG. In clinical practice physical therapy is usually delivered in a multimodal manner, not targeting only one specific outcome but rather designed to improve multiple deficits of Pwp.

### 3.2.7 Multidisciplinary team and integrated care

PD is a complex and heterogeneous disorder from prodromal to advanced stages, with a wide range of motor and non-motor symptoms, so it is necessary for teams working multidisciplinary, including movement disorder neurologists, physiotherapists, occupational therapists, speech and language therapists, psychiatrists or neuropsychologists, dietician, nurse specialist, and social workers. Besides the core care team above, there are other healthcare professionals who should be available for referral, including the gastroenterologist, geriatrician, neurosurgeon, nursing home physician, pain specialist (usually an anaesthesiologist), and urologist [12]. The multidisciplinary team (MDT) pattern improves reductions in motor severity, non-motor symptoms (anxiety, depression, and psychosocial consequences), functional outcomes (gait speed and spatio-temporal gait parameters, ADL, balance, and stability) and even health care utilization.

### 3.2.8 Telerehabilitation

Telerehabilitation evolved from telemedicine that means exchange of information via telecommunication systems between the provider and the patient to improve a patient's health. For instance, specifically, remotely supervised Wii-based balance training could improve activities and participation, especially for patients without cognitive impairment and low fall risk. In addition, it is available for order Pwp with other diseases and limited access to hospital. Nevertheless, telerehabilitation may increase the cost of health care and its efficacy for disease severity needs to be examined further.

### 3.2.9 Others

In addition to above training, there are also some effective approaches for PD, such as community-based exercise, dance/music, Tai chi, Nordic walking, Lee Silverman voice treatment physical (LSVT BIG), and acupuncture could be used alone or in combination depending on specific situation of the Pwp.

## 4. Occupational therapy (OT)

The aim of occupational therapy is to reduce restrictions on participation in meaningful activities and roles. OT intervention may include education and coping strategies for the individual and their families, exercise program, particularly for the upper

limb, providing assistive equipment, creating supportive and functional daily routines, and suggesting and practicing compensatory strategies.

## 4.1 Occupational assessment scales

Similar to physical therapy, the first step of OT is evaluating Pwp's issues related to occupational performance, including living/caring, work, and leisure. The Canadian occupational performance measure (COPM) is recommended instead of using ADL questionnaires [13]. The occupational performance history interview (OPHI-II) or parts thereof is also recommended when more information and background is needed regarding occupational identity, coping, and motivation. In addition, the occupational therapist needs to assess the caregiver's burden and competencies to ensure enough caring and support for Pwp, for example by means of PD caregiver burden questionnaire (PDCB). Other aspects include analyzing the context of problems related to specific activities, assessment of the time of activities and energy distribution, observation of occupational performance, and assessment of impairments in body functions and structures as well as physical environment.

## 4.2 OT interventions

The strategies selected depending on the preference of the Pwp or caregiver as well as the potential for changing aspects of the person, the activity, and the environment. A combination of interventions usually applies. For Pwp, the main tasks are improving and maintaining skills during the performance of activities, applying compensatory skills or strategies during the performance of activities, increasing insight and knowledge in order to adequately deal with current and future limitations in daily activities (self-management).

### 4.2.1 Optimizing daily structure and activities

Setting priorities and rescheduling activities considering the medication or specific situations. To structure the day and promote the patient's motivation for occupational performance through choosing activities matches the interest and capability of Pwp. It may be effective for people who suffer from fatigue to plan a program for teaching the application of energy-saving principles.

### 4.2.2 Dealing with stress and time pressure

Occupational therapist will help the Pwp and caregiver to identify the factors contribute to the stress and time pressure during the assessment phase especially due to the slowed performance. Then try to give advice on reducing the time pressure in the planning and organization of activities, improving the feeling of personal effectiveness through encouraging self-management, optimizing occupational performance, and teaching the Pwp to carry out activities in a relaxed manner.

### 4.2.3 Practicing arm/hand motor skills

The regular practicing of fine motor skills in functional tasks is useful for maintaining and improving these skills for Pwp. Participation in the LSVT BIG

program can improve perceived occupational performance and satisfaction measured by COMP, and produce gains in hand strength and dexterity for Pwp [14]. A sensory motor training intervention alongside constraint-induced movement therapy was effective in improving hand and upper extremity sensory motor function in Pwp [15].

### 4.2.4 Compensatory strategies in activities

Pwp can learn to perform complex tasks step-by-step with focused attention, which is called cognitive movement strategies. This is effective in facilitating the performance of transfers. But complex fine motor actions (e.g., fastening buttons and writing) cannot be adequately reduced to simple steps. In addition, external cue is also one of compensated strategies to facilitate movement.

### 4.2.5 Optimizing the physical environment

Aids, adaptations, and other modifications to physical environment compensate for cognitive and motor problems of Pwp reducing fall frequency and lead to more independent and safe performance. Specific methods are as follows [13]:

- Creating an unobstructed walking and turning route for Pwp who suffer from freezing, removing obstacles that increase the risk of falling;

- Setting up visual reminders, structure, and overview in the arrangement of space and objects for Pwp, especially with cognitive problems;

- Rearranging space and objects based on ergonomic principles for Pwp to promote safety, effectiveness, and efficiency of performing activities;

- Installing visual cues in places where it is important or necessary;

- Creating support points or possibilities for sitting during activities for Pwp with impaired balance;

- Using aids and adaptations according to motivation and acceptance of alternatives, safety, and skills, such as rise-and-recline armchairs, wheeled walkers, stairlifts, bed transfer aids, electric wheelchairs, and so on.

## 5. Speech-language therapy (ST)

With respect to PD, speech-language pathology focuses on three domains [16]:

- Problems with speech: dysarthria and the influence of cognitive impairments on language comprehension, use, and communication skills;

- Problems with chewing and swallowing: dysphagia, choking, slow chewing, and swallowing;

- Problems with controlling saliva: drooling or dribbling of saliva.

### 5.1 Assessment and treatment of dysarthria

The most frequently reported speech problems of Pwp are weak, hoarse, nasal or monotonous voice, imprecise articulation, slow or fast speech, difficulty starting speech, impaired stress or rhythm, stuttering, and tremor. But guideline proposes a video laryngostroboscopy by an otolaryngologist for a Pwp with hypokinetic dysarthria only when vocal fold pathology is suspected which is unrelated to PD.

The intelligibility subscale of the therapy outcomes measures (TOM) is used to quantify the severity of speech problems and treatment results. Spontaneous speech can be evaluated based on features used for all dysarthrias. The best way to evaluate the stimulability of speech is by including automatic speech tasks, maximum phonation time, pitch range, and calling.

The Robertson dysarthria profile (RDP) is a tool designed for the assessment of clients with the motor speech disorder, dysarthria which contains eight domains (respiration, phonation, facial musculature, diadochokinesis, oral reflexes, articulation, intelligibility, and prosody). VHI is a patient-rated scale that has been developed to determine the level of disability experienced by patients with different voice disorders. Recently, acoustic analysis has been developed and applied which could provide more comprehensive information of speech problem (**Table 4**) [17].

Hypophonia is one of the most common problems with speech for Pwp. Traditionally, voice therapy is based either on behavioral treatment, which involves training to strengthen muscles involved with coordination of respiration, phonation, and articulation, or using devices that provide environmental cues or biofeedback for voice amplification. Lee Silverman voice treatment, LSVT LOUD is a standardized and leading treatment of choice for hypophonia in PD. In addition, pitch limited voice treatment (PLVT) is also strongly recommended for Pwp with hypokinetic dysarthria with an intensity of four times a week for 4 weeks. Both treatments produce the same increase in loudness, but PLVT limits an increase in vocal pitch and prevents a strained or pressed voicing [18].

### 5.2 Assessment and treatment of dysphagia

The swallowing disturbance questionnaire (SDQ) represents the most appropriate self-reported patient test for screening swallowing disorders in PD. The Munich dysphagia test (MDT-PD) test, swallowing clinical assessment score in PD (SCAS-PD), and Radboud oral motor inventory for PD(ROMP) may be also considered valid questionnaire-based tools for dysphagia screening in PD [19]. Fiberoptic endoscopic evaluation of swallowing (FEES) and videofluoroscopic swallowing study (VFSS) are both considered to be the gold standard to evaluate opharyngeal dysphagia. The combination of these instrumental methods allows a detailed analysis of disturbance patterns in the oral, pharyngeal, and esophageal phases of swallowing in Pwp.

Treatment of dysphagia should be started when there is clinical or instrumental evidence of impairment of swallowing safety and/or efficiency. It has a relatively high level of evidence in a clinical study on the treatment of dysphagia, including swallowing maneuvers, swallowing exercises, expiratory muscle strength training, and neuromodulation, especially DBS in STN and rTMS as well as botulinum toxin injection [20].

| Deviant speech dimension [vocal task] | Acoustic feature | Definition | Pathophysiological interpretation with respect to hypokinetic dysarthria |
|---|---|---|---|
| **Respiration** | | | |
| Aerodynamic insufficiency [sustained phonation] | MPT | Maximum phonation time, defined as the maximum duration of sustained vowel phonation. | The rigidity of respiratory muscles leads to decrease ability to sustain vowel. |
| Weak inspirations [monolog] | RLR | Relative loudness of respiration, defined as the median of loudness measured relatively between respirations and speech as a difference in logarithmic scale. | Hypokinesia of respiratory muscles and decreased range of rib cage motion make respiration quieter. |
| **Phonation** | | | |
| Harsh voice [sustained phonation] | HNR | Harmonics-to-noise ratio, defined as the amount of noise in the speech signal. | Reduced rate of airflow and improper control of vocal folds causes increased turbulent noise. |
| Decreased voice quality [monolog] | CPP | Cepstral peak prominence, defined as the measure of cepstral peak amplitude normalized for overall amplitude. | Deteriorated control of laryngeal muscles leads to unstable periods of vocal fold opening, causing a dysphonic and breathy voice. |
| **Articulation** | | | |
| Imprecise consonants [syllable repetition] | VOT | Voice onset time, defined as the length of the entire consonant from initial burst to vowel onset. | Hypokinesia causes slowing of lip and tongue movements, leading to a longer time required to pronounce individual consonants. |
| Articulatory decay [monolog] | RFA | Resonant frequency attenuation, defined as the differences between the maxima of the second formant region and minima of local valley region called antiformant. | Hypokinesia leads to decrease spectral energy as a result of decayed articulatory movements. |
| **Prosody** | | | |
| Monoloudness [reading passage] | IntSD | The standard deviation of speech intensity contor extracted from voiced segments. | Hypokinesia leads to the decreased amplitude of respiratory and thyroarytenoid muscles. |
| Monopitch [reading passage] | FOSD | The standard deviation of fundamental frequency contor converted to semitone scale. | Hypokinesia causes the reduced amplitude of vocal cord movements, leading to glottal incompetence. |
| **Speech timing** | | | |
| Slow SMR [syllable repetition] | DDKR | Diadochokinetic rate, defined as the number of syllable vocalizations per second. | Hypokinesia of speech apparatus makes the movements of articulators slower. |
| Prolonged pauses [monolog] | DPI | Duration of pause intervals, defined as the median length of pause intervals. | Hypokinesia of speech apparatus makes initiating of speech difficult, leading to prolonged pause intervals. |

**Table 4.**
*Acoustic measurements [17].*

## 5.3 Assessment and treatment of drooling

There are indications that the drooling severity and frequency scale modified for Parkinson's disease (DSFS-P) is a valid scale for quantifying the severity of drooling. The treatment of drooling by means of a self-use swallow reminder can be effective in reducing the loss of saliva and teaching the patient cognitive movement strategies can also be helpful.

## 6. Cognitive rehabilitation

Cognitive dysfunction is one of the common non-motor symptoms of PD, including mild cognitive impairment(PD-MCI) and Parkinson's disease dementia (PDD). The short-term and instantaneous memory decline, while the impairment of long-term memory and digital-related memory is not obvious. Visual–spatial impairment can be characterized by slower visuomotor speed, decreased visual memory and comprehensive analysis ability, motor coordination ability, as well as spatial abstraction ability. Language naming and semantic comprehension can remain intact in the early stage of PD.

### 6.1 Measurement tools

Neuropsychological scales for overall cognitive function assessment comprise five domains: executive function, attention and working memory, language, memory, and visuospatial skills. The following three scales with ideal clinical measurement characteristics (validity and reliability) are recommended for the assessment of global cognitive function in PD [21, 22]: Montreal cognitive assessment (MoCA), Parkinson's disease cognitive rating scale (PD-CRS), and mattis dementia Rating Scale-2 (MDRS-2). The mini-mental state examination (MMP) and scales for outcomes in Parkinson's disease cognition (SCOPA-COG) are specifically designed scales to evaluate the cognitive function of PD patients despite their assessment value in executive function and visuospatial ability is not enough.

### 6.2 Cognitive training (CT)

CT can be carried out for one or more cognitive domains in paper-and-pencil or computerized training forms. Multi-domain, computer-based cognitive training at a frequency of 2–3 times every week over 3–12 weeks can improve executive functions, memory, processing speed, and attention for Pwp [23]. Aerobic and resistance exercises combined with cognitive training have shown effective for mild cognitive impairment. It is recommended tailoring of CT programs to suit the cognitive domains predominantly affected in the specific sub-population of PD [24]. CT involves the repetition of standardized tasks and may be limited by motor impairment so the use of more recent integrative, adaptive, and assistive technologies, such as virtual reality, may optimize the delivery of CT in PD.

## 7. Rehabilitation of other non-motor symptoms

Non-motor symptoms of PD have become an important factor affecting the quality of life of Pwp (**Figure 4**). And mental, sleep, fatigue, and other general abnormal status are also the major determinants of rehabilitation outcomes.
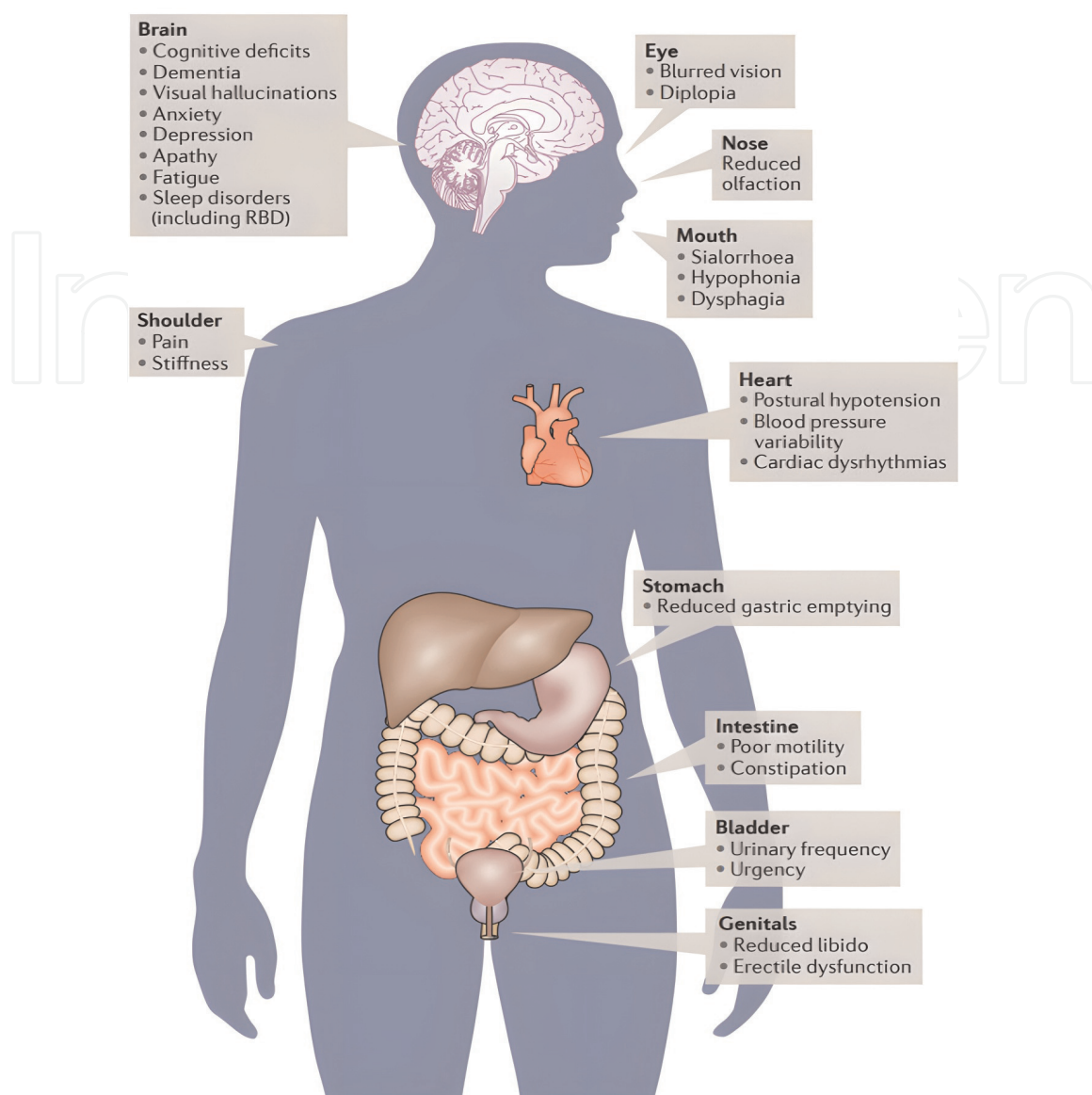
**Figure 4.**
*Non-motor features in PD [25].*

## 7.1 Mood disorders

Mood disorders and anxiety significantly impact the prognosis and disease course of PD, which are related to the frontal lobe caused by catecholamine and serotonin deficiency in the brain tissue. Apathy, anhedonia, and fatigue overlap with diagnostic criteria for anxiety and depression, thus making an accurate diagnosis of mood disorders in Pwp difficult. So, multidisciplinary teamwork with psychologists and psychiatrists is necessary. Beck depression inventory (BDI), Hamilton depression rating scale (HAMD-17), montgomery-asberg depression rating scale (MADRS), 15 item geriatric depression scale (GDS-15), are the most widely recognized tools. HAMD and self-report GDS are recommended for screening and measuring severity of depression in PD, while Cornell scale for depression in dementia (CSDD) can be used to screen for PD in patient with and without dementia [26]. As for anxiety, Parkinson's anxiety scale (PAS) and a PD-specific anxiety scale have higher specificity and sensitivity for their use as a screening tools than other scales [27]. Non-pharmacologic approaches in

addition to classic psychotherapy, for example, cognitive-behavioral therapy (CBT) and other rehabilitative treatments are proven to have certain effects, including exercise therapy, music therapy, yoga, Tai chi, Qigong, and acupuncture.

## 7.2 Sleep disorders

Sleep disorders in PD include both nocturnal manifestations, such as insomnia, REM sleep behavior disorder (RBD), obstructive sleep apnea (OSA) and restless legs syndrome (RLS), and diurnal symptoms, such as excessive daytime sleepiness (EDS). Persian version of Parkinson's disease sleep scale (PPDS) has acceptable validity and reliability for measuring sleep disturbances in Pwp, while polysomnography (PSG) can provide more accurate evaluation data of sleep. Exercise and above treatments for mental and psychological problems can also improve the sleep disorder of PD to some extent.

## 7.3 Pain

Pain was evident in 53% of PD cases and has four different types in Pwp: musculoskeletal pain (due to rigidity, skeletal deformity), radicular–neuropathic pain (due to root lesion, focal or peripheral neuropathy), dystonic pain (related to antiparkinsonian medication), and akathisia (occurs in the off period or drug-induced). The visual analog scale (VAS) and brief pain inventory (BPI) are the commonly used assessment scales for pain. The PD-pain classification system (PD-PCS) is a valid and reliable tool for differentiating PD-related pain from PD-unrelated pain. The popular recommendation currently supports exercise as part of pain reduction treatment plans in a variety of conditions. Additionally, hydrotherapy, massage therapy, acupuncture, and neuromodulation (DBS, rTMS, tDCS) may provide appreciable results in pain management [28].

## 7.4 Autonomic nervous dysfunctions

Among the autonomic disorders, cardiovascular, urogenital, gastrointestinal, and thermoregulatory disorders are the most commonly occur in Pwp. The scale for outcomes in PD for autonomic symptoms (SCOPA-AUT) is a specific scale to assess autonomic dysfunction in PD patients.

### 7.4.1 Orthostatic hypotension (OH)

Orthostatic hypotension questionnaire (OHQ) can be used to evaluate the impact of symptoms on daily activities that require standing and/or walking.

Non-pharmacological treatment for OH includes drinking water (1.5–2.0 L/day) and increasing salt intake, compression stockings, sleeping with the head of the bed elevated (10–15 cm elevation or angle of 30–45 degrees), and physical therapy. Physical maneuvers can be used to activate the skeletal muscle pump and briefly elevate pressures, which include crossing the legs and pushing them against each other, arm flexing, and rocking up on the toes. Combination of both aerobic and resistance training, working toward a goal of performing at least 20–30 min of aerobic training or aquatic exercises three times per week [29].

### 7.4.2 Urinary dysfunctions

Urgency, nocturia, and incontinence are all demonstrations of overactive bladder (OAB) which is the most common lower urinary tract symptoms (LUT) in Pwp, and an objective assessment using urodynamics commonly shows detrusor overactivity (DO) in these patients. SCOPA-AUT includes six urinary items that assess both storage and voiding phases, so it is an acceptable, consistent, reliable, and valid scale. The international prostate symptom score (IPSS) has been used both in men and women for patients with neurological diseases. DBS, sacral neuromodulation (SNM), and posterior tibial nerve stimulation (PTNS) are effective therapies for improving bladder dysfunction [30]. Intradetrusor injection of botulinum toxin (BT) can be used for intractable urinary incontinence. Pelvic floor muscle exercises, behavior therapy, and acupuncture may be beneficial for urinary incontinence [31].

### 7.4.3 Rectal dysfunctions

Among the gastrointestinal disturbances, gastric emptying disorders and constipation are particularly noteworthy. Stool consistency in which the Bristol stool scale may be used as a practical tool, and the Knowles-Eccersley-Scott symptom (KESS) questionnaire was used to assess bowel symptoms. More accurate functional assessment requires instrumentation, such as capsule colonoscopy and EMG. Low colonic transit time (CTT) and pelvic floor dyssynergia (PFD) are major contributors to constipation in Pwp. CTT studies and defecography have been considered as "gold standard" techniques for identifying the causes of constipation as either colonic dysmotility or PFD [32].

In addition, to changing diet (30–40 grams/day of dietary fibers) and bowel habits relaxing puborectalis and pubococcygeus may alleviate this debilitating dysfunction. 30 minutes of moderate-intensity exercise per day are also advised for easing constipation [33].

## 8. Neuromodulation in PD

Neuromodulation is a category of treatment that involves stimulation or direct administration of medications to the nervous system for therapeutic purposes. This aims to modulate the activity of target cells as an approach to treating neurological dysfunctions, including pain, movement disorders, spasticity, and epilepsy. As for PD, it can improve motor and non-motor symptoms by regulating motor circuits and neurotransmitters in invasive or noninvasive methods.

### 8.1 Deep brain stimulation (DBS)

DBS is a widely acceptable 0revolutionized treatment for advanced levodopa-responsive PD with motor complications due to its convincing effect on motor symptoms [34]. It is summarized the different therapeutic effects for the two targets, the subthalamic nucleus (STN) and the internal part of the globus pallidus (GPi) of DBS in **Table 5**. Advancements in DBS hardware, programming, neuroimaging, and surgical techniques have led to progressive improvement in efficacy and safety profiles. By combining the precise placement of an electrode connected to a highly programmable generator of current, a therapeutic effect can be carefully tailored to the patient's specific needs.

|  | STN | GPi |
|---|---|---|
| Tremor | Improves | Improves |
| Bradykinesia | Improves | Improves |
| Rigidity | Improves | Improves |
| On/Off Fluctuation | Improves | Improves |
| Dyskinesia | Improves due to medication reduction | Greater improvement than STN |
| Gait/Balance | Minimal change | Minimal change, may last longer than STN |
| Speech | Worsens | May worsen |
| Cognition | May worsen. Possibly worse than GPi | May worsen |
| Depression | Unclear | Unclear |
| Anxiety | May improve | Unclear |

*DBS: deep brain stimulation; STN: subthalamic nucleus; GPi: globus pallidus interna.*

**Table 5.**
*Comparison of treatment effects for DBS stimulation of the STN versus the GPi [35].*

## 8.2 Repetitive transcranial magnetic stimulation (rTMS)

rTMS is commonly used in the clinical treatment of PD. It achieves therapeutic effects mainly by varying the excitability of the central nervous system, and it is generally believed that high frequencies (HF) ≥ 5 Hz are mainly excitatory, while low frequencies (LF) < 1 Hz mainly produce inhibitory effects. Recently, a meta-analysis
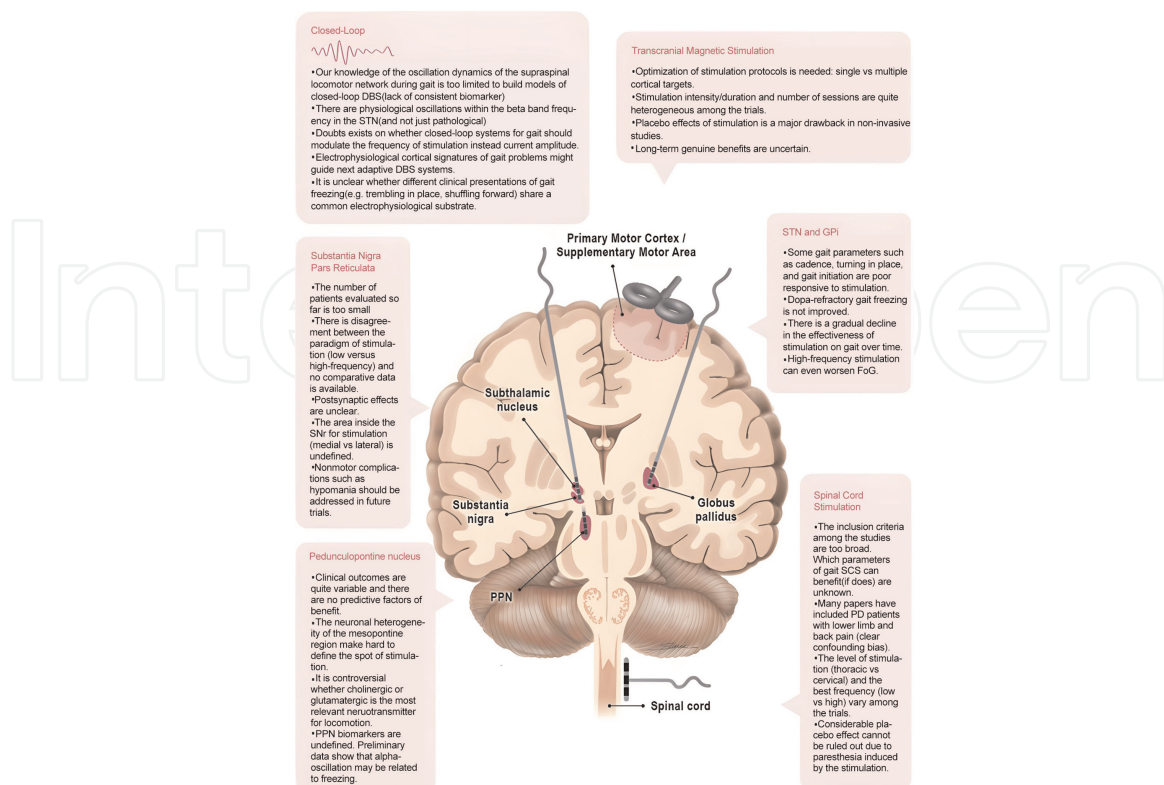


**Figure 5.**
*Gaps of neuromodulation for gait problems in PD [27].*

concluded that the pooled evidence suggested that rTMS relieves motor symptoms of Pwp and high-frequency stimulation on M1 is the most effective mode of intervention. HF rTMS has significant therapeutic effects on limb motor function, including upper limb and lower limb, akinesia, rigidity, and tremor [36]. However, for the gait impairment of PD, there are still several critical unanswered questions in the neuromodulation field that need further research [37].

In summary, the different rehabilitation approaches have in common "exercise" as a basic element and should be scheduled according to individual characteristics of the patients. Multidisciplinary collaboration maximizes the effectiveness of rehabilitation. Close monitoring and avoidance of fatigue or sports injury are paramount. Although high-intensity exercise has initially the disease-modified effects the mechanism is not clear presently. With the wide application of artificial intelligence technology and telerehabilitation technology, there will be more and more effective methods for PD, which may meet the needs of home rehabilitation in the future. At last, most of studies on rehabilitation involved mild and moderate Pwp currently so interventions to improve the patient's motor or no-motor dysfunction and quality of life in late-stage need to be explored further (**Figure 5**).

## Author details

Qing Zhao*, Lingjing Jin, Lin Ma, Tingting Sun and Mengdie Zhou
Department of Neurology and Neurological Rehabilitation, Shanghai Yangzhi
Rehabilitation Hospital (Shanghai Sunshine Rehabilitation Center), School of
Medicine, Tongji University, Shanghai, China

*Address all correspondence to: qingzhao2010@hotmail.com

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