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Updates in Neurorehabilitation

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Update on Parkinson's Disease Rehabilitation

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HIGHLIGHTS

- Various rehabilitation programs might improve motor function in Parkinson's disease.
- Expiratory muscle strengthening exercise have been effective for dysphagia.
- Well-designed randomized controlled trials are needed to establish the evidence.

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ABSTRACT

Parkinson's disease (PD) is the second most common neurodegenerative disorder. Although dopaminergic drugs are the mainstay for improving PD symptoms, there are still few effective disease-modifying therapies. With the increasing prevalence of PD and the rapid transition to an aging society, more emphasis needs to be placed on rehabilitation that could slow the disease progression combined with pharmacological therapy. In this review, we present an update on evidence related to rehabilitation programs for motor function, swallowing difficulty, and speech disorders in PD. Aerobic exercise, music therapy, dance, virtual reality, and non-invasive brain stimulation have been shown to improve motor function, and telerehabilitation could also be feasibly applied in PD. Recent studies have shown the effectiveness of expiratory muscle strengthening exercises and Lee Silverman Voice Treatment for swallowing difficulty and speech disorders, respectively. Although many rehabilitation programs have been tried, the evidence is still limited. Well-designed future randomized controlled trials with large numbers of participants are needed to establish evidence for rehabilitation in PD.

Keywords: Parkinson Disease; Rehabilitation; Motor Function; Swallowing Difficulty; Speech Disorders

INTRODUCTION

Parkinson's disease (PD) is the second most common neurodegenerative disorder, and is characterized by prominent motor symptoms, such as resting tremor, muscular rigidity, bradykinesia, and postural instability [1]. Although dopaminergic drugs are the mainstay for improving PD symptoms, there are still few effective disease-modifying therapies [2]. As PD progresses, patients with PD gradually experience difficulties walking and often experience falls, along with aspiration pneumonia caused by dysphagia. Thus, there is an increasing need for rehabilitation treatment that could slow disease progression and prevent complications, along with pharmacological treatment. With the increasing prevalence of PD and the rapid transition to an aging society [3], PD is expected to cause substantial social and economic costs to society [4], and the role of rehabilitation treatment for efficient disease management is likely to be emphasized to a greater extent [5].

Several rehabilitation programs have been attempted in relation to motor function, swallowing difficulty, and speech disorders; however, the overall level of evidence is still limited [6]. In real-world clinical situations, referral to rehabilitation is often delayed, and patients with PD often initiate rehabilitation programs after freezing of gait (FOG) and frequent falls. A recent nationwide cohort study in Korea reported that physical activity (PA) at the time of diagnosis of PD was significantly related to the mortality rate in patients with PD [7]. The mortality rate was lower in physically active than in physically inactive PD patients, and there was a significant inverse dose-response relationship between the total amount of PA and all-cause mortality. Therefore, it seems necessary to evaluate the functional level of PD patients at the initial stage of the disease and plan rehabilitation strategies, including lifestyle modification, to slow the disease progression. In this review, we would like to present the current evidence of rehabilitation programs for various symptoms of PD, with a particular focus on updates over the past 2 years. We review the effects of various rehabilitation programs, ranging from traditional rehabilitation to virtual reality (VR) and telemedicine.

REHABILITATION FOR MOTOR FUNCTION

Various rehabilitation programs such as aerobic exercise, balance training, and VR have been tried in patients with PD, with limited evidence [6]. A systematic review in 2021 suggested that aerobic exercise was effective on the functional capacity and quality of life (QOL) in patients with PD [8]. Based on 10 randomized controlled trials (RCTs) including a total of 411 patients with PD, although the overall level of evidence was low, aerobic exercise was effective for mobility, lower limb muscle strength, and gait function (e.g., walking speed and stride length) in mild- to moderate-stage PD patients. Since patients with PD have a decreased balance ability in the advanced stage, a bicycle is advantageous in that it can be applied more safely than a treadmill in patients with reduced balance ability. A meta-analysis including 505 PD patients in 2021 demonstrated that bicycling led to improvement in physical functionality, gait speed, balance, and QOL in patients with PD [9].

In addition to rehabilitation programs for therapeutic purposes in hospital settings, leisure activities have also been attempted in rehabilitation strategies for patients with PD. A recent meta-analysis including 5 studies reported that yoga improved the Unified Parkinson's Disease Rating Scale (UPDRS) motor score in PD patients; however, there was no significant effect on balance and anxiety [10]. Since advanced PD patients have reduced autonomicity during gait, there have been many trials of music-and dance-based therapy using regular rhythm [11-13]. As for the type of dance, social dances such as tango, waltz, and foxtrot have been tried for PD. In a meta-analysis of 20 studies, experimental groups with various dance programs showed improvements in the UPDRS motor scale, and the effect was maintained for up to 12 months [12].

Non-invasive brain stimulation (NIBS) has also been tried in patients with PD to improve motor and cognitive functions [14,15]. In a meta-analysis in 2021, 52 and 28 studies were reviewed to identify the effects of repetitive transcranial magnetic stimulation (rTMS) and transcranial direct current stimulation (tDCS), respectively [14]. In that study, the level of evidence was divided into 3 categories: level A, definitely effective or ineffective; level B, probably effective or ineffective; and level C, possibly effective or ineffective, according to the study design of each paper. Based on this level of evidence, both rTMS and tDCS treatment

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showed no level A evidence for motor function. As level B evidence, high-frequency rTMS on the primary motor cortex was associated with improvement in overall motor symptoms and gait performance, and high rTMS on the dorsolateral prefrontal cortex (DLPFC) alone or on the DLPFC and primary motor cortex was also related to improved overall motor symptoms. In addition, the application of low-frequency rTMS on the supplementary motor cortex showed improvement in overall motor symptoms. As for the effects of tDCS, anodal tDCS on the primary motor cortex or the primary motor cortex and DLPFC improved overall motor symptoms or gait performance, respectively, with level B evidence. Furthermore, applying anodal tDCS combined with physical therapy showed level B evidence for overall motor symptoms and gait performance in PD.

Dynamic balance training has been suggested to improve postural balance, gait function, and the ability to perform activities of daily living (ADL) in patients with PD. In the last 2 decades, VR applications, including gaming devices, have been used as rehabilitation intervention tools [16,17]. In a meta-analysis of 12 RCTs, VR improved the Berg Balance Scale (BBS), Timed Up and Go, 10-Meter Walk Test (10MWT), and Modified Barthel Index in patients with PD [16]. Another recent meta-analysis suggested that VR had effects on balance, ADL, and further improved QOL [17]. That study investigated factors related to the effects of VR, and the authors reported that the patient's age was relevant, not therapeutic factors such as the treatment period, frequency, and number of sessions [17]. Specifically, there was a negative relationship between age and the effects of VR.

With recent technological progress, telerehabilitation has now become a viable option for managing patients with PD. In a recent RCT published in 2021, group exercise, home exercise, and self-management sessions were conducted for all patients during block 1 (the period before randomization) [18]. After that, the patients were divided into center-based and home-based exercise groups for the block 2 period. The primary outcome was the feasibility and acceptability of home-based exercise program, and the secondary outcome was gait and balance function. The adherence rate was 93% for center-based participants and 84% for home-based participants, suggesting that home-exercise was also feasible. Furthermore, there was no significant difference between the 2 groups in the Mini Balance Evaluation Systems Test, 10MWT, and New Freezing of Gait Questionnaire, indicating that telerehabilitation could be effectively applied to patients with PD. A meta-analysis published in 2021 also reported that telerehabilitation was effective for gait, balance, and upper limb dexterity in PD [19].

Patients with PD are often referred for rehabilitation after the disease has progressed, and patients at this advanced stage often show FOG and Pisa syndrome. FOG refers to a phenomenon in which a patient is unable to move forward by taking his or her feet off the ground despite a willingness to walk, and patients often express that their feet seem to be stuck to the ground or attached to a magnet [20]. FOG is observed in more than 50% of PD patients in the advanced stage, and it is a risk factor that greatly increases the risk of falling [21]. In a recent meta-analysis, 41 previous studies were reviewed, and rehabilitation treatment was divided into 3 categories: FOG-specific, FOG-relevant, and generic exercise [22]. FOG-specific treatments are those that directly alleviate imminent FOG or prepare patients for upcoming FOG, such as cueing, and FOG-relevant treatment involves training to reduce the severity or amount of FOG, including cognitive training and dual-task training. Finally, generic exercise refers to conventional physical therapies that are frequently offered to healthy elderly patients such as dance, yoga, and aquatic training. FOG improved in all 3 treatment categories,

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and the authors recommended applying each training program according to frequency of FOG: generic exercise for patients without FOG and occasional FOG, FOG-reverent treatment for patients with occasional FOG, and FOG-specific treatment for patients with frequent FOG. They also suggested that this framework might attenuate the progression of FOG severity. Pisa syndrome bears a name given because the patient's posture resembles the Leaning Tower of Pisa, which means that the trunk has been severely laterally flexed more than 10° and can be completely reversed by passive mobilization or supine position [23]. Pisa syndrome is also more often observed in the advanced stage of PD. In a recent review paper [24], deep brain stimulation, lidocaine injection, oculomotor correction, and spinal cord stimulation showed effects for Pisa syndrome based on researches using a case study design. Four RCTs of botulinum toxin and posture correction presented improvements in outcomes such as UPDRS and posture in PD patients with Pisa syndrome [24].

UPDRS and BBS are widely used as test methods to evaluate the effectiveness of various rehabilitation treatments. The important point is that a specific time of day should be set and the evaluation should be repeated at the same time. Patients with PD have substantial discrepancies in motor function depending on the on and off states of medication; therefore, evaluations must be consistently performed at the same time in relation to drug use to accurately measure functional changes.

REHABILITATION FOR SWALLOWING DIFFICULTY

Patients with PD complain of dysphagia as the disease progresses, and the prevalence of dysphagia is reported to be high, ranging from about 77% to 95% [25,26]. Since there have been many reports of silent aspiration in PD, a video fluoroscopic swallowing test or endoscopic swallowing test is recommended for high-risk patients with excessive drooling, weight loss, and frequent aspiration symptoms [26]. The symptoms of dysphagia vary from simple discomfort to a stage where it is impossible to take drugs and eat food. Various treatments have been tried, including medication such as levodopa or levodopa-carbidopa and palliative swallowing rehabilitation, as well as surgical treatments such as deep brain stimulation, but there have been many limitations, as in the general treatment of PD [27]. Deep brain stimulation has been tried to target the subthalamic nucleus with high-frequency stimulation in the majority of the studies. Glottic insufficiency has been reported in about 60% of PD patients, and injection laryngoplasty to augment the vocal fold has been tried [27]. It has been suggested that aspiration can be prevented by tucking the chin and increasing the viscosity. Classical methods such as controlling food consistency, eating small amounts, and double swallowing are also helpful. Swallowing muscle training, Lee Silverman Voice Treatment (LSVT), and verbal cues have been suggested as effective options for improving dysphagia in PD [28-30].

Several recent studies have reported that expiratory muscle strengthening training was related to improvements in dysphagia, as well as respiratory function [31,32]. In a recent RCT comparing an expiratory muscle strengthening group and a sham group, the expiratory muscle strengthening group showed significantly lower residue scores than the sham group after 4 weeks of training [31]. Expiratory muscle strengthening training was performed using a commercial device (EMST 150; Aspire Products, Gainesville, FL, USA) and 75% of maximum expiratory pressure was set for training of each patient. During the 4-week training period, the participants used the device 5 days per week, performing 5 sets of 5 breaths per day. In this study, magnetoencephalography was performed at the start and end

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of expiratory muscle strength training to confirm the cortical swallowing network, and there was no significant difference before and after treatment. Therefore, the authors suggested that the improvement of swallowing through expiratory muscle strength might originate from the improved peripheral mechanism of swallowing efficiency.

REHABILITATION FOR SPEECH DISORDERS

Speech disorders have been reported to occur in about 89% of advanced-stage PD patients [33]. However, speech disorders may exist from the beginning of the disease, and one survey reported that 82% of early PD patients were not satisfied with their speech [34]. Speech disorders interfere with communication, limiting the social activities of PD and impairing their QOL. The main manifestations of speech disorders are reduced loudness, monotonous voice and pitch, inaccurate articulation, decreased speech intelligibility, hypophonia, and rate changes (rushed, dysfluent, or hesitant speech) [35].

LSVT focuses on increasing the voice intensity and maximizing vocal and breathing efforts, and is known to be effective for speech disorders in patients with PD. A meta-analysis in 2021 compared a group treated with LSVT with an untreated group. At a 1-month follow-up, the LSVT group showed better results in vocal intensity for sustained "ah" phonation, reading the "rainbow passage," monologue, and describing a picture [35]. At 6–7 months of follow-up, although the overall effect size was reduced, the effect was maintained significantly in the LSVT group. Since vocalization is also related to lung capacity, it has been suggested that respiratory training is also effective in speech improvement. A meta-analysis compared the effects of LSVT and respiratory training and reported that the LSVT group had a superior effect in the items of local intensity for sustained "ah" phonation, reading the "rainbow passage," and monologue, and this effect was maintained for 24 months.

CONCLUSION

In this review, we present updated evidence of rehabilitation programs for motor function, swallowing difficulty, and speech disorder in PD. Aerobic exercise, music therapy, dance, VR, and NIBS have been shown to improve motor function, and telerehabilitation could also be feasibly applied in PD. In recent studies, expiratory muscle strengthening exercises and LSVT have shown effectiveness for swallowing difficulty or speech disorder, respectively. Although many rehabilitation programs have been tried, the evidence is still limited. Well-designed future RCTs with large numbers of participants are needed to establish evidence for rehabilitation in PD.

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