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Power training induced change in bradykinesia and muscle power in Parkinson's disease

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ABSTRACT

Power-based resistance training (PWT), using low load and high velocity, can improve physical function and quality of life in older persons. Patients with Parkinson's disease (PD), exhibiting muscular weakness and reduced movement speed, have been shown to be benefit from resistance training; however, little is known about the advantages of PWT for PD.

Purpose: To evaluate the effects of PWT on bradykinesia and muscular performance in older patients with PD.

Methods: Twenty-six patients with mild to moderate PD were randomly assigned to a PWT or control group (CON). The PWT program was three months, incorporating two sessions/wk of high-speed resistance training combined balance and agility drills. Outcome measures included: upper and lower limb bradykinesia scores, one repetition maximums (1RM) and peak powers on biceps curl, chest press, leg press, hip abduction and seated calf, and quality of life (PDQ-39).

Results: The PWT group produced significant improvement in both upper and lower limbs bradykinesia scores, 1RM and muscle peak power ($p < .05$), which surpassed the CON group except for power during the seated calf exercise. No significant correlations between changes in clinical measure of bradykinesia and muscle peak power were observed after training. Significant improvements were seen in the PDQ-39 overall score, subsections for mobility, activities of daily living and social support for the PWT group.

Conclusion: The 3-month PWT program significantly reduced bradykinesia and increased muscle strength and power in older patients with PD. Power training is an effective training modality to improve physical function and quality of life for PD.

1. Introduction

Parkinson's disease (PD), which predominately impairs motor function, affects .5-1% of individuals aged 65–69 years of age and 1–3% of those above 80 years of age [1]. One of the cardinal symptoms, bradykinesia, defined by James Parkinson in part as “lessened muscular power”, presents as slowness of movement [2]. In addition to bradykinesia, declines in muscle power are also associated with slower walking velocity [3], increased fall probability [4,5], and loss of physical independence [6]. Muscle weakness has been observed across various muscle groups in the upper [7] and lower limbs [4]. Electromyographic (EMG) studies have found decreased rates of force development, prolonged contraction time, segmentation of force production, and irregularly shaped force–time curves during isometric testing in PD patients [8,9].

Resistance training has become an increasingly popular intervention for preserving muscle function and enhancing functionality for people with PD. One systematic review examining the impact of resistance training on mild to moderate PD [10] reported significant improvement in muscle strength for a number of exercises, including biceps curl, chess press and leg extension, as well as improved mobility assessed using gait speed, stride length and stair descent. Additionally, a recent randomized control trial reported reduced bradykinesia during gait due to high-intensity resistance training [11].

A specific type of resistance training, power training (high-velocity, low resistance), has gained prominence as an effective exercise intervention for improving strength, power and physical performance in healthy older adults [12,13]. This explosive-type resistance training may result in an optimal combination of both

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muscle hypertrophy and neural adaptation, and thus elicit gains in movement speed and muscle power [14]. Given that power training focuses on velocity by reducing training loads, it would be beneficial to examine its capacity to affect positive impacts on bradykinesia and muscle functions in older persons with PD. However, to our knowledge, no study has investigated the training effect of power-based resistance training on bradykinesia and muscular power in this population.

The purpose of this study, therefore, was to evaluate the effects of a specially designed power training program on bradykinesia, muscle strength and power in older adults with mild to moderate PD. We hypothesized that:

1. Our specially designed power training program would reduce upper and lower limb bradykinesia and increase muscle strength and power; and,
2. Changes in clinical measures of bradykinesia would correlate with changes in muscular power and movement velocity after power training.

2. Methods

2.1. Design and participants

This randomized controlled trial was part of a larger study examining the comparative impacts of power resistance training (PWT) and power yoga on overall UPDRS motor score, balance, mobility and leg press strength and power resulting from a 3-month exercise intervention. We used baseline and 3-month post-training data to conduct secondary analysis to examine the impact of PWT in comparison to a non-exercise control group (CON) in this study. All participants signed an informed written consent approved by the University of Miami Subcommittee for the Use and Protection of Human Subjects. All testing was conducted at the Laboratory of Neuromuscular Research and Active Aging 1 h after participants took their usual PD medications (“on” state), to minimize motor fluctuation and variability of motor symptoms among participants. The variables examined in this analysis were the UPDRS upper and lower limb bradykinesia subscores and strength and power for two upper body and three lower body movement patterns. Tests were administered in the following order: 1) the Unified Parkinson's Disease Rating Scale (UPDRS) motor exam; 2) muscle strength tests; 3) muscle power tests. Pretests and post-tests were performed within a 2-week period before and after the intervention, respectively. All assessments were performed by the same testers. After baseline assessments, participants were allocated to the PWT or CON group using stratified randomization controlling for the Hoehn & Yahr Classification of Disability for PD (H&Y Scale) employing Excel software (Microsoft Excel 2013; Microsoft Corp., Redmond, WA).

Participants were recruited from local support groups, clinics and hospitals in the greater Miami area. Patients were included if they were aged 60–90 years, diagnosed idiopathic PD with mild to moderate impairment (H&Y stages I-III), capable of ambulation for at least 50 feet with or without an assistive device, able to get up and down from the floor with minimal assistance, and with no cognitive impairment (Folstein Mini-Mental State Examination (MMSE) < 24). Participants were excluded if they were experiencing unstable cardiovascular disease or other uncontrolled chronic conditions which would affect either their safety, the conduct of testing, or the interpretation of the results. Additionally, they may not have regularly practiced (1–2 times weekly) high-intensity resistance training within the past year.

2.2. Outcome measures

The primary outcome for this study was limb bradykinesia score. Secondary outcomes included muscle strength and power, and quality of life (QoL).

Bradykinesia: An upper limb bradykinesia subscore was derived by summing UPDRS motor exam items 23, 24 and 25 [15]; while a lower limb bradykinesia subscore was the sum of UPDRS motor exam items 26, 27, 29 and 31 [4]. Two testers evaluated subjects' performance in the UPDRS motor examination separately and inter-rater reliability ($r = .904$) was high for this test.

Strength and power: Measurements of strength and power were taken during the performance of the biceps curl, chest press, leg press, hip abduction and seated calf. Muscle strength and power were assessed using computerized pneumatic resistance machines (Keiser A420, Keiser Sports Health Equipment, Fresno, CA). As resistance is adjustable for each machine, muscle strength and power could be measured at each participant's unique movement speed profile, and therefore, be useful for measuring muscle strength independent of bradykinesia in these patients [4]. One repetition maximum (1RM) represented muscle strength in kilogram (kg). All tests were completed within six repetitions to reduce the likelihood that fatigue might affect the test results.

Muscle power was assessed 20 min after measurement of the 1RM for each movement using the same pneumatic resistance machines. Peak power was assessed at seven relative intensities (30%, 40%, 50%, 60%, 70%, 80%, and 90% 1RM) for each exercise. The testing order was randomized to reduce any fatigue or learning effects. For strength testing participants were provided a 2-min recovery between trials; while for power testing, a 1-min recovery was provided.

Quality of life: The Parkinson's Disease Questionnaire (PDQ-39) was used to measure the QoL before and after training. This questionnaire is sensitive to changes that matter to patients, but which are not the primary focus of clinicians' assessments that concentrate on impairment and physical function [16].

2.3. Intervention

Power training: The PWT program used evolving optimal loads on 11 pneumatic machines, including: biceps curl, triceps push-down, chest press, seated row, lat pull-down, shoulder press, leg press, leg curl, hip abduction, hip adduction, and seated calf. Each session included 3 circuits of 10–12 repetitions on each machine, twice weekly, for 12 weeks. One circuit included alternating upper and lower body exercises on all 11 machines.

Training loads were determined using the peak power produced across seven relative intensities (30%–90% 1RM) on each machine. Following a one-week adaptation period, training loads for each exercise were increased each week from the third week onward based on participants' reaching power plateaus. Briefly, when the patterns of power increase plateaued (within 5%) across two consecutive sessions, loads were increased by 5% and training continued until the next power plateau. For each exercise, participants were instructed to exert force as fast as possible during the concentric phase and move slowly through the eccentric phase. Additionally, two 2-week (weeks 5 and 6; weeks 11 and 12) translational training cycles were incorporated into the PWT program. These cycles utilized balance and agility activities, including line, cone, ladder, chair, step, and ball drills. The drills were designed to improve movement speed and coordination, thereby translating improvements in strength and power into improved functional performances by using motor skill practice [17].

Control: One-hour non-exercise, health education classes, concentrating on life style modification, medication, therapy and