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Feasibility study: Effect of hand resistance exercise on handwriting in Parkinson's disease and essential tremor

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ABSTRACT

Study Design: A single group, repeated measures design was used.
Introduction: Tremor can lead to impaired hand function in patients with Parkinson's disease (PD) and essential tremor (ET). Difficulty with handwriting is a common complaint in these patients suffering from hand tremors. The effect of hand resistance exercise on handwriting is unknown.
Purpose of the Study: To explore the influence of 6 weeks of home-based hand resistance exercise on handwriting in individuals with PD and ET.
Methods: Nine individuals with PD and 9 with ET participated in the study. The average age was 65.3 (6.0) years with an average disease duration of 7.8 years. Participants were instructed to perform a home-based, hand and arm resistance exercise program 3 times a week for 6 weeks. Samples of the area of handwriting and maximal grip strength were measured at baseline and after 6 weeks of exercise. The area of the handwriting sample and maximal grip strength measured before and after 6 weeks were compared.
Results: Mean grip strength of the participants with PD improved after 6 weeks of hand resistance exercise ($P = .031$), but grip strength did not change in ET ($P = .091$). The size of the handwriting samples (words and sentences) did not change after exercise in either participants with PD or ET.
Discussion: Micrographia in patients with PD and macrographia in patients with ET represent complex fine motor skills. More research is needed to understand what therapies could be effective in modifying the size and quality of handwriting.
Conclusions: The purpose of this feasibility study was to explore the influence of home-based wrist resistance exercise on handwriting in individuals with PD and ET. Despite small gains in grip strength, the size of the handwriting samples (words and sentences) did not change for patients with PD or ET following a 6-week home-based hand resistance exercise program.
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Introduction

Parkinson's disease (PD) is a neurodegenerative disease characterized by clinical features including resting tremor, rigidity, bradykinesia, and postural instability.[1] Essential tremor (ET) is one of the most common types of tremor. It is characterized by bilateral action tremor including both postural and kinetic tremors of the hands. The action tremors most commonly involve the upper extremities in a symmetric manner. As the disease progresses, it may also involve the legs, head, neck, voice, and tongue.[2]

Difficulty in writing is a common complaint in individuals with upper limb tremors commonly experienced by individuals with PD[3] or ET.[4] Individuals with PD often show reductions in writing size as the length of the text increases. This clinical sign is called micrographic, a well-recognized manifestation and often an early sign of PD. Approximately, 75% of patients with PD demonstrate

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micrographia.[3] Although the presence of mild bradykinesia also has been reported in individuals with ET, handwriting characteristics in ET are opposite from PD. Macrographia has been recently reported in individuals with ET[5]; these individuals write letters with increased width and height as compared with those of healthy controls.

Micrographia can be improved by certain nonmedical interventions. Oliveira et al[6] reported positive effects of visual targets and of verbal commands on micrographia. Patients with PD wrote with more normal amplitude when given either a visual or verbal cue. Visual cues such as parallel and grid lines can be used to increase the length of words in persons with PD.[7] PD patients also wrote larger when provided with a grid of squares as an external visual cue together with verbal reminders.[8] In addition, the use of sensory cueing is a well-established rehabilitation technique for improved locomotion and speech in persons with PD.[9-12] The provision of external cues may involve recruitment of other cortical areas to contribute to the generation of movements and may allow parkinsonian patients to bypass their poorly functioning basal ganglia.[13] This hypothesis potentially supports the positive effects of cueing on letter size in persons with PD.

Decreased strength and increased difficulty in digit torque control were reported in persons with PD.[14] Although the weakness in PD is still debated, muscle weakness was identified as one of the contributing factors for bradykinesia.[15] Resistance exercise training could potentially transfer to improvement in micrographia due to possible benefit on bradykinesia. This hypothesis was supported by the finding that power-based strength training significantly reduced bradykinesia and increased muscle strength and power in older patients with PD.[16] Although there was no previous evidence of muscle weakness in ET, resistance training was found to improve digit steadiness in ET[17] and could possibly improve handwriting.

Previous studies have demonstrated that resistance training improves digit force steadiness and intramuscular and intermuscular coordination, all of which may improve movement control in neurologically impaired persons.[18,19] Resistance exercises were reported to increase steadiness in older adults[20] and in individuals with ET.[17] Subjects who performed the training program with heavy loads experienced an increase in steadiness of their index finger. These findings suggest that resistance training can decrease the magnitude of tremor. In addition, in another pilot study in patients with ET, 6 weeks of resistance training improved fine manual dexterity.[21] These findings suggest that resistance training may decrease the magnitude of the handwriting disability imposed by the ET. No other rehabilitation intervention for handwriting difficulty in ET has been reported.

It is also possible that strengthening could decrease bradykinesia in patients with PD. In this case, the strengthening could potentially increase the size of handwriting. However, the effects of resistance exercise training have not been formally studied in patients with PD or ET. The main purpose of this study was to assess whether resistance exercises (6 weeks of home-based training) would positively modify handwriting letter size for patients with PD and ET. We hypothesized that the resistance exercise program would result in changes in handwriting size. Specifically, we aimed to determine whether the training would increase letter size in PD and decrease letter size in ET.

Methods

Participants

Nine individuals with PD and 9 with ET were recruited from the Parkinson's Disease Research Education and Clinical Center, Houston. All participants experienced tremor either from PD or ET and reported having difficulty in writing. Each participant had a Montreal Cognitive Assessment score $\geq$ 24.[22] All participants signed a consent form approved by the institutional review boards of the Baylor College of Medicine and the Michael E. DeBakey VA Medical Center. Sixteen participants wrote with their right hand, and one wrote with the left hand (Table 1). All participants with PD had bilateral symptoms; with 6 participants had more tremors on left side and 2 had more on the right side.

Procedure

This study used a within-subjects pre-post test design to compare handwriting before and after 6 weeks of a home resistance exercise program for the upper limb. Participants were their own controls. All participants performed the writing task while on their usual medications at the same time of the day both at baseline and follow-up evaluations. Participants sat in an armrest-equipped chair at a table in their customary writing posture and used the same ballpoint pen for the entire experiment. They were asked to supply 2 writing samples: (1) A set of 3 words (Monday, Tuesday, and Wednesday) and (2) The sentence "Today is a nice day" in their usual size. Each sample was written on a blank, white 80 $\times$ 21.5 cm sheet of paper. No additional verbal reminders or cueing were given after the participants started writing. Writing samples were scanned, and areas around the words (ie, height and width) were measured by an independent rater. The handwriting rater was unaware of the hypothesis of the study, the intervention (ie, resistance exercise program) and the testing condition (ie, pre or post exercise of writing samples). The Area Measuring Tool in Adobe Acrobat 9 was used to measure the size of writing samples. Using this tool, lines were drawn around each word. The spaces (ie, area of words) within the lines surrounding the words were combined to represent the total area written. Combined areas of the 3 words and the area of the sentence were used for data analysis.

Maximal grip strength was measured to confirm that the upper limb/hand resistance training had a measurable impact on strength. Grip strength was measured using a Smedley digital hand dynamometer (Model 12-0286; Fabrication Enterprises Inc., White Plains, NY). Participants were tested sitting in a standard chair with the humerus in a neutral position, arm touching the side of the

Table 1
Characteristics of the sample ($N = 17$)

Characteristics	PD ($N = 8$)	ET ($N = 9$)
Age (y)	65.88 ± 7.22	64.78 ± 5.09
Height (cm)	174.94 ± 3.94	175.40 ± 9.26
Weight (kg)	90.66 ± 18.83	91.42 ± 16.59
BMI (kg/m^2)	29.46 ± 4.97	29.87 ± 6.08
Disease duration (y)	5.38 ± 3.11	9.89 ± 9.03
UPDRS motor score	23.33 ± 9.87	N/A
Handedness		
Right	8 (100%)	8 (88.9%)
Left	0 (0%)	1 (11%)
Medication		
Levodopa/carbidopa	8 (100%)	
Entacapone	3 (37.5%)	
Ropinirole	2 (25%)	
Selegiline	2 (25%)	
Rasagiline	2 (25%)	
Pramipexole	1 (12.5%)	
Amantadine	1 (12.5%)	
Trihexyphenidyl	2 (25%)	
Primidone		8 (88.9%)
Propranolol		1 (11.1%)

BMI = body mass index; ET = essential tremor; PD = Parkinson's disease; SD = standard deviation; UPDRS = Unified Parkinson's Disease Rating Scale.
Values are mean ± SD or *N* (%).