

## BRIEF REPORT

# The Safety and Feasibility of High-Force Eccentric Resistance Exercise in Persons With Parkinson's Disease

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**ABSTRACT.** Dibble LE, Hale T, Marcus RL, Gerber JP, LaStayo PC. The safety and feasibility of high-force eccentric resistance in persons with Parkinson's disease. *Arch Phys Med Rehabil* 2006;87:1280-2.

**Objective:** To examine the effect of high-force eccentric resistance exercise on measures of muscle damage and injury in persons with mild to moderate Parkinson's disease (PD).

**Design:** Before-after trial.

**Setting:** Tertiary care center clinical laboratory.

**Participants:** Ten persons with PD (Hoehn and Yahr Staging Scale, stage 1-3).

**Intervention:** Participants trained 3 days a week for 12 weeks on an eccentric ergometer, performing high-force eccentric resistance exercise with bilateral lower extremities.

**Main Outcome Measures:** Serum creatine kinase (CK) concentrations, muscle pain scores, and isometric force production were measured before, during, and after training.

**Results:** Mean CK levels did not differ and did not exceed the threshold of muscle damage at any time point ( $P=.17$ ). Muscle visual analog scale scores were low and only differed at week 2 ( $P=.04$ ). Participants were highly compliant, whereas total negative work and isometric force increased over time ( $P=.02$ ,  $P=.006$ , respectively).

**Conclusions:** Persons with mild to moderate PD can safely and feasibly participate in high-force eccentric resistance training. The data we present provide a basis for future investigations of the efficacy of this type of training on muscle size, strength, and mobility in persons with PD.

**Key Words:** Exercise; Muscles; Parkinson disease; Rehabilitation.

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**T**HE POSITIVE EFFECTS OF resistance training in persons with Parkinson's disease (PD) have recently been reported.<sup>1,2</sup> However, these studies have assumed the safety of resistance training and have not measured muscle damage or injury. To examine systematically the safety and feasibility of

high-intensity resistance training, our objective was to examine muscle damage and injury indices<sup>3,4</sup> during an eccentric training regimen known to produce some of the highest muscle forces possible.<sup>5,6</sup> The rationale for using this eccentric training regimen lies in the fact that the high level of muscle forces are generated with minimal oxygen-consumption demands relative to an equivalent amount of positive (concentric) work.<sup>6,7</sup>

## METHODS

Ten people with PD were recruited through local movement-disorders clinics using the following inclusion criteria: stages 1 through 3 on the Hoehn and Yahr Staging Scale and an age between 40 and 85 years. Persons with PD were excluded if they had unpredictable motor fluctuations or if they had any medical condition that limited their tolerance to testing and training procedures. The hospital institutional review board approved the study, and all participants provided informed consent. Participants were tested and trained within 1 to 1.5 hours of taking their PD medications.<sup>8</sup> Age, sex, and disease-specific information were collected on receiving consent.

All subjects with PD trained on a high-force eccentric ergometer 3 days a week for 12 weeks. This specially constructed ergometer, previously described and used safely with frail elderly,<sup>9</sup> used a motor to drive the pedals in a reverse direction. As the pedals rotated, the participant attempted to slow the pedals by applying force, resulting in high-force eccentric contractions of the quadriceps muscles and negative work. To put the high force of these contractions into perspective, in a previous study,<sup>9</sup> elderly persons with sarcopenia undergoing this training increased their workload by nearly 4-fold during a training period and ended at an average workload of about 250W. This corresponds to very high forces (roughly equivalent to lifting a 50-kg mass 30cm off the ground 1500 times per session). As a control for cardiovascular exertion, participants gradually increased their rating of perceived exertion (RPE) from "very, very light" (RPE of 9) to "light" (RPE of 11) over the first 3 weeks via the Borg rating of perceived exertion scale.<sup>10</sup> RPEs were kept constant after week 4 in "somewhat hard" (RPE of 13) to "hard" (RPE of 15) range.

Serum creatine kinase (CK) concentrations and visual analog scale (VAS) muscle-pain ratings were used as indices of muscle damage, whereas isometric muscle force was used to determine the presence of muscle injury.<sup>4</sup> Serum CK samples were collected via venous blood draws, and the CK concentrations (in U/L) were calculated using commercial laboratory enzymatic analysis. Numeric muscle pain results (in centimeters) were determined by the use of a 10-cm VAS anchored at 0cm (no pain) and at 10cm (worst possible pain). Participants marked their leg pain along the scale before each training session. Isometric muscle force production for the more-affected extremity was tested by using unilateral isometric knee extension force (in newtons) via handheld dynamometry.<sup>a</sup> Participants performed three 3-second quadriceps contractions when seated unsupported with the knee in 90° of flexion.<sup>11,12</sup>

Compliance, total work (in kilojoules), and maximal isometric quadriceps strength were used as measures of training

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Table 1: Training Safety and Feasibility Measures

Variable	Age	PDD	UPDRS	Week 1	Week 2	Week 6	Week 12
Participant 1	48	10	7				
Serum CK (U/L)/VAS				74/0	105/4	104/1	87/0
Total work (kJ)/RPE				44.0/14	76.3/14	155.7/14	250.0/14
Muscle force (N)/MIQS (N)*				209/412.3	217	248	314/454.9
Participant 2	59	15	28				
Serum CK/VAS				215/0	411/4	131/0	110/0
Total work (kJ)/RPE				40.6/14	68.3/14	154.7/14	250.0/15
Muscle force (N)/MIQS (N)*				209/282.8	211	208	201/467.3
Participant 3	68	4	48				
Serum CK/VAS				NT/0	NT/ 3	NT/ 0	NT/0
Total work (kJ)/RPE				5.0/14	8.0/13	33.7/14	55.2/13
Muscle force (N)/MIQS (N)*				104/135.2	117	113	121/152.5
Participant 4	75	4	35				
Serum CK/VAS				72/0	112/3	65/0	67/0
Total work (kJ)/RPE				7.0/11	23.0/13	81.7/12	111.0/13
Muscle force (N)/MIQS (N)*				200/532.4	214	251	297/573.2
Participant 5	55	7	17				
Serum CK/VAS				65/0	49/2	42/0	51/0
Total work (kJ)/RPE				21.7/12	47.0/13	127.7/12	187.5/13
Muscle force (N)/MIQS (N)*				137/356.9	189	239	250/631.3
Participant 6	59	5	19				
Serum CK/VAS				92/0	79/2	42/0	68/0
Total work (kJ)/RPE				19.3/12	71.0/14	142.5/15	200.0/13
Muscle force (N)/MIQS (N)*				155/344.5	153	200	176/377.3
Participant 7	62	7	18				
Serum CK/VAS				121/0	56/3	60/0	45/0
Total work (kJ)/RPE				19.0/15	23.0/15	71.7/16	102.0/15
Muscle force (N)/MIQS (N)*				200/249.1	233	226	199/419.1
Participant 8	73	3	31				
Serum CK/VAS				138/0	95/3	37/1	38/0
Total work (kJ)/RPE				8.0/13	17.5/14	56.0/14	137.7/16
Muscle force (N)/MIQS (N)*				NT/370.2	NT	NT	NT/373.3
Participant 9	79	11	31				
Serum CK/VAS				61/0	86/2	60/0	64/0
Total work (kJ)/RPE				20.3/12	44.5/13	91.7/16	123.8/13
Muscle force (N)/MIQS (N)*				158/220.3	166	165	218/233.6
Participant 10	65	4	15				
Serum CK/VAS				70/0	62/3	60/1	56/0
Total work (kJ)/RPE				21.7/12	66.0/13	181.7/12	151.0/11
Muscle force (N)/MIQS (N)*				173/304.1	186	183	216/449.5

NOTE. Participant 3 is missing CK values because of lack of consent to the blood draws. Participant 8 is missing muscle force values because of equipment problems.

Abbreviations: MIQS, maximal isometric quadriceps strength; NT, not tested; PDD, PD duration; UPDRS, Unified Parkinson's Disease Rating Scale<sup>15</sup> motor subsection score.

\*Knee extension strength of the most-affected extremity at pre- and postintervention tests.

feasibility. Compliance was determined as the ratio of training sessions attended to the total possible training sessions. Total work on the ergometer was recorded each training session. Unilateral maximal isometric quadriceps strength of the more-affected extremity was tested with a KinCom dynamometer<sup>b</sup> during training weeks 1 and 12. Participants were seated with their knees fixed at 60° of flexion. Three 5-second-long maximal contractions were performed, with a 3-minute rest between trials. The variable (maximal isometric quadriceps strength) was calculated as the average force (measured in newtons).<sup>13</sup>

Weekly averages at 4 time periods (week 1 [pretraining], week 2, week 6, week 12 [posttraining]) of the outcome measures were used for statistical analysis. To determine the safety of eccentric resistance training, we hypothesized that there would be no time period differences on muscle-damage indices (serum CK, VAS scores) and that muscle force would increase

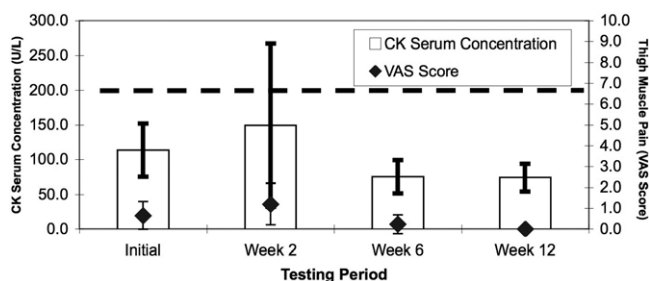
over time. To determine feasibility, we hypothesized that participants would be greater than 80% compliant and that total work and maximal isometric quadriceps strength would increase over time. Equivalence of muscle damage was assessed by the overlap of 95% confidence intervals (CIs) of CK concentrations at each time period.<sup>14</sup> Separate Wilcoxon matched pairs or Friedman analyses of variance were used to test all outcome measures ( $P < .05$ ).<sup>c</sup> As needed, post hoc tests were performed.

## RESULTS

All 10 subjects with PD initially enrolled completed the training and are described in table 1.

### Safety Measures

The 95% CI for CK from all testing periods overlapped; mean CK levels did not differ significantly, nor did they exceed



**Fig 1. Serum CK and muscle-pain results.** The left y axis depicts the serum CK concentrations ( $\pm 95\%$  CI), whereas the right y axis depicts the VAS muscle pain scores ( $0-10\text{cm}$ ) ( $\pm 95\%$  CI). The x axis represents the time points when measures were taken (week 1, week 2, week 6, week 12). The dashed line indicates the threshold for muscle damage (200U/L).

the threshold of muscle damage at any time point ( $P=.17$ ), (overall mean, 100U/L muscle; damage threshold,  $>200\text{U/L}$ ). Muscle VAS scores were low (overall mean, 0.5cm) and only different at week 2 ( $P=.04$ ). Muscle force consistently increased over time ( $P=.02$ ) (see table 1, fig 1).

### Feasibility Measures

The mean compliance was 92% (33/36 sessions). Total negative work and maximal isometric quadriceps strength significantly increased over time (total negative work,  $P=.02$ ; maximal isometric quadriceps strength,  $P=.006$ ). The total work differences were between week 1 and weeks 6 and 12 (see table 1).

### DISCUSSION

Clinically insignificant serum CK and muscle pain levels, coupled with increased quadriceps isometric strength, indicated that high-force eccentric resistance training can be implemented in mild to moderately affected subjects with PD safely and feasibly. To our knowledge, this is the first study to systematically examine the safety of high-force eccentric resistance training in subjects with PD. The lack of significant measures of muscle damage indicate that subjects with PD respond similarly to both young and frail elders exposed to high-force eccentric exercise.<sup>9</sup> This type of exercise has been reported as a means of inducing muscle mass, strength, and mobility gains in non-neurologically impaired persons<sup>9</sup> and may be ideally suited for subjects with PD because high levels of muscle force are generated with low metabolic demands.<sup>7</sup> The application of this type of exercise in a chronic progressive manner appears to allow muscle adaptation rather than muscle damage of naive subjects with acute bouts of high eccentric forces.

### CONCLUSIONS

This preliminary report provides support for future research to determine the efficacy of high-force eccentric resistance training on muscle structure and mobility in subjects with PD.

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### Suppliers

- a. J-Tech Medical Inc, 70 Lawndale Dr, Ste G, Salt Lake City, UT 84115.
- b. Chattanooga Group Inc, PO Box 489, Hixson, TN 37343.
- c. Version 13.0; SPSS Inc, 233 S Wacker Dr, 11th Fl, Chicago, IL 60606.