Effects of pedaling rate on upper extremity motor improvements during passive leg cycling in Parkinson's disease

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Abstract

In previous studies, we developed a rate-based exercise paradigm to augment the movements of Parkinson's disease (PD) patients by assisting them in safely achieving an exercise rate greater than their voluntary ability. Our findings showed that a single session of high-rate active cyclical exercise (> 80 revolutions per minute, rpm's) resulted in a 42% motor improvement in the Unified Parkinson's disease Rating Scale (UPDRS) and increased levels of activation within cortical structures. However, it is unknown if passive leg cycling at high rates will show a similar effect on motor function in Parkinson's disease. Previous studies in stroke and spinal cord-injured individuals have shown that passive leg movement can alter motor neuron excitability. Therefore, the goal of this study is to examine if passive leg rotation can promote motor improvement and to determine the optimal pedaling rate in individuals with PD. Subjects were asked to participate in four separate sessions on a motorized bicycle (Motomed Viva 2, RECK, Germany). In the first session, baseline fitness was assessed using the YMCA submaximal cycling protocol. In the 2nd-4th sessions, a motorized bicycle was set to rotate their legs at rates of 60, 70 or 80 rpm's. Subjects were asked to be passive, but not resist, and let the motor rotate the legs. The 30 minute main set was preceded and concluded by a 5 minute warm up/cool down at 40 rpm. Functional assessments were carried out immediately before and after each session. Each subject returned to complete the remaining sessions in 1 week. Change in motor function from baseline to immediately after each bout of passive leg cycling was examined using a handwriting task, a point-to-point reaching task and motor function tests of the UPDRS. The Kinesia device (CleveMed, Cleveland, OH) was worn on the finger and wrist of the patient and wirelessly transmitted quantitative data regarding the motor function during reaching and motor function tests. Our results show that passive leg cycling can reduce tremor and bradykinesia in PD individuals with these primary symptoms. These findings also suggest that each individual has an optimal pedaling rate which promotes maximal motor improvement. Future studies will examine the mechanisms for changes in motor function in these individuals.

Goals and Methods

Goals

- To determine if passive leg cycling with a motorized bike promotes motor improvement in Parkinson's disease
- To determine if changes in motor function are sensitive to the rate of passive leg cycling
- To test the sensitivity of two quantitative measures of motor function to changes after passive leg cycling

Testing Conditions and Data Collection

- Four data collection/cycling sessions (separated by one week):
  - On meds- baseline and submaximal VO_2 testing
  - Off meds- 60 rpm passive cycling
  - Off meds- 70 rpm passive cycling
  - Off meds- 80 rpm passive cycling
- Cycling sessions on Motomed Viva 2 (Fig. 1)
- Tremor & bradykinesia assessment (Kinesia™, Fig. 2) and Automated Movement Analysis System
- Repeated measures ANOVA was used to examine time (pre/post) by rate (60, 70, 80 rpm) interactions.

Participants

Gender	Age (Years)	H & Y stage	Disease Duration (Years)	Estimated VO_{2max} (ml/kg/min)
Male	65	1	5	48
Female	51	3	9	31
Male	62	1	7	32
Male	62	3	12	26
Female	57	1	5	26
Male	57	3	6	19
Female	41	2	6	16
Male	66	2	2	18
Male	74	2	3	23
Male	67	1	5	29
Female	73	3	6	-
Female	54	2	3	24
Male	67	1	1.5	34
Male	57	1	0.5	31
Female	70	2	7	17
Male	68	3	5	24
Male	68	3	3	22
Male	56	2	2	35
Female	71	1	6	34
Male	71	2	9	35
AVG	**63 ± 8**	**2 ± 0.8**	**5 ± 3**	**28 ± 8.0**

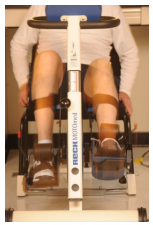

Photo: Jeff Glidden

Figure 1: *The Motomed Viva 2 was modified to allow for passive cycling up to 90rpm. Patients sat in a chair that was bolted to the base of the cycle.*

Photo: Jeff Glidden

Figure 2: *Kinesia™ was used to objectively quantifying tremor and bradykinesia in Parkinson's disease.*

Passive Motorized Cycling

- The 30 minute main set was preceded and concluded by a 5 minute warm up/cool down at 40 rpm.
- Heart rate, rate of perceived exertion (RPE) and patient work were monitored during each session.
- A trainer provided support and encouragement.
- All sessions on the motorized bicycle were completed at 9 or 10AM on the same day of the week.
- Functional assessments were carried out immediately before and after each session.

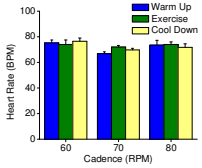

Figure 3: *Radial pulse was measured during the warm-up, main set and cool-down to document heart rate responses to passive exercise. There were no significant differences among heart rate during these times periods. Furthermore, patients reported RPE values of 6-8 during the main set. Error bars- standard error of the mean.*

Quantitative movement assessment of the upper extremity

Kinesia™: Cleveland Medical Devices

Figure 4: *Three orthogonal accelerometers and three orthogonal gyroscopes provide linear acceleration along and angular velocity about the X, Y and Z axes (left) B. The Clinical Evaluation Mode of the Kinesia software provides video and verbal instruction to guide patients through motor tasks similar to those completed during the Unified Parkinson's Disease Rating Scale motor exam (right).*

- Patients completed three tremor tasks (rest, postural and kinetic) and three bradykinesia tasks (finger tap, hand grasp, hand pronation-supination).
- For tremor analysis, patients were divided into two groups depending on their baseline 'off' medication resting tremor score. <1= mild tremor (N=10), >1= moderate tremor (N=10)

Tremor Tasks Results

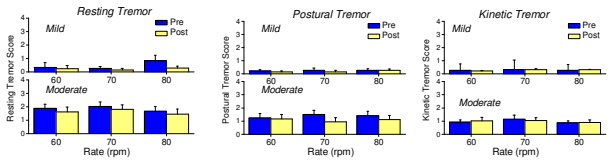

Figure 5: *Subjects with mild tremor show no significant change over time (pre/post) or rate (60, 70, 80 rpm). However, there was a significant decrease in resting (p= 0.007) and postural (p= 0.017) tremor scores in the moderate tremor group with time only. In the moderate tremor group, the greatest change from pre (1.51) to post (0.96) cycling was detected in the postural tremor score at 70 rpm.*

Bradykinesia Tasks Results

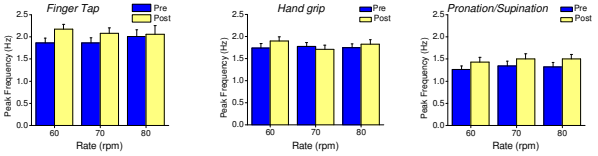

Figure 6: *The power spectrum of the movement signal was calculated and the peak frequency was measured for each task . Subjects showed significant increases in frequency during the finger tap (p= 0.001), hand grip (p= 0.24) and pronation/supination (p < 0.001) after passive leg cycling. Furthermore, there was a significant time by rate interaction (p= 0.011) in the finger tap task. .*

Automated Movement Analysis System

- Patients completed five trials of each test with the dominant hand (100 trials per time point)
- Total time to completion was calculated as the time between leaving the left most target and touching the final target.
- This task tests the ability to grasp the pen and move between three targets efficiently and accurately.

Pre-cycling

Post-cycling

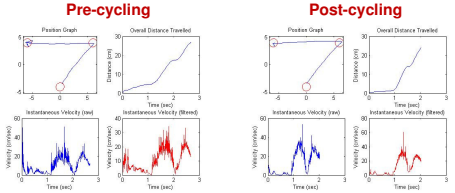

Figure 7: *Sample data before and after passive cycling at 80 rpm. Data were analyzed using code written in Matlab.*

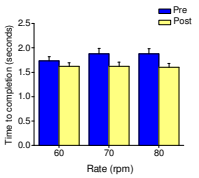

Figure 8: *Time to completion significantly decreased after passive cycling(p < 0.001) with the greatest improvement at 70 (0.26 s) and 80 rpm (0.28 s)*

Conclusions

- Passive leg cycling can promote motor improvement, specifically in tremor and bradykinesia, in individuals with Parkinson's disease. Individuals with more severe symptoms show the greatest benefit.
- There does not appear to be a strong effect of cycling rate on improvement during passive cycling. All rates of leg cycling contributed to improvements.
- Kinesia and the Automated Movement Analysis System are sensitive to changes in motor function after passive cycling. However, these tests are only useful for individuals who have tremor and/or bradykinesia as their primary symptom.
- Future research should examine the effects of active-assisted cycling on tremor and bradykinesia as well as posture and locomotion in Parkinson's disease.

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