Research Symposium
Update on Exercise in Parkinson Disease

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Director: Center for Neurorehabilitation
Boston University

Exercise Goals

- Slow Progression of Disease?
- Slow Progression of Disability
- Optimize independence and participation in home, work and leisure activities
- Optimize independence and safety in performing function tasks (gait, balance, sit to stand, bed mobility, ADL’s)
- Preserve or improve physical capacity (cardiovascular endurance, strength and flexibility)
- Prevent falls – reduce fall risk
Could Exercise Be Neuroprotective?

Increase in Striatal GDNF levels
Cohen et al. 2003

Exercise increases dopamine release in dorsolateral striatum
Akopian et al. 2008

Exercise suppresses expression of dopamine transporter
Fisher et al. 2004

Exercise-induced neuroplasticity in human PD

<table>
<thead>
<tr>
<th>PLASTICITY MARKER</th>
<th>PD N</th>
<th>EXERCISE/ACTIVITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decrease in corticomotor excitability</td>
<td>30</td>
<td>24 sessions over 8 weeks of high intensity treadmill training; 3.0 MET level &amp;/or 75% MHR for 45 minutes</td>
</tr>
<tr>
<td>Increase in DA-D2r expression</td>
<td>4</td>
<td>SAME</td>
</tr>
<tr>
<td>Change in gray matter volume</td>
<td>47</td>
<td>6 training sessions of balance exercise over 6 weeks</td>
</tr>
<tr>
<td>Increase in BDNF</td>
<td>12</td>
<td>24 cycling sessions over 8 weeks; 60-75% MHR for 60 minutes</td>
</tr>
<tr>
<td>Increase in BDNF</td>
<td>11</td>
<td>24 cycling sessions over 8 weeks; 60-75% MHR for 60 minutes</td>
</tr>
<tr>
<td>Increase in BDNF</td>
<td>25</td>
<td>80 therapy/exercise sessions: aerobic exercise; stretching; balance &amp; gait training; treadmill training</td>
</tr>
</tbody>
</table>

(Hirsch et al., 2016)
Regular exercise matters in Parkinson's disease

- Analysis of registry data including 2252 persons with Parkinson disease
- Regular exercise (> 150 mins/week) at baseline were associated with better
  - Quality of life
  - Mobility
  - Physical function
  - Cognition
- And less
  - disease progression
- One year later........


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Smart Exercise: Designing the program that is best for you!

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Boston University College of Health
School of Public Health
Department of Physical Therapy & Athletic Training
Q. What kind of exercise is best for people with Parkinson Disease?

A. Exercise that is tailored to your needs, preferences and goals will result in the best outcome...

Traditional Model of Rehabilitation in Parkinson Disease

- Onset of pre-clinical symptoms
  - No Rehabilitation Intervention
  - Diagnosis PD (pre-disability)
  - Pharmacological Rx (pre-disability)

- Discrete Episodes of Care
  - No follow up
  - Referral PT
  - Onset of overt disability (Rehab compromised)
  - Acute Event: Hip fracture
  - Decline in Quality of Life
  - Referral PT
Dental Model of Care (Secondary Prevention)

Onset of pre-clinical symptoms

Referral to PT

Diagnosis PD (pre-disability)

Delay onset of disability

Rehabilitation provided at regular intervals over disease continuum
- Standardized outcome measures administered at each f/u visit
- Exercise prescription tailored to meet the needs of each individual patient

Focus of Rx:
- Prevention
- Remediation

Options to Maintain Exercise Between Episodes of PT:
- mHealth supported: home / gym
- Community Exercise Programs

Exercise Category Examples

<table>
<thead>
<tr>
<th>Exercise Category</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aerobic Exercise</td>
<td>Treadmill&lt;br&gt;Walking overground&lt;br&gt;Biking&lt;br&gt;Boxing</td>
</tr>
<tr>
<td>Strength Training</td>
<td>Weight training&lt;br&gt;machines, dumbbells, theraband, weighted vests, body weight</td>
</tr>
<tr>
<td>Balance Training</td>
<td>Balance Training&lt;br&gt;Tai Chi class&lt;br&gt;Dancing</td>
</tr>
<tr>
<td>Stretching</td>
<td>Flexibility exercises&lt;br&gt;Yoga</td>
</tr>
<tr>
<td>Task Specific Training / Movement Strategy Training</td>
<td>Walking; Cueing with Music</td>
</tr>
</tbody>
</table>
Aerobic Exercise

+ Motor Skill Training + Strengthening

Assessment Participants, No Mean Change (SE) Within-Person Percentage Change P value
6MWT
HIT 22 77 (31.1) 6.3 (2.5) .07
LIT 19 161 (51) 11.6 (3.7) .001
S-R 19 107 (47.8) 9.1 (5.5) .019

10-m Fast pace, s
HIT 23 −0.4 (0.2) −4.6 (1.9) .049
LIT 22 −0.48 (0.3) −6.2 (3.5) .02
S-R 22 −0.1 (0.2) −1.2 (2.3) .63

Cardiovascular Assessment Peak VO2, mL/kg/min
HIT 23 1.54 (0.4) 8.1 (2.1) .003
LIT 22 1.53 (0.7) 6.7 (2.7) .004
S-R 21 −0.052 (0.4) −0.2 (1.7) .92

Benefits of aerobic exercise:

Shulman et al. 2013

5/29/2017
Aerobic Walking Exercise in PD

- Walking 3x per week for 45 minutes
- Community Setting
- Mean HR = 70% HR max (HR = 107.8)

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Adjusted for levodopa equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>VO2 max (max O2 uptake; mL/min/kg)</td>
<td>1.66 ± 2.90 (&lt;0.001)</td>
</tr>
<tr>
<td>7-m walk (seconds)</td>
<td>-0.62 ± 1.05 (&lt;0.001)</td>
</tr>
<tr>
<td>UPDRS Motor</td>
<td>-2.75 ± 7.12 (0.002)</td>
</tr>
<tr>
<td>UPDRS Mental</td>
<td>-0.52 ± 1.58 (0.025)</td>
</tr>
<tr>
<td>Flanker task – (% increase score)</td>
<td>-3.70 ± 8.17 (0.005)</td>
</tr>
<tr>
<td>Fatigue Severity Scale</td>
<td>-0.52 ± 1.13 (0.002)</td>
</tr>
<tr>
<td>Geriatric Depression Scale</td>
<td>-0.77 ± 2.58 (0.043)</td>
</tr>
<tr>
<td>PDQUALIF, total (quality of life)</td>
<td>-1.14 ± 4.21 (0.064)</td>
</tr>
</tbody>
</table>

N = 126

Mod Intensity = Exercise 4 days per week 60-65% HRmax

High Intensity = Exercise 4 days per week 80-85% HRmax
Strengthening Exercises + Balance Training

2-year (2x/wk) RCT
Progressive Resistance Exercise in PD

Significant improvements:
• Motor UPDRS (off meds)
• Strength
• Movement Speed

Corcos et al. 2013
Targeting Strength

Enhance Postural Extension
- Hip Extensors
- Hip Abductors
- Knee Extensors
- Gastroc Soleus
- Trunk Extensors

Balance Exercises

+ Cognitive Training
Clinic based
2x/wk for 90 mins;
37% decline in fall rate per month

Predicting Falls

1. Have you fallen in past 12 months?

2. Have you experienced freezing of gait in the past month?

3. Timed 4 meter walk test

Total Score: Probability of Falling in next 6 months

Predicting Falls in PD over next 6 months:
Canning C et al. 2014

Validation study: Duncan RP et al. 2015
Stretching Exercises

- + Balance Training

Targeting Flexibility & ROM

- Flexibility
  - Gastroc / soleus
  - Hamstrings
  - Hip flexors
  - Pectoralis major and minor
  - Elbow flexors
  - Finger flexors

- ROM
  - Cervical rotation
  - Axial extension
  - Trunk rotation
  - Trunk extension
  - Pelvis – anterior tilt
Exercise + Socialization

How much Exercise is Recommended?

<table>
<thead>
<tr>
<th>Exercise Type</th>
<th>American College Sports Medicine Guidelines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiorespiratory Exercise</td>
<td>• 150 minutes (2.5 hours) of moderate intensity per week</td>
</tr>
<tr>
<td>Resistance Exercise</td>
<td>• 2-3 days per week</td>
</tr>
<tr>
<td></td>
<td>• 2 sets, 8-12 repetitions</td>
</tr>
<tr>
<td>Flexibility Exercise</td>
<td>• At least 2-3 days per week</td>
</tr>
<tr>
<td></td>
<td>• Hold for 30 seconds</td>
</tr>
<tr>
<td></td>
<td>• Repeat 2-4 times</td>
</tr>
<tr>
<td></td>
<td>• Perform when muscles are warm (after exercise)</td>
</tr>
<tr>
<td>Balance / Neuromotor Exercise</td>
<td>• 2-3 days per week</td>
</tr>
<tr>
<td></td>
<td>• 30 minutes</td>
</tr>
</tbody>
</table>
Of 10 domains of functioning, patients with PD rated the following in order of importance:

- **Walking**
- **Slowness**
- **ADL**
- **Fatigue**
- **Stiffness**
- **Sleep**
- **Thinking**
- **Tremor**
- **Emotional distress**
- **Pain**

Gait disturbance is most important to patients with PD.

L-dopa has limited therapeutic effects on gait.

Gait disturbance is a known strong predictor of disability and health related quality of life.
Using Music to Improve Walking….

- 80 steps / min
  - I’m a Believer by Neil Diamond
    https://www.youtube.com/watch?v=sWQv0dkVzVU

- 100 steps / min
  - Jack & Diane by John Mellencamp
    https://www.youtube.com/watch?v=zjMwrXGk4xU

- 126 steps / min
  - September by Earth, Wind & Fire
    https://www.youtube.com/watch?v=ter0p_iylxk
Step Activity Classification

**Adults**

<table>
<thead>
<tr>
<th>Physical Activity Level</th>
<th>Criterion (steps / day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basal Activity</td>
<td>&lt; 2,500</td>
</tr>
<tr>
<td>Limited Activity</td>
<td>2,500-4,999</td>
</tr>
<tr>
<td>Low Active</td>
<td>5,000-7,499</td>
</tr>
<tr>
<td>Somewhat Active</td>
<td>7,500-9,999</td>
</tr>
<tr>
<td>Active</td>
<td>10,000-12,499</td>
</tr>
<tr>
<td>Highly Active</td>
<td>&gt;12,500</td>
</tr>
</tbody>
</table>

Adapted from Tudor-Locke et al. (2011) - Color added

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Progression of Disability in PD

![Effect Sizes Graph](image)

<table>
<thead>
<tr>
<th>Effect Size Cohen's d</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 months</td>
</tr>
<tr>
<td>12 months</td>
</tr>
<tr>
<td>18 months</td>
</tr>
<tr>
<td>24 months</td>
</tr>
</tbody>
</table>

Ellis et al. 2016 Parkinsonism & Related Disorders
Changes in Walking in Persons with Parkinson Disease over 1-year

<table>
<thead>
<tr>
<th>Variable</th>
<th>% change / effect size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steps*</td>
<td>-12 / 0.28</td>
</tr>
<tr>
<td>Moderate intensity minutes*</td>
<td>-40 / 0.30</td>
</tr>
</tbody>
</table>

Most Common Barriers to Exercise in Persons with PD:
- **Low outcome expectation**
- Fear of falling
- Lack of time
What are the Factors Associated with Exercise Behavior in PD?

Most Robust Factors Associate with Exercise in PD:

**Self-Efficacy**: the measure of one ability to exercise successfully

Accuracy of Activity Trackers

- Fitbit Zip
- Fitbit Surge
- Jawbone UP2
- Jawbone Up Move
Accuracy of Activity Trackers

- Fitbit Zip
- Fitbit Surge
- Jawbone UP2
- Jawbone Up Move

Peer Coaching Program

Boston University College of Health
5 Rehabilitation Sciences: Sargent College
Department of Physical Therapy & Athletic Training
Peer Coaching Program

Steps per day increased by 31% from 5,428 to 7,115 steps.

Mobile Health Technology to Promote Physical Activity in Persons with Parkinson Disease

Boston University College of Health
Sargent College
Department of Physical Therapy & Athletic Training
Study Design

Baseline Assessment
1 Week Step Activity Monitor

Randomization

mHealth PT + Ex
1-2 PT Visits

Exercise
1-2 PT Visits

mHealth Exercise Platform:
• Tailored Exercise Videos
• Monitoring by a PT
• Visual Feedback
• Fitbit

Home Exercise Program:
• Tailored Photos of Exercise
• Written Instruction
• Pedometer
• Calendars

1-Year Assessment
1 Week Step Activity Monitor

Exercise Intervention

• Walking with pedometer
• Strengthening

Funded by:

Boston University College of Health
5 Rehabilitation Sciences: Sargent College
Department of Physical Therapy & Athletic Training
Mobile Health Technology

Wellpepper App: User Version

Boston University College of Health
Sargent College Department of Physical Therapy & Athletic Training
# Promoting Exercise

<table>
<thead>
<tr>
<th>Theoretical Approach</th>
<th>Intervention Components</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tailored Exercise Videos</td>
</tr>
<tr>
<td>Self-efficacy</td>
<td>✓</td>
</tr>
<tr>
<td>Outcome expectations</td>
<td>✓</td>
</tr>
<tr>
<td>Motivation</td>
<td>✓</td>
</tr>
<tr>
<td>Knowledge</td>
<td>✓</td>
</tr>
<tr>
<td>Social Persuasion</td>
<td>✓</td>
</tr>
</tbody>
</table>

## Outcomes

- Feasibility, safety, acceptability and adherence
- Physical Activity: measured during a one-week period following the baseline and 12-month assessment sessions using the StepWatch™ Activity Monitor (SAM)
- HRQOL, walking endurance, balance
- Self-Efficacy, outcome expectation
### Satisfaction & Safety

<table>
<thead>
<tr>
<th>Survey</th>
<th>mHealth</th>
<th>Active Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Satisfaction Rating (mean, SD)</td>
<td>8.7 (+/- 1.3)</td>
<td>8.5 (+/- 1.6)</td>
</tr>
<tr>
<td>(0=Not satisfied - 10=Highly satisfied)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;Would you like to continue doing the program?&quot;</td>
<td>85% Yes</td>
<td>75% Yes</td>
</tr>
<tr>
<td>&quot;Would you recommend this program?&quot;</td>
<td>100% Yes</td>
<td>100% Yes</td>
</tr>
</tbody>
</table>

Safety: No serious adverse events related to the intervention

---

### Making Exercise a Habit

#### Adherence per Quarter

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Subjects</td>
<td>76%</td>
<td>64%</td>
<td>55%</td>
<td>50%</td>
</tr>
<tr>
<td>&gt;75% 1st Qtr</td>
<td>89%</td>
<td>84%</td>
<td>83%</td>
<td>76%</td>
</tr>
<tr>
<td>&lt;75% 1st Qtr</td>
<td>57%</td>
<td>38%</td>
<td>27%</td>
<td>23%</td>
</tr>
</tbody>
</table>
The hardest thing about exercise is to **start** doing it. Once you are doing **exercise regularly**, the hardest thing is to **stop**.

**Mean Daily Steps**

*Boston University College of Health*

5. Rehabilitation Sciences: Sargent College

Department of Physical Therapy & Athletic Training
Moderate-intensity Minutes*

* # minutes in which 100 steps or more were accumulated

Boston University College of Health
5, Rehabilitation Sciences: Sargent College
Department of Physical Therapy & Athletic Training

Changes in Walking in Persons with Parkinson Disease over 1-year

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Boston University College of Health
5, Rehabilitation Sciences: Sargent College
Department of Physical Therapy & Athletic Training

Cavanaugh, Ellis, Earhart, Ford, Foreman, Dibble, 2012
Steps

More noticeable (yet still non-significant) between-group differences over time were observed when the original dataset was divided according to the baseline level of physical activity.

The suggestion is that the mobile health technology may have differentially benefitted less active participants.

“Low Active” (<7500)

| mHealth: Increase in 5495 steps per week |
| Exercise: Increase in 2856 steps per week |

Moderate Intensity Minutes

This result raises the possibility that the mHealth technology was differentially beneficial for less active participants.

mHealth: increase from 35 to 95 mod intensity minutes per week

Control: increase from 35 to 49 mod intensity minutes per week

mHealth: increase from 35 to 95 mod intensity minutes per week

Control: increase from 35 to 49 mod intensity minutes per week
Case Study: Outcomes Measures Since Initial Diagnosis

<table>
<thead>
<tr>
<th>Functional Outcome Measure</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>PDQ-39</td>
<td>8</td>
<td>8</td>
<td>12</td>
<td>16</td>
<td>12</td>
</tr>
<tr>
<td>MOCA</td>
<td>27/30</td>
<td>27/30</td>
<td>25/30</td>
<td>25/30</td>
<td>23/30</td>
</tr>
<tr>
<td>MDS-UPDRS Part I</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>6</td>
<td>9</td>
</tr>
<tr>
<td>MDS-UPDRS Part II</td>
<td>18</td>
<td>15</td>
<td>15</td>
<td>13</td>
<td>13</td>
</tr>
<tr>
<td>MDS-UPDRS Part III</td>
<td>34</td>
<td>32</td>
<td>32</td>
<td>34</td>
<td>31</td>
</tr>
<tr>
<td>5 times sit to stand</td>
<td>9.5</td>
<td>7.6</td>
<td>10.2</td>
<td>10.0</td>
<td>13.4</td>
</tr>
<tr>
<td>MiniBEST test</td>
<td>26/28</td>
<td>26/28</td>
<td>27/28</td>
<td>27/28</td>
<td>24/28</td>
</tr>
<tr>
<td>FGA</td>
<td>28/30</td>
<td>28/30</td>
<td>28/30</td>
<td>27/30</td>
<td>27/30</td>
</tr>
<tr>
<td>10 meter: Comfortable</td>
<td>1.5 m/s</td>
<td>1.5 m/s</td>
<td>1.6 m/s</td>
<td>1.4 m/s</td>
<td>1.4 m/s</td>
</tr>
<tr>
<td>10 meter: Fast</td>
<td>2.0 m/s</td>
<td>2.0 m/s</td>
<td>1.8 m/s</td>
<td>1.8 m/s</td>
<td>1.7 m/s</td>
</tr>
<tr>
<td>6 MWT</td>
<td>529m</td>
<td>570m</td>
<td>567m</td>
<td>563m</td>
<td>554m</td>
</tr>
<tr>
<td>9 Hole Peg Test</td>
<td>R 30 L 23</td>
<td>R 27 L 22</td>
<td>R 28 L 24</td>
<td>R 30 L 28</td>
<td>R 31 L 27</td>
</tr>
</tbody>
</table>
Thank You for Your.....

National & International Presentations

Boston University College of Health & Rehabilitation Sciences: Sargent College
Department of Physical Therapy & Athletic Training
Publications:

APTA Chattanooga Research Award

The award recognizes the most significant research paper contributing to the science and practice of physical therapy published in the Physical Therapy Journal (PTJ) in 2015.
Research Study at Boston University

Effort and Motivation Study in Persons with Parkinson Disease

You are invited to join a research study in which you would participate in a series of tasks on the computer, walk for a brief period, and answer some questions about your thoughts and behaviors.
Evaluating Capacity vs Performance during Outpatient Physical Therapy

- Emerald was developed by MIT’s Computer Science & Artificial Intelligence Lab (CSAIL)
  - Dina Katabi
  - Chen-Yu Hsu
Uses wireless signal to detect motion in a home

Example: Walking in the living room

Presented at White House Demo Day!

Community Wellness Program Training for Professionals
Training Students….Future Experts in PD

Upcoming Training Dates:
July 10 - July 13
Center for Neurorehabilitation at
Boston University
Faculty: Terry Ellis, P.T., Ph.D., N.C.S.
Josh Aiello  
Assistant Dean of Development & Alumni Relations  
jaiello@bu.edu  
617-353-2286
Thank You: Collaborators

BUMC: Parkinson’s Disease & Movement Disorders Center
U of Utah, Wash U, U of Alabama, U of New England
Health & Disabilities Research Institute

APDA National Rehabilitation Resource Center at BU

- First of its kind…Parkinson’s Exercise Helpline:
  1-888-606-1688
- E-mail: rehab@bu.edu
Questions

To Make an Appointment for Physical Therapy or to Participate in a Study, Please call Leslie Caiola at 617-353-7525.