Quantitative Parkinson’s Gait Assessment: A high resolution measure of change in impairment

Tuesday July 22\textsuperscript{th}, 2014
Starts at 12:00 PM EST
Presented by
Elizabeth Brokaw, PhD
• Impairment due to Parkinson’s Disease
• Deep Brain Stimulation
• Evaluations with wearable sensors
• DBS cessation research
• Role of Kinesia to improve gait outcomes
Parkinson’s Disease Motor Impairments
Parkinson’s Disease

• Wide range of motor symptoms
• Treatments outcomes often focus on the upper extremity
• Mobility is important for quality of life
• Increased fall risk after PD
  – 68.3% fell during one year
Parkinson’s Disease

• Gait
  – Freezing of gait
  – Slowed movement
  – Shortened stride length
  – Flat foot strike (shuffled steps)
  – Impaired balance and posture
Deep Brain Stimulation
Deep Brain Stimulation

• Became a standard treatment for PD in the 1990’s
• Effective method for improving symptoms and reducing medication burden
• Typically indicated for
  – Tremor
  – Bradykinesia
  – Rigidity
• Researcher have observed STN stimulation induced improvement in
  – Stride length
  – Walking speed
  – Freezing of gait
• Evaluation of settings and location is ongoing
  – Frequency effects
  – Pedunculopontine nucleus (PPN)
Deep Brain Stimulation

– Effects some symptoms quickly

Time For Effect on Motor Function After DBS Change
(In Minutes)

- Tremor and Rigidity
- Bradykinesia
- Gait

– Effect on gait is slow and less predictable
  
  • Unknown final effect on gait and balance
  • Not optimized to improve gait and balance
Wearable Sensors
• Quantitative Evaluation of Movement
  – Acceleration
  – Angular Velocity
Benefits of Wearable Movement Sensors

- Objective measure of impairment
- High resolution
- Not confined to in clinic evaluations
The goal is to examine changes in impairment related to changes in DBS settings.
• Quantitative assessment of
  – Tremor
  – Bradykineisia
  – Dyskinesia
  – Gait
  – Freezing of gait

• For more information
  – http://glneurotech.com/publications/
Sensors placed on the more affected thigh, back and top of feet.
• Individuals with Parkinson’s Disease and DBS
  – Started off medication and with DBS on

• Kinesia Evaluation: Unified Parkinson’s Disease Rating Scale tasks

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Protocol

- Toe Tapping
- Leg Lifts
- Arise
- Gait
Protocol

- Clinician UPDRS at study start DBS on and 3 hours after DBS off
- 2 Kinesia evaluations at each time point

Time After DBS Was Turned Off In Minutes

DBS On  DBS Off  15  30  60  120  180

- Times of Kinesia evaluations
- Times of clinician evaluations
Study Goals

• Evaluate changes in impairment over time
• Evaluate ability to minimize sensor number to reduce user burden
  – Sensors data from both legs
  – Sensor data from just the subject reported more affected limb
• 8 Individuals with Parkinson’s Disease
• STN DBS implanted
• DBS surgery average of $1.8 \pm 2.3$ years prior
• Average of $14 \pm 1.5$ hours off medication
## Overall Effect of DBS Cessation

<table>
<thead>
<tr>
<th></th>
<th>Average Kinesia Score</th>
<th>Average Clinician Score</th>
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</thead>
<tbody>
<tr>
<td><strong>Gait</strong></td>
<td></td>
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<tr>
<td>DBS on</td>
<td>0.77 ± 0.38</td>
<td>0.5 ± 0.53</td>
</tr>
<tr>
<td>DBS off 3 hr</td>
<td>1.00 ± 0.45</td>
<td>0.88 ± 0.99</td>
</tr>
<tr>
<td><strong>P value</strong></td>
<td><strong>0.001</strong> *</td>
<td>0.28</td>
</tr>
<tr>
<td><strong>Toe Taps</strong></td>
<td></td>
<td></td>
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<tr>
<td>DBS on</td>
<td>2.19 ± 0.57</td>
<td>1.63 ± 0.92</td>
</tr>
<tr>
<td>DBS off 3 hr</td>
<td>2.58 ± 0.49</td>
<td>2.38 ± 1.06</td>
</tr>
<tr>
<td><strong>P value</strong></td>
<td><strong>&lt;0.0001</strong> *</td>
<td><strong>0.02</strong> *</td>
</tr>
<tr>
<td><strong>Leg Lifts</strong></td>
<td></td>
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<tr>
<td>DBS on</td>
<td>1.67 ± 0.76</td>
<td>0.57 ± 0.53</td>
</tr>
<tr>
<td>DBS off 3 hr</td>
<td>2.54 ± 0.94</td>
<td>2 ± 0.58</td>
</tr>
<tr>
<td><strong>P value</strong></td>
<td><strong>&lt;0.0001</strong> *</td>
<td><strong>0.003</strong> *</td>
</tr>
</tbody>
</table>
Effect of DBS Cessation Over Time

Gait

Both Legs
Paired t-tests
- DBS On to 120 min (p=0.002)
- 120 to 180 min (p=0.53)

Average Change in Gait Impairment with Time Off DBS for Both Legs

- DBS On
- DBS Off
Effect of DBS Cessation Over Time

Gait

More Impaired Leg
Paired t-tests
- DBS On to 120 min
  (p=0.04)
- 120 to 180 min
  (p=0.25)

Average Change in Gait Impairment with Time Off DBS for the Most Impaired Leg
Effect of DBS Cessation Over Time

Toe Tapping

Both Legs
Paired t-tests
- DBS On to 15 min (p=0.016)
- 15 to 180 min (p=0.1)

Average Change in Toe Taping Impairment with Time Off DBS for Both Legs
Effect of DBS Cessation Over Time
Toe Tapping

More Impaired Leg
Paired t-tests
- DBS On to 15 min  
  \( p = 0.02 \)
- 15 to 180 min  
  \( p = 0.13 \)
Both Legs
Paired t-test
- DBS On to Off (p=0.002)
- Off to 120 min (p<0.001)
- 120 to 180 min (p=0.4)
Effect of DBS Cessation Over Time
Leg Lifts

**More Impaired Leg**

Paired t-test
- DBS On to Off (p=0.007)
- Off to 60 min (p<0.001)
- 60 to 180 min (p=0.99)
• Increase in impairment after off 3 hour with DBS off
  – Except clinician gait score
• Different movements showed very different time response.

Summary of DBS Cessation

<table>
<thead>
<tr>
<th>Time After DBS Was Turned Off In Minutes</th>
<th>Initial Significant Response</th>
<th>Ultimate Significant Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>Toe Tap</td>
<td></td>
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<tr>
<td>30</td>
<td>Leg Lift</td>
<td></td>
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<tr>
<td>60</td>
<td>Gait</td>
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<tr>
<td>120</td>
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<tr>
<td>180</td>
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Limitations

- Small sample size (study is ongoing)
- DBS cessation as a model for change in DBS settings
Role of the Kinesia Systems
Kinesia

**Tune DBS settings in the clinic**

**Independent home assessments**
• Integrate remote evaluation and DBS tuning
  – This will improve knowledge of DBS effects
  – Allow for tuning of gait parameters
Conclusions

• DBS changes over time

![Graph showing time after DBS was turned off with response levels](image)

- Initial Significant Response
- Ultimate Significant Response

• Kinesia system
  – High resolution quantitative evaluation
  – Not limited to use in the clinic
  – Integration of Kinesia and DBS tuning could improve gait outcomes
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Questions

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