Capturing mobility using wearable technology vs self-report assessments: implications for research and clinical use

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Research Question

Are wearable GPS units valid and reliable measures to study real-life mobility in a clinical population?
Background

- **Mobility:**
  “the ability to move oneself, either independently or by using assistive devices or transportation, within community environments that expand from one’s home, to the neighbourhood, and to regions beyond”¹

- **Community mobility:** a clinically important instrumental activity of daily living: capacity + performance

- ** Declines in mobility:**
  - increases risk of death and dependence²
  - increased in older adults and individuals with movement disorders (such as Parkinson’s Disease)²,³
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Image source = 1
Background

• Common community mobility measures: participant recall
  ◦ **longitudinal:**
    daily mobility diaries
  ◦ **cross-sectional:**
    Life Space Assessment (LSA)\(^4\)

No available gold standard.
Background

Current most common: motion sensors (e.g., GPS, accelerometer, gyroscopes, etc.)

- Not been used in PD to study community mobility
- Not been used for >7 days with self-report
- Not been compared against self-report to determine how well alternative assessment tools substitute each other
Research Question

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Methods: Dataset

**Primary data collection:**

CIHR Ecological Mobility in Aging and Parkinson’s (EMAP) Team Grant study.

- Data collection with 70 PD patients, Hoehn and Yahr stages I – III

- Sample size: estimated number of participants necessary to obtain power ≥ 0.80 using pilot study data (n=7 PD participants with same inclusion/exclusion criteria)
Methods: Dataset

**Primary data collection:**

Took place in the home and community of participants in Southwestern Ontario (200km radius from London) from late spring and early fall 2012 - 2014.
Methods: Community Mobility Measures

- **longitudinal:**
  - daily mobility diaries
    - (daily 14 days)

- **cross-sectional:**
  - Life Space Assessment (LSA)
    - (2 administrations, 14 days)

- **longitudinal:**
  - WIMuG PS 7
    - (daily 14 days)

VS

Sampling rate: 1Hz
## Methods: Dataset

<table>
<thead>
<tr>
<th>Assessment Pairs</th>
<th>Outcome assessed for agreement</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LSA and WIMuGPS</strong></td>
<td><strong>Size of life space</strong>&lt;br&gt;(Day 14 LSA composite score, maximum span of ellipse area [km²])</td>
</tr>
<tr>
<td><strong>Displacement Diary and WIMuGPS</strong></td>
<td><strong>Daily number of trips outside of own property</strong></td>
</tr>
<tr>
<td><strong>Displacement Diary and WIMuGPS</strong></td>
<td><strong>% of daily time sampled outside of own property</strong></td>
</tr>
</tbody>
</table>
Methods: Participants

- 54/70 met WIMuGPS sampling criteria: 6 days of 600 minutes
- Mean age: 67.8± 6.2 (55 - 79) years
- Years since diagnosis = 6.6 ± 5.8 (range = 0-30)
- Self perceived impact of disease = low to moderate
  = PDQ-39 score of1.8-64.7 (mean = 19.1 ± 13.7)
- Spread across different residence settings, incomes and education strata
- Most were: men (38; 70.4%), retired (46; 85.2%)
Hypotheses

1. Wearable GPS units and self-report measures are valid alternatives for community mobility outcomes ($r > 0.5$).

2. Wearable GPS units and diaries cannot consistently agree on real-life community mobility outcomes in the PD population ($\text{ICC} = 0.4 - 0.50 = \text{fair}^9$).
Results: Validity

Hypothesis 1: Wearable GPS units and self-report measures are valid alternatives for community mobility outcomes ($r > 0.5$).

<table>
<thead>
<tr>
<th>Assessments</th>
<th>WIMuGPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>% of daily time sampled outside</td>
<td>$r_s = 0.693$, $p&lt;0.0001$</td>
</tr>
<tr>
<td>Daily # of trips outside</td>
<td>$r_s = 0.452$, $p = 0.0006$</td>
</tr>
<tr>
<td>Life space size</td>
<td>$r_s = 0.393$, $p=0.0033$</td>
</tr>
</tbody>
</table>

$r_s =$ spearman correlation coefficients, $N = 54$, $p \leq 0.05$

Valid alternatives only for: time and trips outside.
Results: Validity

Hypothesis 1: Wearable GPS units and self-report measures are valid alternatives for community mobility outcomes ($r > 0.5$).

Relationship between size of life space measured by WIMuGPS and the Life Space Assessment

\[ r_s = 0.393, \ p = 0.0033 \]

<table>
<thead>
<tr>
<th>Community Mobility Outcome</th>
<th>Mean ± Standard deviation (range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Life space size (WIMuGPS) maximum span of ellipse area (km²)</td>
<td>4048.8 ± 6432.3 (8.2 - 29448.6)</td>
</tr>
<tr>
<td>Life space size (Life Space Assessment Score) Maximum = 120</td>
<td>84.8 ± 16.3 (48-120)</td>
</tr>
</tbody>
</table>
Results: Reliability and Agreement

Hypothesis 2: Wearable GPS units and diary cannot consistently agree on real-life community mobility outcomes in the PD population (ICC = 0.4 - 0.50 = fair\(^9\)).

<table>
<thead>
<tr>
<th>Agreement between WIMuGPS and Diary</th>
<th>% of daily time sampled outside</th>
<th>Daily # of trips outside</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICC = 0.674</td>
<td>95% CI of 0.420 – 0.815, p&lt;0.00001</td>
<td>ICC = 0.599</td>
</tr>
<tr>
<td>95% CI of 0.148 – 0.795, p=0.000017</td>
<td></td>
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</tbody>
</table>

Good, but imperfect, agreement on: time and trips outside.
Results: Reliability and Agreement

Differences in % of daily time sampled outside, according to assessment type (n=54)

Greater time outside reported by WIMuGPS.

<table>
<thead>
<tr>
<th>WIMuGPS &gt; Diary</th>
<th>43 (79.63%) participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>WIMuGPS &lt; Diary</td>
<td>11 (20.37%) participants</td>
</tr>
<tr>
<td>WIMuGPS = Diary</td>
<td>0</td>
</tr>
</tbody>
</table>

Test of differences (Wilcoxon signed rank):
\[ W < W_{\alpha=0.05,53} = 500.5, \ p < 0.0001 \]

25.0% ± 11.6% (6.2% - 60.8%)  20.3% ± 12.2% (0.2% - 57.4%)
Results: Reliability and Agreement

Differences in daily # of trips outside, according to assessment type (n=54)

Greater trips outside reported by diary.

<table>
<thead>
<tr>
<th></th>
<th>Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>WIMuGPS &gt; Diary</td>
<td>8 (14.8%)</td>
</tr>
<tr>
<td>WIMuGPS &lt; Diary</td>
<td>44 (81.5%)</td>
</tr>
<tr>
<td>WIMuGPS = Diary</td>
<td>2 (3.7%)</td>
</tr>
</tbody>
</table>

Test of differences (Wilcoxon signed rank): $W<_{W_{\alpha=0.05,53}}=-512$, $p<0.0001$

1.5 ± 0.7 (0.43 – 3.7)  
2.2 ± 1.1 (0.6 – 6.4)
Discussions

• The Life Space Assessment has previously unreported floor effect. WIMuGPS may be better estimator of life space size.

• WIMuGPS is a valid and reliable alternative for daily diaries when recording time or trips outside.

• Among older adults with Parkinson’s disease, WIMuGPS recorded greater amounts of daily time outside but fewer trips outside than diary.

Contrary to existing literature on general populations show diaries to over-report duration of outside time \(^9\) and underreport number of trips \(^{10}\).

• Next steps:
  1. Covariate analysis on validity and different types of agreement.
  2. Days of the week analysis.
Conclusions

• This study is one of the first to validate the use of wearable GPS sensors in an older adult and clinical population.
• The WIMuGPS sensor is more discriminative than the LSA to capture size of life space.
• Wearable GPS is a good way to assess real-life mobility.
• The researcher/clinician need to establish cut points for “good” time and trips outside.
• Every sensor model is different, need to treat wearable sensors as all measurement tool, and test its validity and reliability before applying to research and clinical use.
References


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Thank you for your attention! Questions?

Ecological Mobility in Aging and Parkinson’s (EMAP) – CIHR Research team in mobility and aging

http://mobilityinaging.com

(new website this month)

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