Evaluation of the Performance of a Previous Day Recall and the ActiGraph Monitor for Measures of Active and Sedentary Time

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## Acknowledgements

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Limitations of Questionnaires to Estimate Usual Physical Activity (PA) and Sedentary Behavior

• Success in etiologic studies, but measurement errors are large \( (r \sim 0.3 \text{ to } 0.5) \)

• Cognitive demands associated with reporting long-term averages are extraordinary

• Scope of questionnaires often limited (e.g., only leisure-time, television, or MVPA)

• Systematic reporting errors typically assumed (i.e., social desirability)

• Assessment of sedentary behavior in its infancy
Study Objectives

• Evaluate the validity of an interview administered Previous-day Recall (PDR) of time spent in physically active and sedentary behaviors in free-living adolescents and adults (vs. activPAL)

• To provide insight into PDR measurement properties in comparison to an established instrument, we also examined the validity of the ActiGraph monitor in a parallel analysis (also vs. activPAL)
Measurement error model

\[ Y_{ij} = \beta_0 + \beta_1 T_{ij} + r_i + \epsilon_{ij} \]

- PDR or ActiGraph
- Reference measure (activPAL)

Overall intercept
Slope term (Y vs. activPAL)
Person-specific bias
Random error

- Reference measure assumed to be unbiased
- Mixed models fit by lmer from lme4 package in R to estimate variances for model parameters
- Correlations (R) between measures calculated
activPAL vs. Direct Observation

- 27 participants
- 47 observation periods (focal sampling, PDA)
- Avg 3.8 hrs/period (1.8 to 6.6 hrs)
Study Design

Adolescents (12-17 yr) and adults (18-71 yr) enrolled in study to develop sedentary behavior questionnaire (N=213)

Study sites: Nashville, TN and Amherst, MA

Seven-day study period

• 3 Previous-day Recalls (2 week-, 1 weekend day)
• activPAL and ActiGraph, 7 days, during waking hours
• Wear time estimated via log and algorithm of Choi et al. MSSE 2011

Matched observations (date and observation time)

• PDR vs. activPAL: n=179 participants
  – 619 (PDR days), 448 (date-match), 345 (± 2 hrs of observation)
• ActiGraph vs. activPAL: N=185 participants
  – 1,200 (valid days), 1,029 (date-match), 915 (± 2 hrs observation)
Previous-day Recall (PDR) Methods

Interviewers elicited open-ended reports of specific behaviors from the previous day (midnight-midnight) by phone

**Key elements of the recall process**

- Segments of the day (morning, afternoon, evening)
- Individual behaviors reported (largely) in chronological order
- Contextual information about each behavior
  - **Location** (home, community, work/school)
  - **Activity type** (active or sedentary)
  - **Purpose** of behavior (e.g., leisure, work, school, transport)
- Time cues available to interviewers (over/under time)
- Review information at end of each segment
ActiGraph Methods

- ActiGraph GT3X
- Secured to right hip by elastic belt
- Recorded vertical acceleration in one-second epochs
- Low-frequency extension selected

- **Sedentary time** (hrs/d < 100 cpm)
- **Active time** (hrs/d 100+ cpm)
**Definition of Target Behaviors**

**Sedentary behaviors** - Seated/reclining behaviors that require only low levels of energy expenditure (eg, < ~1.8 METS)

**Active behaviors** - Upright (standing) behaviors, or any behavior that results in higher levels of energy expenditure (eg, 1.8+ METS).

Owen, Sparling, Healy, Dunstan, Matthews Mayo Clin Proc. 2010

<table>
<thead>
<tr>
<th></th>
<th><strong>Active</strong></th>
<th><strong>Sedentary</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>activPAL</td>
<td>Stand, step</td>
<td>Lie, sit, recline</td>
</tr>
<tr>
<td>Previous-day Recall</td>
<td>Upright or ~1.8+ METS</td>
<td>Lie, sit recline</td>
</tr>
<tr>
<td>ActiGraph</td>
<td>100+ cpm</td>
<td>&lt; 100 cpm</td>
</tr>
</tbody>
</table>
## Participant Characteristics

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Adolescents</th>
<th>Adults</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yrs)</td>
<td>14.3</td>
<td>41.3</td>
</tr>
<tr>
<td>Female (%)</td>
<td>49.1</td>
<td>53.7</td>
</tr>
<tr>
<td>Caucasian (%)</td>
<td>61.3</td>
<td>74.7</td>
</tr>
<tr>
<td>Education (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6-8\textsuperscript{th} grade</td>
<td>53.1</td>
<td>--</td>
</tr>
<tr>
<td>College degree</td>
<td>--</td>
<td>63.7</td>
</tr>
<tr>
<td>In school (%)</td>
<td>59.4</td>
<td>--</td>
</tr>
<tr>
<td>Working (%)</td>
<td>20.8</td>
<td>83.0</td>
</tr>
<tr>
<td>Body mass index (kg/m\textsuperscript{2})</td>
<td>22.0</td>
<td>26.9</td>
</tr>
</tbody>
</table>
Slope term ($\beta_1$) and correlation ($R$) for Previous-day Recall (vs. activPAL)

### Sedentary

<table>
<thead>
<tr>
<th></th>
<th>Men</th>
<th>Women</th>
<th>Boys</th>
<th>Girls</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\beta_1$</td>
<td>1.13</td>
<td>1.05</td>
<td>0.96</td>
<td>0.80</td>
</tr>
<tr>
<td>$R$</td>
<td>0.81</td>
<td>0.81</td>
<td>0.80</td>
<td>0.60</td>
</tr>
</tbody>
</table>

### Active

<table>
<thead>
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<th>Girls</th>
</tr>
</thead>
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<tr>
<td>$\beta_1$</td>
<td>0.97</td>
<td>1.09</td>
<td>0.77</td>
<td>0.75</td>
</tr>
<tr>
<td>$R$</td>
<td>0.88</td>
<td>0.80</td>
<td>0.64</td>
<td>0.52</td>
</tr>
</tbody>
</table>
Variance estimates for Person-specific bias ($\sigma^2_r$) and random error ($\sigma^2_\varepsilon$) terms for the Previous-day Recall (vs. activPAL)

Sedentary

- Men (n=40): Person-specific bias = 0.58, Random error = 0.70
- Women (n=48): Person-specific bias = 1.24, Random error = 0.27
- Boys (n=43): Person-specific bias = 3.43, Random error = 1.89
- Girls (n=48): Person-specific bias = 3.51, Random error = 2.67

Active

- Men (n=40): Person-specific bias = 0.78, Random error = 0.91
- Women (n=48): Person-specific bias = 0.44, Random error = 0.21
- Boys (n=43): Person-specific bias = 2.79, Random error = 2.02
- Girls (n=48): Person-specific bias = 2.82, Random error = 2.10
Slope term ($\beta_1$) and correlation ($R$) for ActiGraph (vs. activPAL)

### Sedentary

<table>
<thead>
<tr>
<th></th>
<th>Men (n=40)</th>
<th>Women (n=44)</th>
<th>Boys (n=51)</th>
<th>Girls (n=50)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\beta_1$</td>
<td>0.73</td>
<td>0.69</td>
<td>0.67</td>
<td>0.70</td>
</tr>
<tr>
<td>$R$</td>
<td>0.63</td>
<td>0.75</td>
<td>0.68</td>
<td>0.70</td>
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### Active

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<th>Girls (n=50)</th>
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<tbody>
<tr>
<td>$\beta_1$</td>
<td>0.65</td>
<td>0.72</td>
<td>0.68</td>
<td>0.74</td>
</tr>
<tr>
<td>$R$</td>
<td>0.61</td>
<td>0.79</td>
<td>0.57</td>
<td>0.67</td>
</tr>
</tbody>
</table>
Variance estimates for Person-specific bias ($\sigma^2_r$) and random error ($\sigma^2_\varepsilon$) terms for the ActiGraph (vs. activPAL)

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<th>Active</th>
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<td>Men (n=40)</td>
<td>Women (n=44)</td>
<td>Boys (n=51)</td>
<td>Girls (n=50)</td>
</tr>
<tr>
<td>Person-specific bias ($\sigma^2_r$)</td>
<td>1.41</td>
<td>1.27</td>
<td>1.29</td>
<td>1.35</td>
</tr>
<tr>
<td>Random error ($\sigma^2_\varepsilon$)</td>
<td>0.83</td>
<td>0.76</td>
<td>0.61</td>
<td>0.65</td>
</tr>
<tr>
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<td>Men (n=40)</td>
<td>Women (n=44)</td>
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<td>0.82</td>
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<tr>
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<td>0.70</td>
<td></td>
<td>0.55</td>
<td></td>
</tr>
</tbody>
</table>
Conclusions

• Correlations between the PDR and activPAL were high
• Systematic reporting errors on the PDR were lower than random errors
• PDR performance was comparable to the ActiGraph
• PDRs may have value in studies of physical activity and health
Strengths and Limitations

**Strengths**
- Large sample, wide age-range
- Valid reference measure
- Behavioral constructs/definitions very similar for both the PDR and the reference measure (measuring the same thing?)

**Limitations**
- Convenience sample
- Absence of accurate/precise reference measure for light and moderate-vigorous activity
Thanks!
Direct Observation System

- Focal Sampling and Duration Coding

**Location**

**Function**

**Body position**
- lying
- sitting
- standing still
- standing still with upper body movement
- standing/moving
- moving-moderate (> 3 METS)
- moving-vigorous (> 6 METS)

Sedentary time (lying, sitting)

Active time (lying, sitting)

Courtesy of Sarah Kozey Keadle; Patty Freedson
Sedentary behaviors

Random error

Person-specific bias

Previous-day Recall (hrs/d)

activPAL (hrs/d)
Options for improving measures of activity-related behaviors and obtaining better estimates of behavior-disease associations

Current status: Large measurement errors and high levels of attenuation

Option 1. Use measurement error correction methods to minimize the impact of reporting errors

Option 2: Eliminate reporting errors: use objective indicators of behavior (e.g., accelerometers)

Option 3. Use short-term recalls to reduce the amount of reporting error in active and sedentary behaviors

Matthews et al. ESSR (in press) 2012
What kinds of studies do our measures need to serve?

**Association studies** (etiology of active and sedentary behaviors and disease outcomes, determinants studies)
- Long-term average, or usual level of behavior
- Specificity: targeted behaviors & contexts

**Interventions** (assess changes in sedentary time in response to intervention messages)
- Specificity (targeted behaviors) / responsiveness

**Surveillance** (estimate population average, or prevalence during specific period of time).
- Specificity (behaviors tracked by PHS)
## Approaches to Self-Reported Physical Activity

<table>
<thead>
<tr>
<th>Category</th>
<th>Level of Detail</th>
<th>Timeframe</th>
<th>Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diaries</td>
<td><strong>High</strong> (all activities)</td>
<td>Real time</td>
<td>Validation</td>
</tr>
<tr>
<td>Logs</td>
<td><strong>High</strong> (specific activities)</td>
<td>Real time, past day</td>
<td>Intervention adherence</td>
</tr>
<tr>
<td>Recalls</td>
<td><strong>Medium</strong> (selected activities)</td>
<td>Past 1 to 7 days</td>
<td>Changes, current activity</td>
</tr>
<tr>
<td>Questionnaires</td>
<td><strong>Medium</strong> (selected activities)</td>
<td>Past year, usual</td>
<td>Usual activity</td>
</tr>
<tr>
<td>Global surveys</td>
<td><strong>Low</strong> (broad categorization)</td>
<td>Current, unspecified</td>
<td>Ranking usual activity</td>
</tr>
</tbody>
</table>

Adapted from Sternfeld JPAH 9:S19, 2012

National Cancer Institute
Impact of measurement error

Attenuation and loss of statistical power

Type II errors (false negatives)

Dose-repose relations less precise

Inconsistency, weaker evidence for association/mechanisms
Physical Activity Questionnaires for Adults
A Systematic Review of Measurement Properties

85 Questionnaires (versions) reviewed

Reliability/validity studies generally poor quality

7 Questionnaire vs. Doubly Labeled Water (TEE, \( r = 0.31 \) to 0.58)

41 Questionnaire vs. Accelerometer studies
• Only 1 of 41 studies \( r > 0.5 \)
• Vigorous (\( r_{\text{avg}} = 0.32 \)) better than moderate (\( r_{\text{avg}} = 0.22 \))
• Last week (\( r_{\text{avg}} = 0.41 \)), Usual (\( r_{\text{avg}} = 0.26 \)), Last year (\( r_{\text{avg}} = 0.30 \))