Participation Metrics for Accelerometer-Based Research

Christopher Antoun
Alexander Wenz

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Motivation

- Accelerometers used by researchers to measure physical activity
  - Common devices: Fitbit, AppleWatch, GENEActiv
- Non-participation is a key challenge
- Occurs at two hierarchical levels:
  - Sample members: missing because they do not participate
  - Measurements: missing due to non-wear (among participants)
- Unlike with surveys, no standards exist for computing participation rates
- Efforts to examine the level of non-participation bias are rare
Our aims

• Conceptual aim
  • Propose definitions and formulas for calculating participation rates in accelerometer-based studies
  • Propose methods for assessing non-participation bias

• Empirical aim
  • Illustrate these concepts using data from National Health and Nutrition Examination Survey (NHANES) 2011-2012 and 2013-2014
Basic steps in accelerometer-based studies

1. Implement screening
2. Invite eligible individuals to participate in study
3. Provide accelerometer devices
4. Collect devices
5. Extract and process data
   5a. Measurements aggregated into periods (e.g., 1 minute, 5 minutes)
   5b. Classification of wear vs non-wear periods using statistical algorithm
Sample members
Complication (1 of 2)

• Sample members that do not participate in screening step
  • Eligibility is unknown
  • Unclear whether they should be included in denominator of participation rate

• Addressing this issue: as in surveys, estimate proportion that are eligible using information from other cases
  • Or present two participation rates: one including all cases of unknown eligibility in the denominator and one excluding these cases
Complication (2 of 2)

• Individuals do not wear devices for the full study period
  • Unclear what amount of wear-time is sufficient to be deemed a participant

• Addressing this issue: develop a priori definition of what constitutes “sufficient” wear-time in a particular study
  • For example: ≥72 of 168 hours; ≥5 of 7 days with at least 10 hrs/day
  • Participant inclusion criteria vary across studies
Participation rate

- Proportion of eligible cases who provided sufficient data

\[
\frac{S}{S + IN + T + D + R + e(U)}
\]

where

- \( S \) = Sufficient (inferred) wear-time
- \( IN \) = Insufficient (inferred) wear-time on returned device
- \( T \) = Technical problem extracting or processing data on returned device
- \( D \) = Device never returned
- \( R \) = Refusal/Non-consent
- \( U \) = Unknown eligibility (no screener completed)
- \( e \) = Estimated eligibility rate
Assessing non-participation bias

• Compare characteristics of participants and non-participants
  • If sample is recruited from respondents to a previous survey, can use self-report information for both groups
  • Self reports of physical activity capture information directly about the behavior of interest
Illustration: NHANES 2011-2012 and 2013-2014

• Cross-sectional study of U.S. general population
  • Participants first interviewed in homes, subsequently examined in Mobile Examination Center (MEC), then given accelerometer

• Data source: Actigraph GT3X+ (waterproof) accelerometer
  • 80 Hz raw data aggregated to 1-minute measurement periods
  • Ages 3 yrs + (6+ for 2011)

• Protocol:
  • 24-hour wear requested over 7 complete days
  • Return device by mail ($40 incentive paid upon receipt)
# Participation rates

<table>
<thead>
<tr>
<th>Step</th>
<th>2011 NHANES</th>
<th>2013 NHANES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>Rate</td>
</tr>
<tr>
<td>Study Sample(^a)</td>
<td>7,821</td>
<td></td>
</tr>
<tr>
<td>Returned Device (w/ readable data)</td>
<td>6,917</td>
<td></td>
</tr>
<tr>
<td>Adherent Participants(^b)</td>
<td>6,467</td>
<td>83%</td>
</tr>
<tr>
<td>Participation rate</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(^a\) Responded to household interview; examined in Medical Examination Center; eligible for accelerometer study

\(^b\) Algorithm-estimated wear time of at least 10+ hours on 4+ days of the 7-day study period.
Assessment of non-participation bias

<table>
<thead>
<tr>
<th>Step</th>
<th>2011 NHANES</th>
<th>2013 NHANES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>Average Weekly PA (METs)</td>
</tr>
<tr>
<td>Study Sample - BENCHMARK</td>
<td>6,549</td>
<td>3,097</td>
</tr>
<tr>
<td>Adherent Participants</td>
<td>5,385</td>
<td>3,060</td>
</tr>
<tr>
<td><strong>Overall Discrepancy</strong></td>
<td></td>
<td><strong>-37 (-1%)</strong></td>
</tr>
</tbody>
</table>

Analysis restricted to participants aged 12+
MET: Unit of energy expenditure. Computed using NHANES responses as follows:
METs = (Mins Moderate PA x 4.0) + (Mins of Vigorous PA x 8.0)
Measurements
Within-participant missing data

- Among those deemed to be participants, there may be missing measurements (due to non-wear or technical problems)
- Wear rate: proportion of wear periods of all measurement periods among participants

\[
\frac{W}{W + NW + NC}
\]

where

\(W\) = wear periods
\(NW\) = non-wear periods
\(NC\) = non-classifiable periods

Hereafter labeled as “non-wear” for simplicity
Assessing non-wear bias

• In practice, no information is available about physical activity during non-wear periods

• Addressing this issue:
  • Replace these periods with the average of wear periods from other participants at the same time of day.
  • Then compare characteristics of wear and non-wear periods.
Non-wear rates

<table>
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<tr>
<th>Step</th>
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<th>2013 NHANES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>Rate</td>
</tr>
<tr>
<td>Total Periods</td>
<td>10,080</td>
<td></td>
</tr>
<tr>
<td>Classifiable Periods&lt;sup&gt;a&lt;/sup&gt;</td>
<td>9,638</td>
<td></td>
</tr>
<tr>
<td>Wear Periods</td>
<td>9,119</td>
<td></td>
</tr>
<tr>
<td><strong>Wear Rate</strong></td>
<td>91%</td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup> Classifiable into wear vs. non-wear categories, as reflected by algorithm-assigned “confidence value”.

Future step is to assess non-wear bias: Compute $\bar{y}$ by replacing non-wear periods with average of wear periods at the same time of day, and compare it to $\bar{y}_w$. 
Discussion and Conclusion

• Estimates in accelerometer-based studies are based on data that exclude: (level 1) non-participants and (level 2) non-wear periods among participants

• To compute participation rates, we divided cases into high-levels groups -> more fine-grained categories can be used

• Our indicators of non-participation bias have limitations
  • Self-report data from different reference period; contains some amount of measurement error
  • Actual values of non-wear periods are generally unknowable

• Potential next step is to extend to other data sets
Thank You!

Chris Antoun
University of Maryland
JPSM and iSchool
antoun@umd.edu

Alex Wenz
University of Mannheim
School of Social Sciences
a.wenz@uni-mannheim.de