Participation Metrics for Accelerometer-Based Research

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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 <u>two hierarchical levels:</u>
  - 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 <u>self-report information</u> for both groups
    - Self reports of <u>physical activity</u> 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

Step	2011 NHANES		2013 NHANES	
	N	**Rate**	**N**	**Rate**
Study Sample[a]	7,821		8,913	
Returned Device (w/ readable data)	6,917		7,776	
Adherent Participants[b]	6,467		7,114	
Participation rate		**83%**		**80%**

[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

Step	2011 NHANES		2013 NHANES	
	N	**Average Weekly PA (METs)**	**N**	**Average Weekly PA (METs)**
Study Sample - *BENCHMARK*	6,549	**3,097**	6,979	**3,156**
Adherent Participants	5,385	**3,060**	5,597	**3,103**
Overall Discrepancy		**-37 (-1%)**		**-53 (-2%)**

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

Step	2011 NHANES		2013 NHANES	
	N	Rate	N	Rate
Total Periods	10,080		10,080	
Classifiable Periods^a	9,638		9,665	
Wear Periods	9,119		9,071	
Wear Rate		**91%**		**90%**

[b] 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!

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