

# **My First Exposure to Accelerometer Data was for 100000 People from UK Biobank**

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presentation: [http://johnmuschelli.com/ENAR\\_2019](http://johnmuschelli.com/ENAR_2019)

# Disclaimer (Acknowledgements?)

Work done with  
[Andrew Leroux](#)

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PhD Student at Johns  
Hopkins



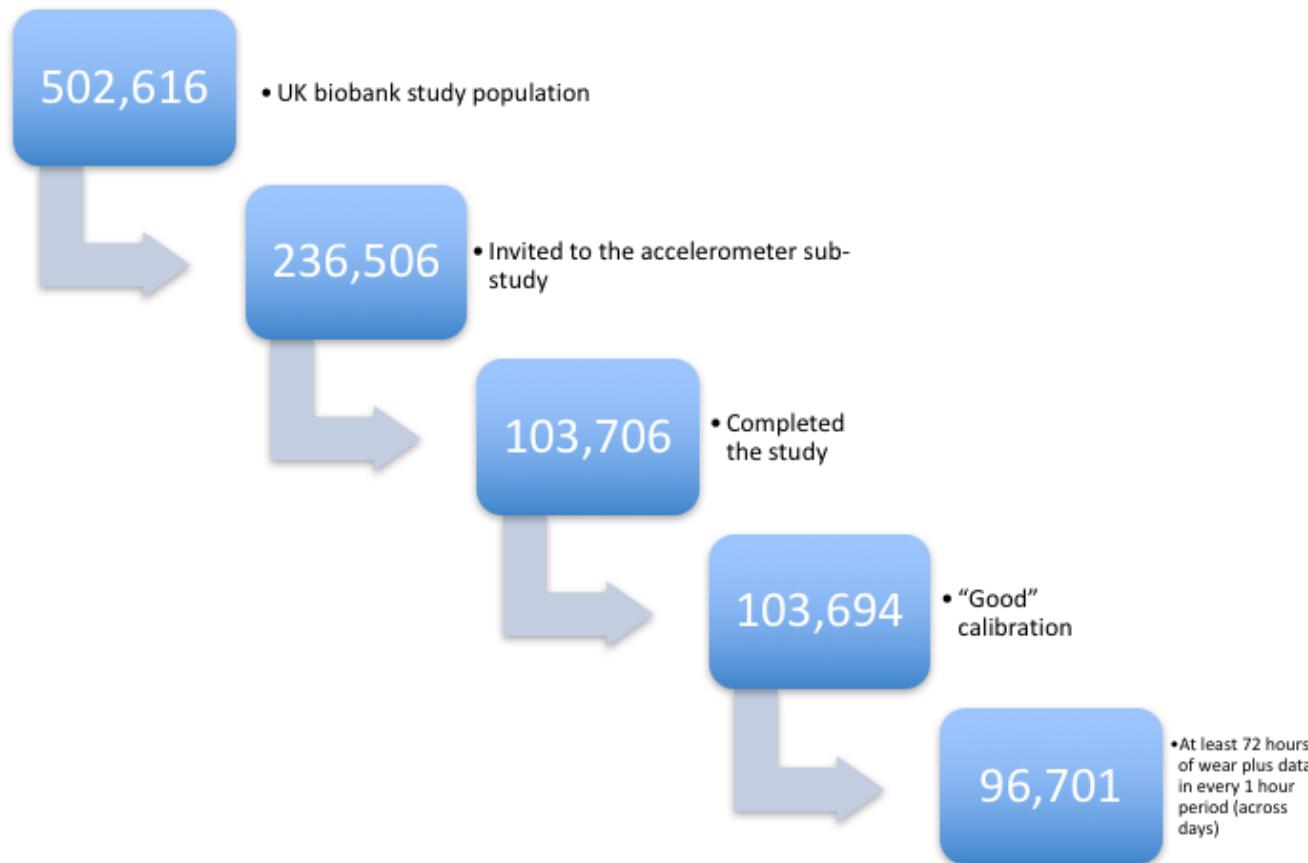
# UK Biobank Data

- Overall 500,000 participants (UK),  $\approx$  100,000 included in the sub-study

In this presentation:

- Explore the data
- Assess “bias” in different devices (see if “autocalibration” is working)
- Also discuss inclusion criteria “bias”
- Get similar findings (Doherty et al. 2017) analysis

# Where do 100K come from?



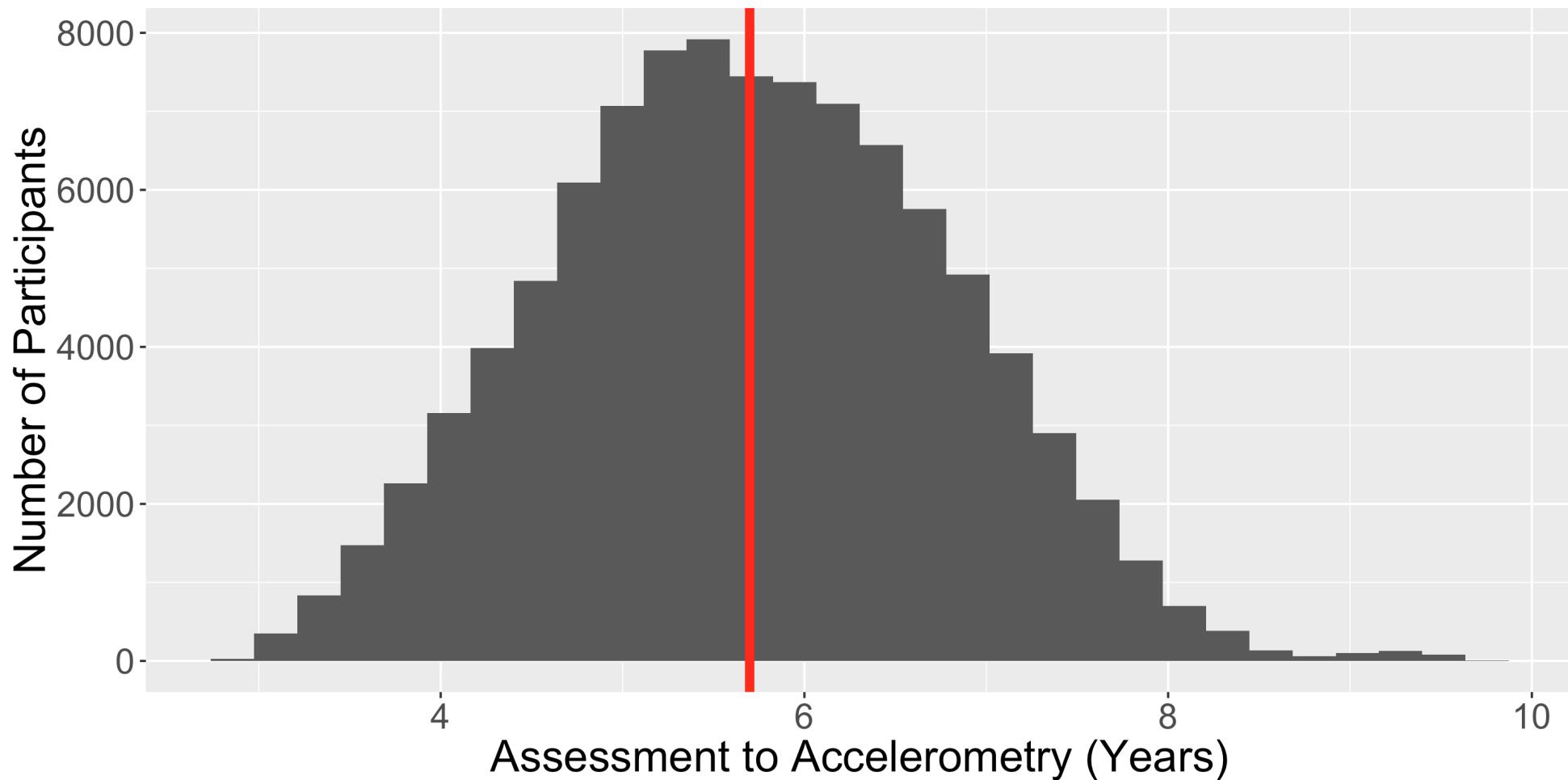
# Demographics: Lots of Non-Response

	Completed: good data	Completed: bad data	No response	Not asked
n	96701	7005	132800	266110
Age at Initial Visit (mean (sd))	56.6 (7.8)	55.2 (7.9)	56.4 (8.0)	57.5 (8.1)
Male (% Male)	42255 (43.7)	3156 (45.1)	62601 (47.1)	121151 (45.5)
Ethnicity (% Non-White)	2983 (3.1)	335 (4.8)	7617 (5.8)	16102 (6.1)

Many people DIED before being able to be asked

> 50% no response

# Assessment to Accelerometry can be a WHILE



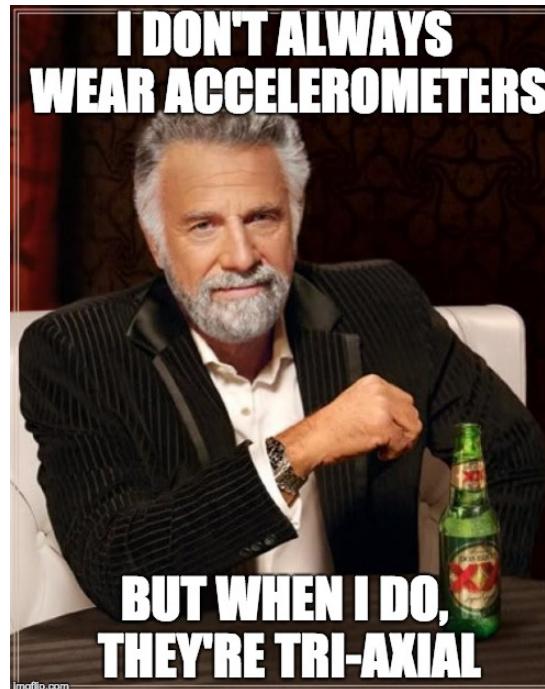
# Responders are Healthier (Self-Reported)

Overall health (%)	Completed: good data	Completed: bad data	No response	Not asked
Excellent	20987 (21.8)	1464 (21.0)	21583 (16.3)	37849 (14.4)
Good	57849 (60.0)	4057 (58.1)	78968 (59.7)	148196 (56.2)
Fair	15149 (15.7)	1261 (18.0)	26669 (20.2)	62313 (23.6)
Poor	2482 (2.6)	205 (2.9)	4969 (3.8)	15124 (5.7)

# Lesson #1: The devil is in the inclusion criteria (or can be)

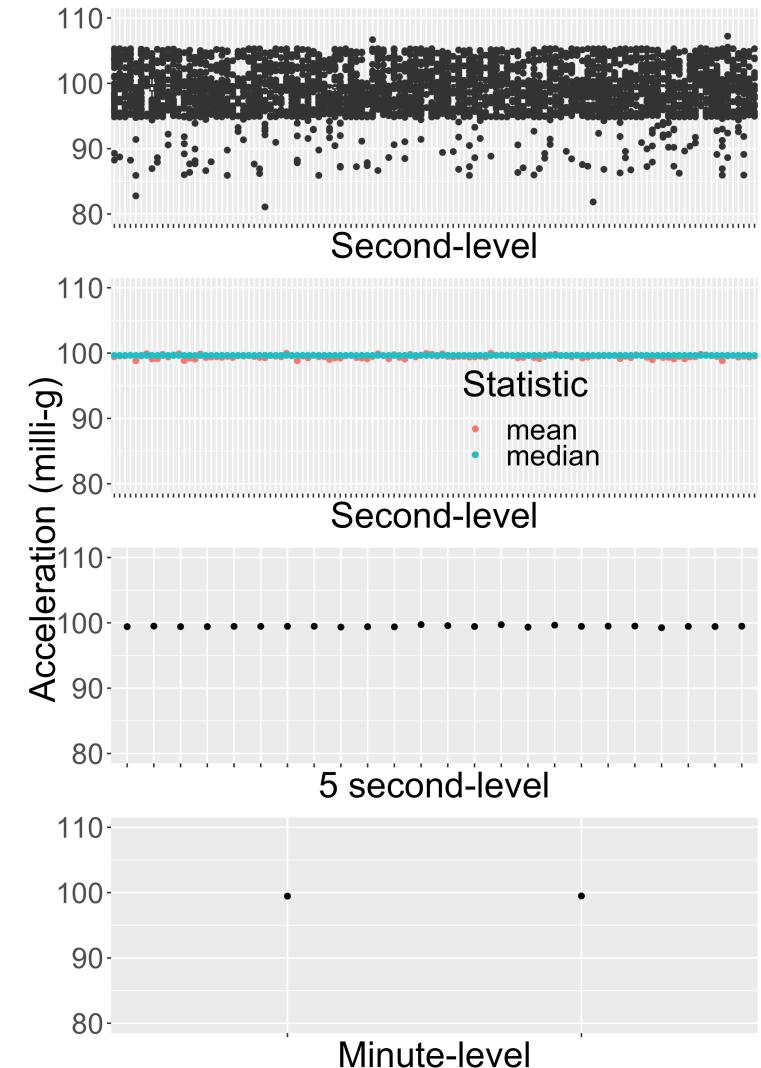
# Data Gathered

- Tri-axial Axtivity 100Hz over 7 days
- Started at 10AM and ended at 10PM (spoiler: will be important)
- Data measured in milli-g ( $1g = 9.80665 \text{ ms}^2$ )
  - not counts or steps as other devices



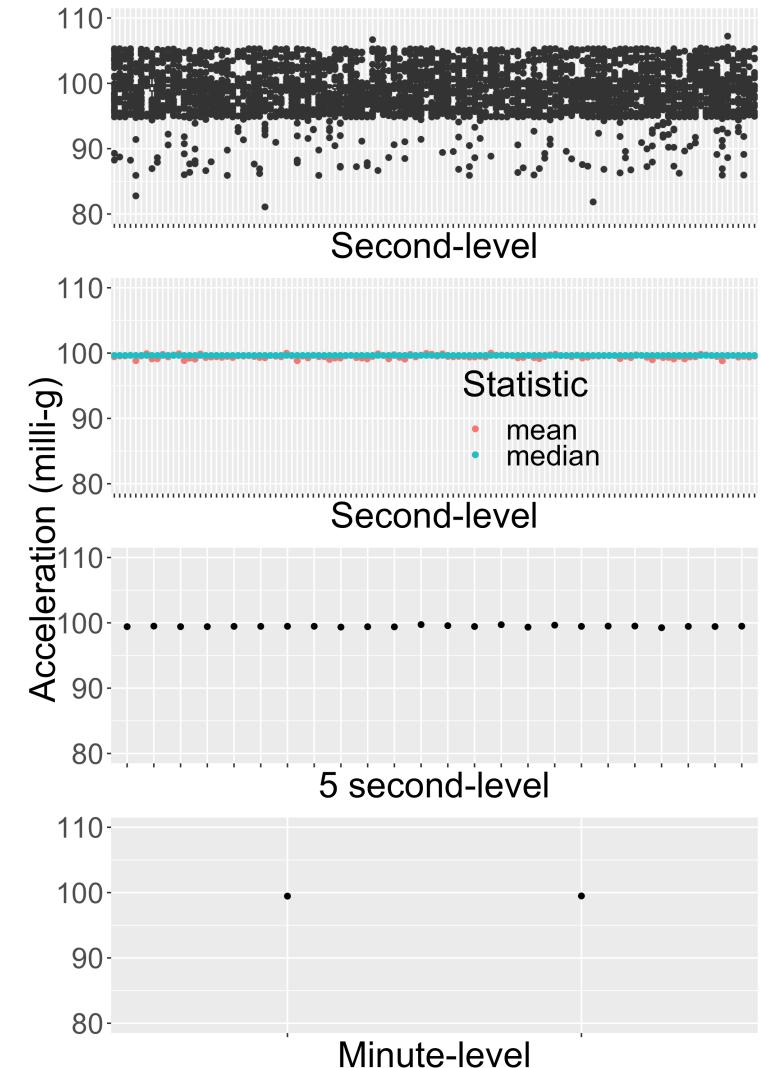
# Accelerometry Data Available

- Data at varying levels
  - Axtivity CWA format (Highest resolution, 100Hz) (200Mb per user)
    - very large for 100K subjects (20Tb)
- 5 second level data
  - UKBB imputation/processing done
  - averaged into 1440 minute-level data
- Overall statistics (mean/median): overall, daily, hourly, day of week
  - removed “non-wear” periods



# Accelerometry Data Available

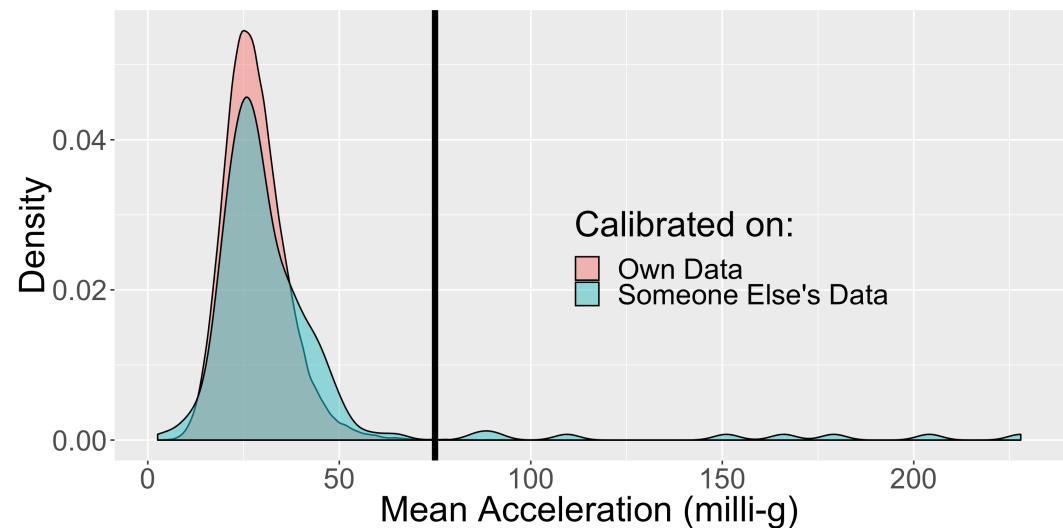
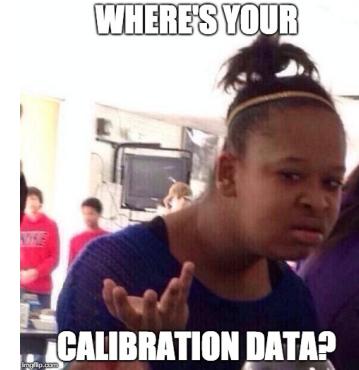
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# UKBB Processing: Auto-calibration

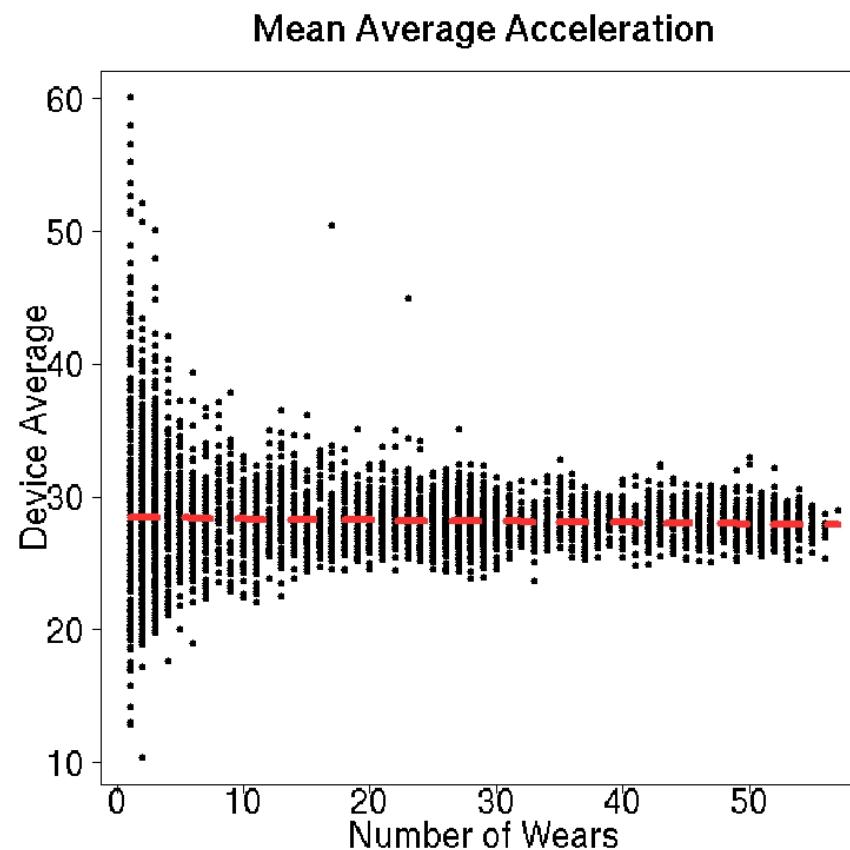
(Hees et al. 2014)

1. Use 10s window all axes  
SD < 13.0 mg.
2. Fit a unit gravity sphere  
using OLS.
3. If 3 axes had values  
outside a  $\pm 300$ mg range  
- use calibration  
coefficient
4. If not, use **next person's**  
calibration coefficient  
from the same device



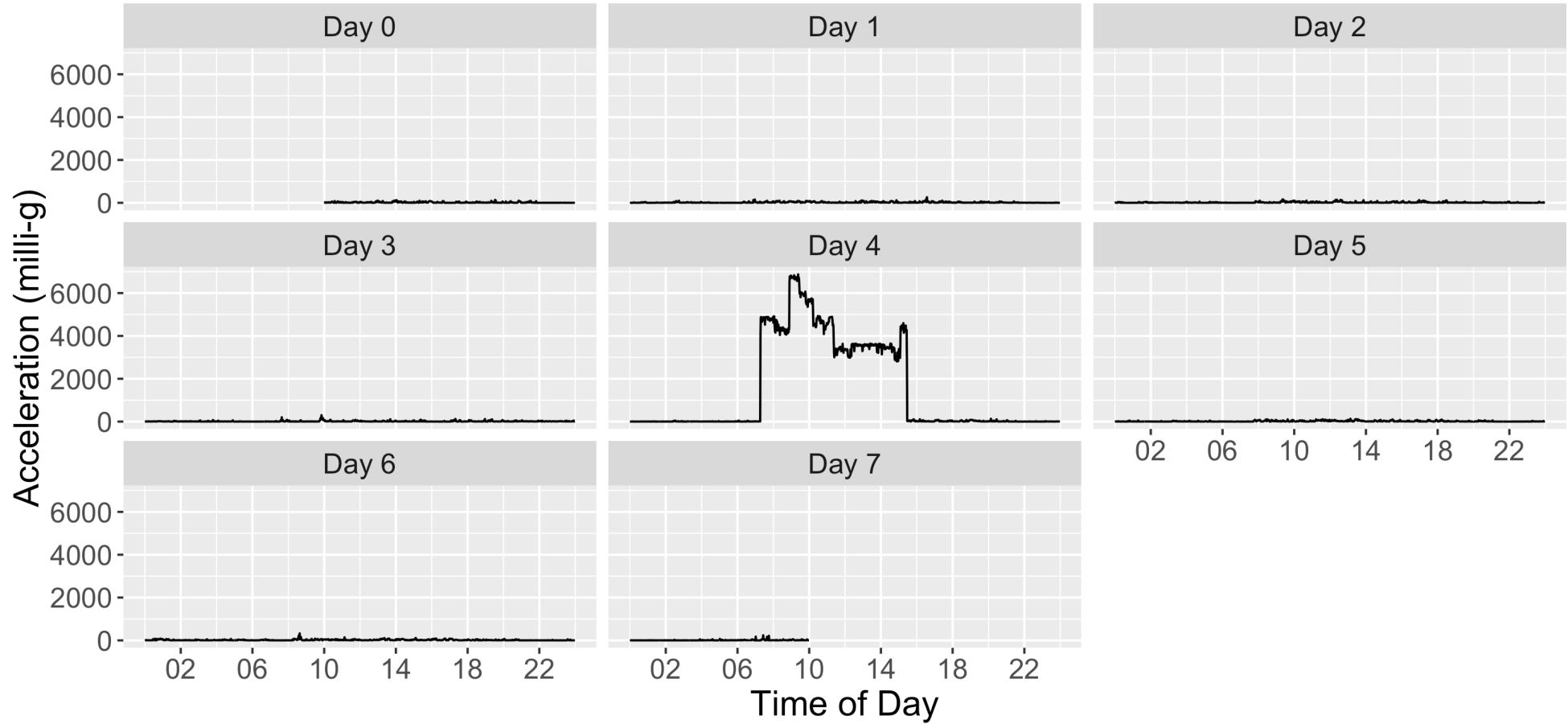
# Auto-calibration seems to “work”

- Within-person average, within-device average (one point per device)
- Plotted against # of wears per device ( $\hat{\sigma}$  should decrease with  $\sqrt{n_{\text{wear}}}$ )



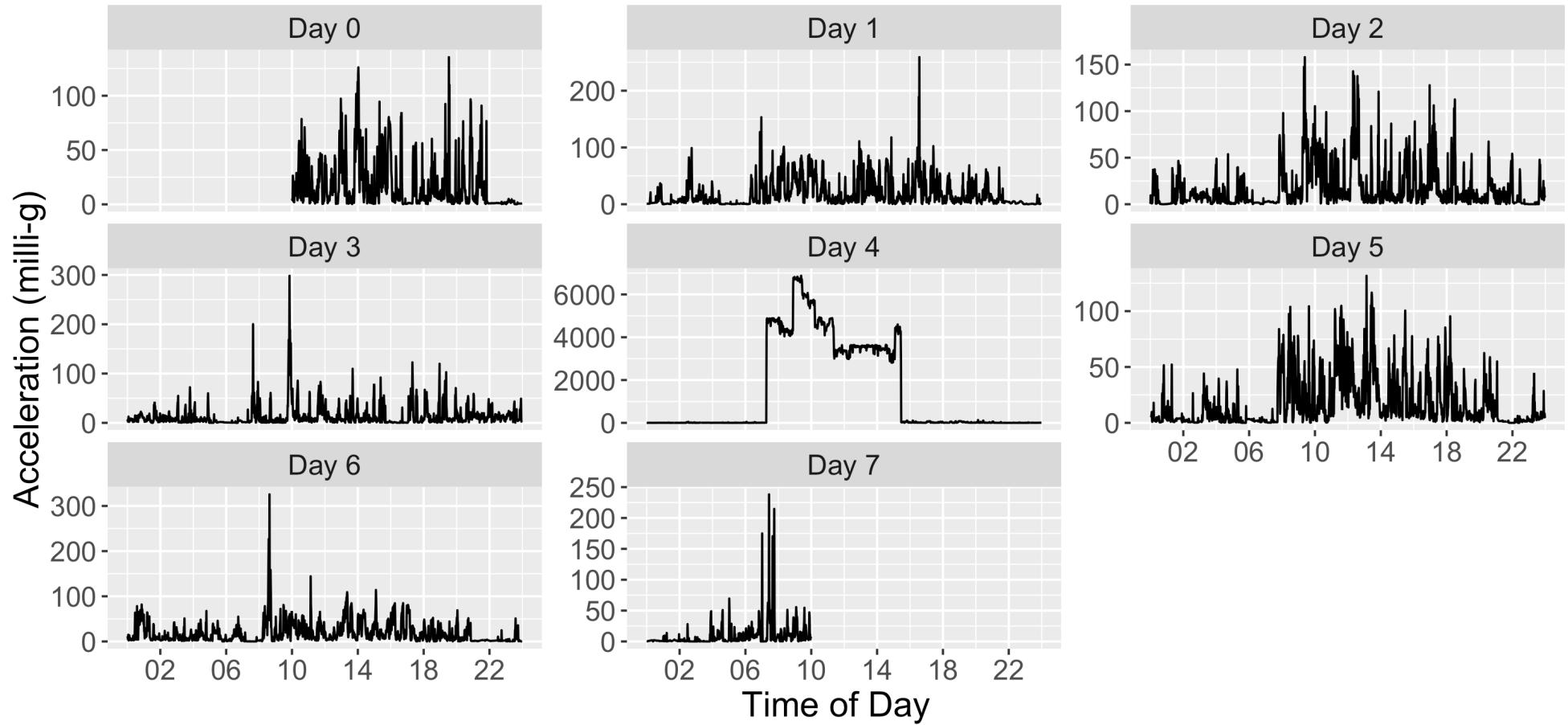
# Doesn't work for all cases

Participant 2586235 Calibrated on Someone Else's Data



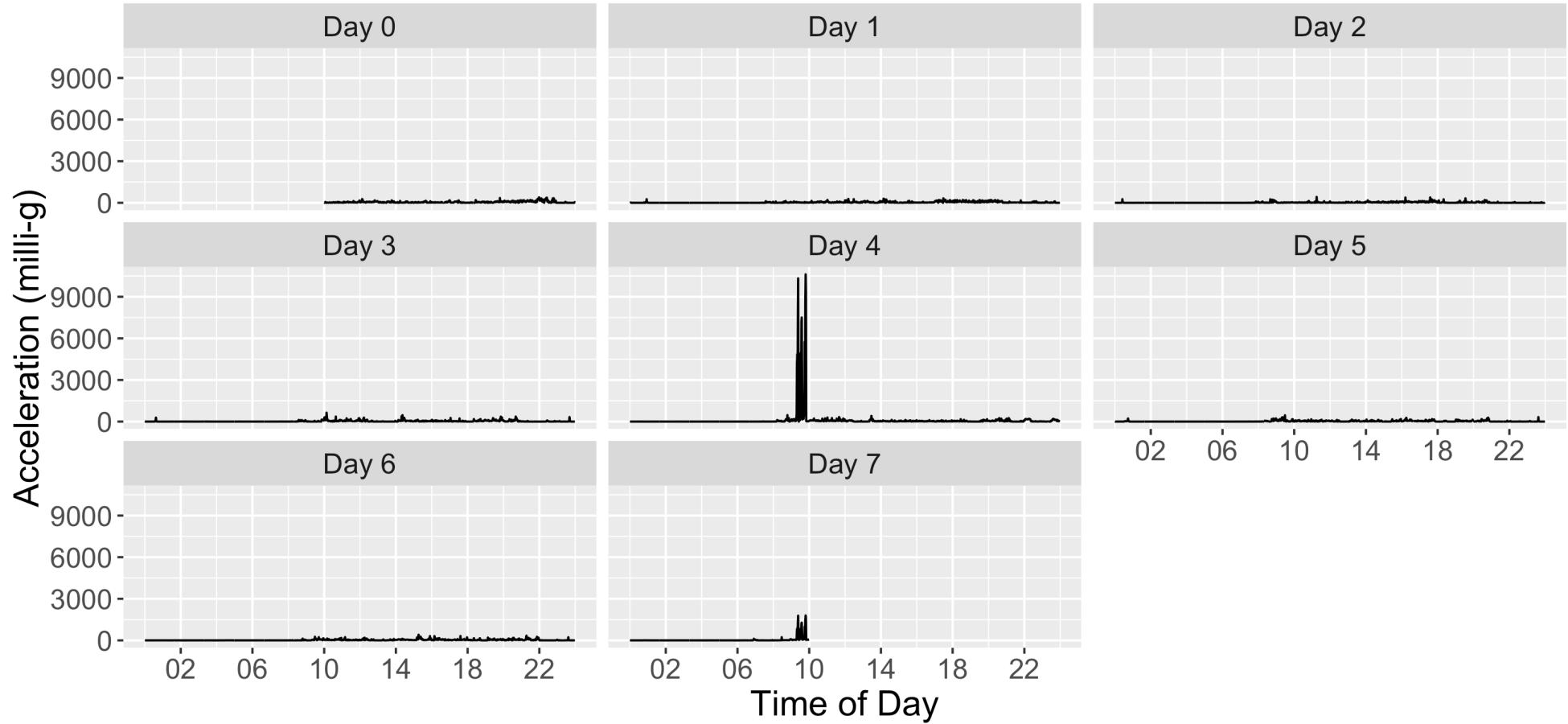
# Doesn't work for all cases (scales day-dependent)

Participant 2586235 Calibrated on Someone Else's Data



# Doesn't work for all cases

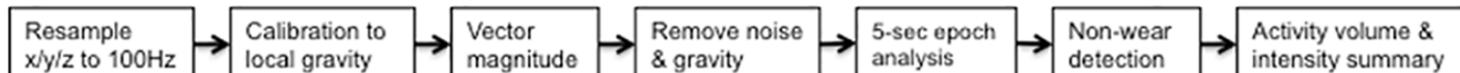
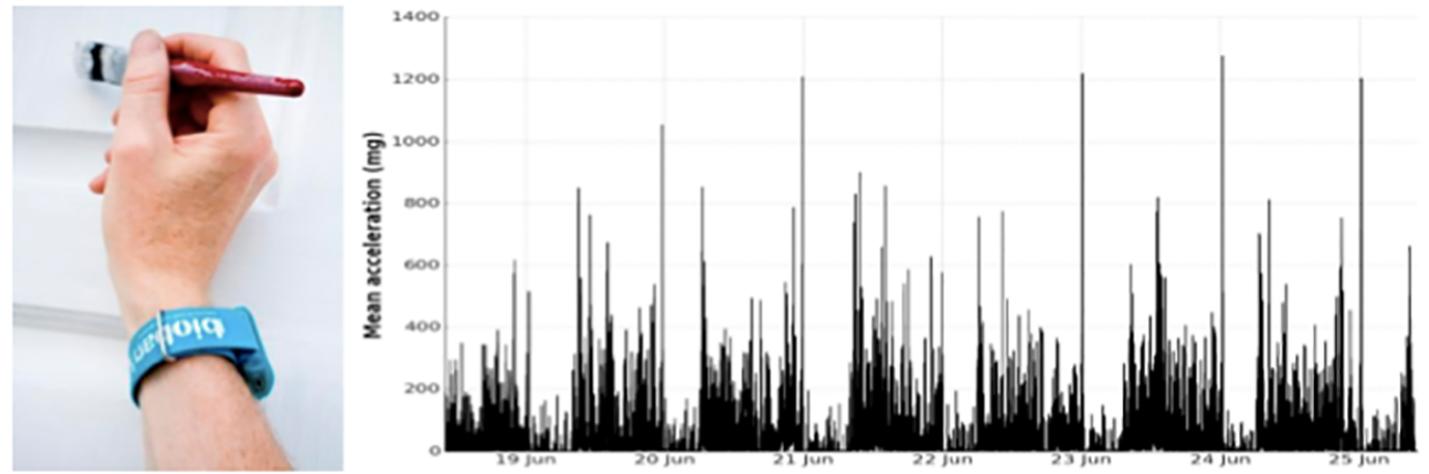
Participant 3462861 Calibrated on Own Data



Lesson #2: If magnitude is important, need calibration (“batch effect” correction), but may not be perfect

# UKBB Processing: Doherty et al. (2017)

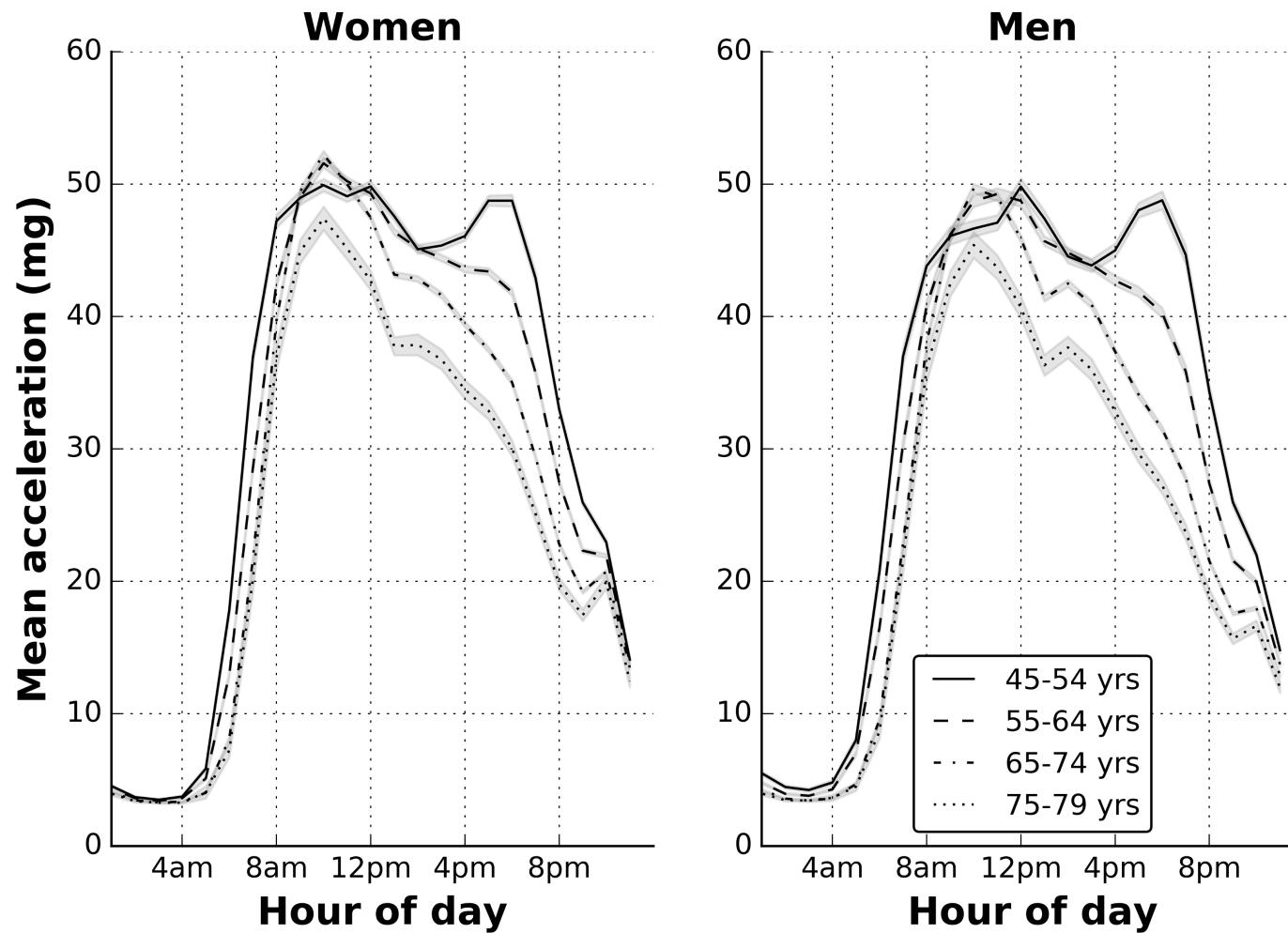
- Recording errors and 'interrupts' flagged (plug in accelerometer to computer)
- \pm8g flagged
- Resampled to 100 Hz (interrupts > 5 seconds set to missing)
- Euclidean norm, fourth order Butterworth low pass filter ( $f = 20\text{Hz}$ ).
- Subtract 1g, negative values set to 0



They have software (Python) on  
**GitHub**

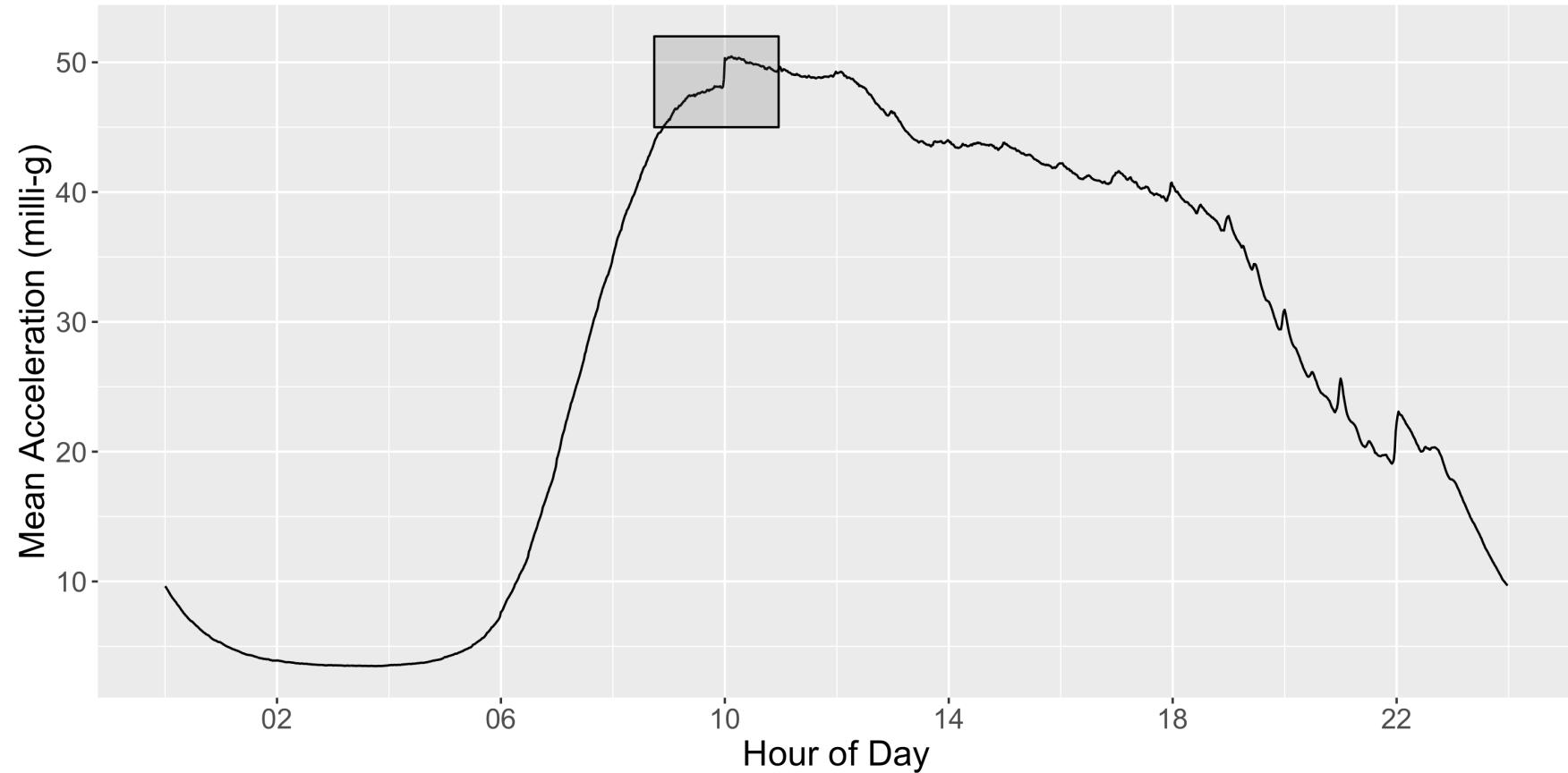
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# One result from (Doherty et al. 2017) analysis



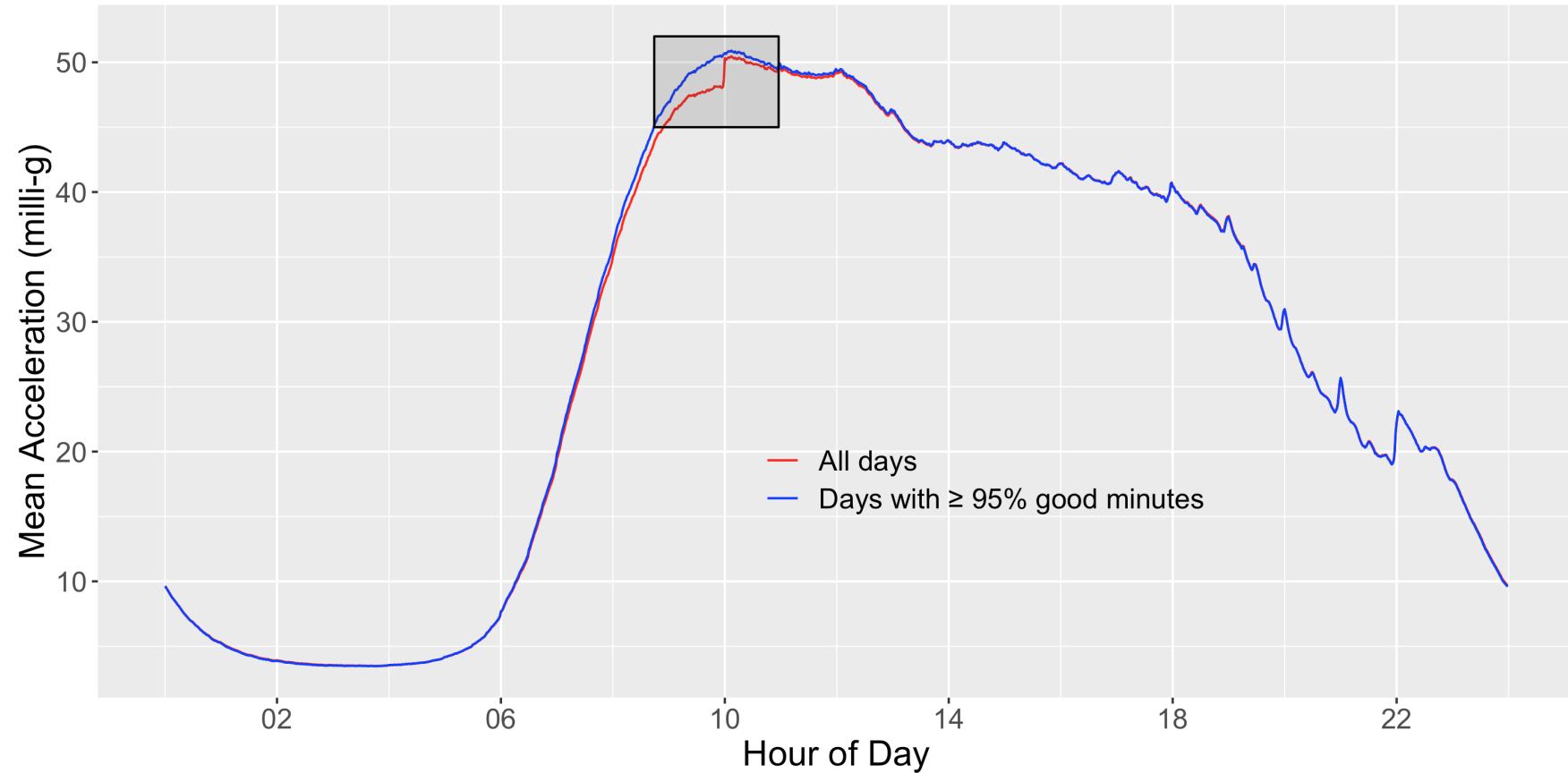
# How do people typically move?

- Average over minute - regardless of multiple visits per person



# How do people typically move?

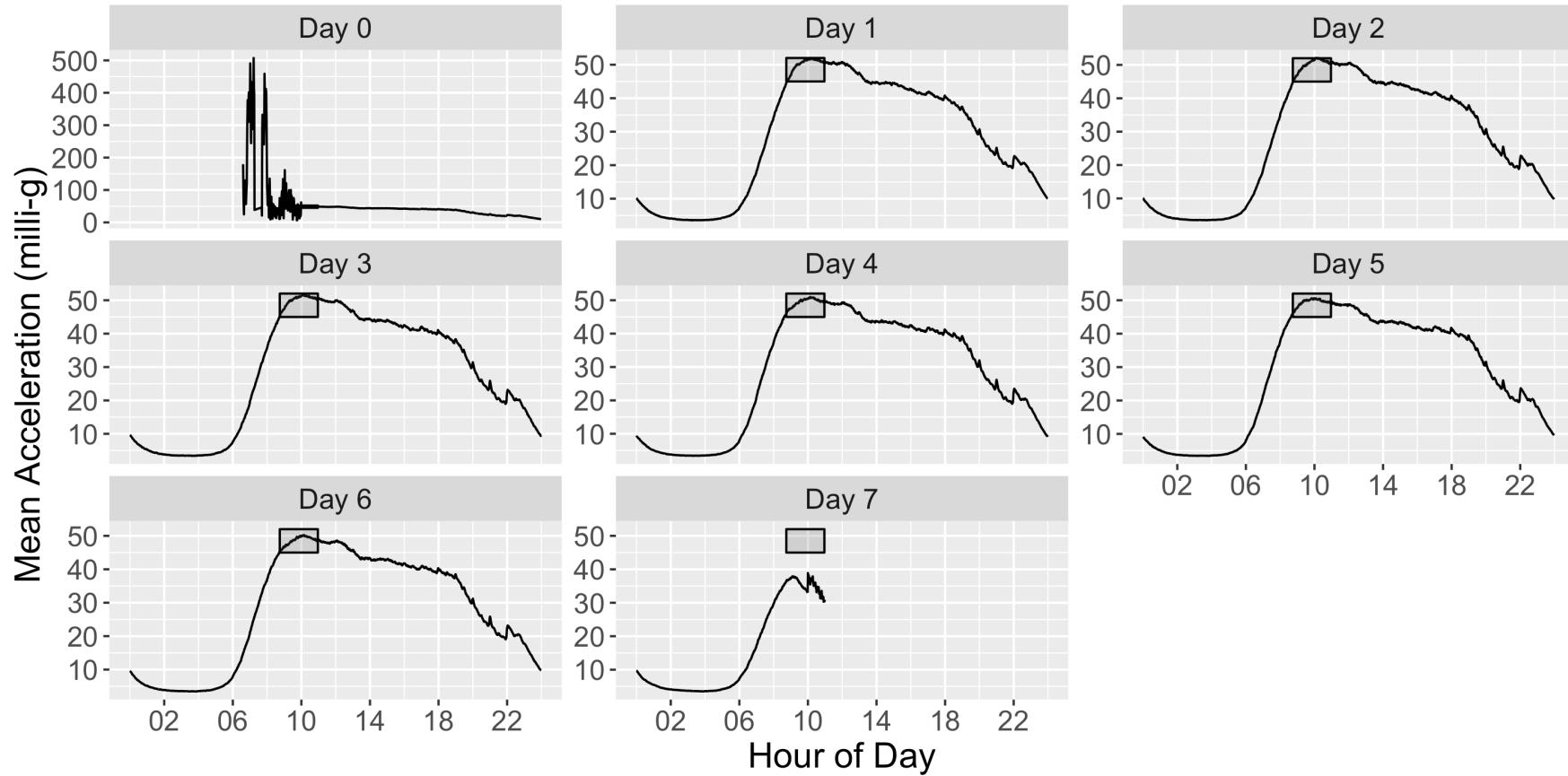
- Average over minute with days > 95% non-missing data



(Maybe) Lesson #3: Keep only “full” days

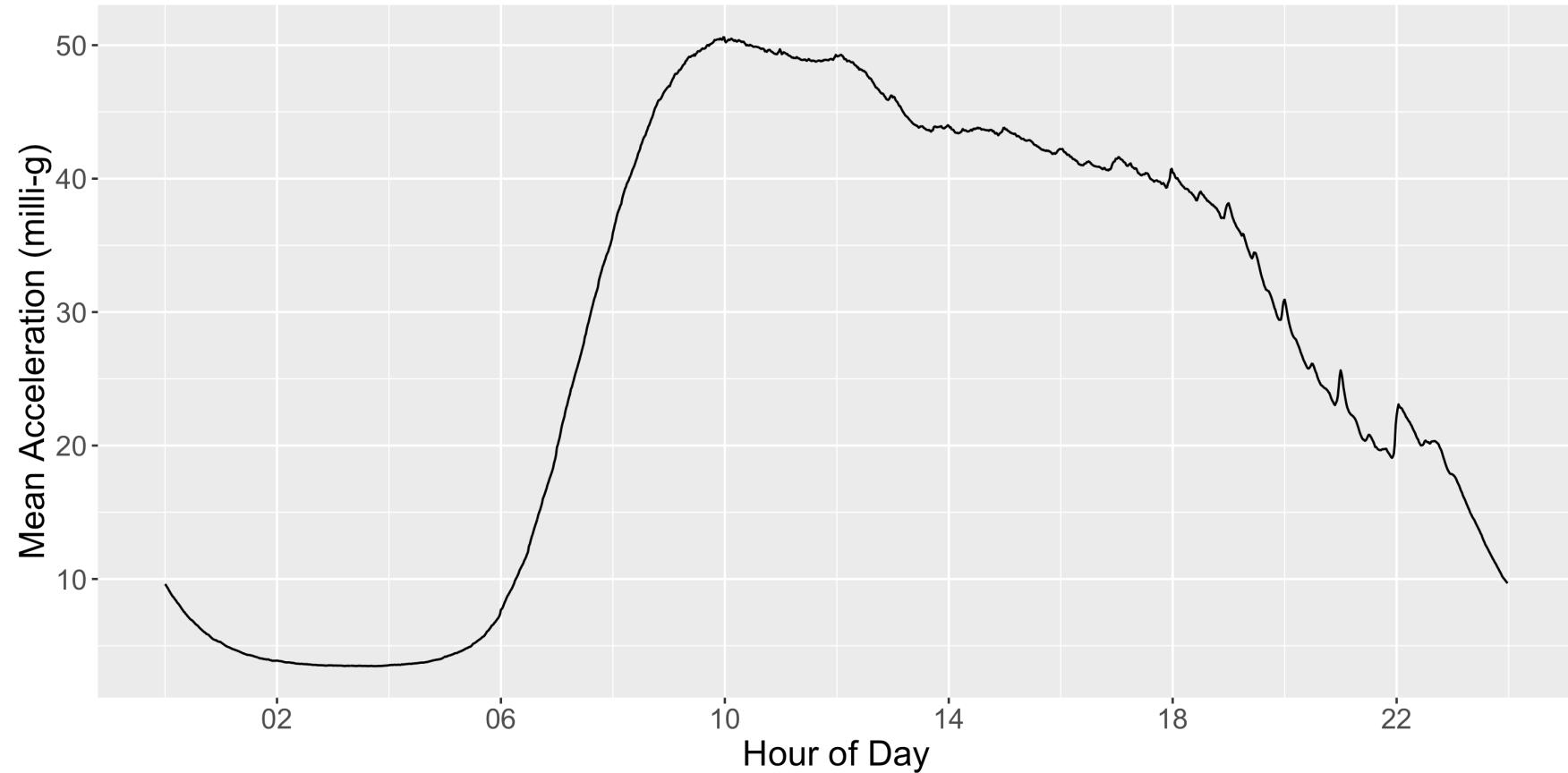
# Not so fast, let's look day by day

- Average over minute for days separately, one row per subject



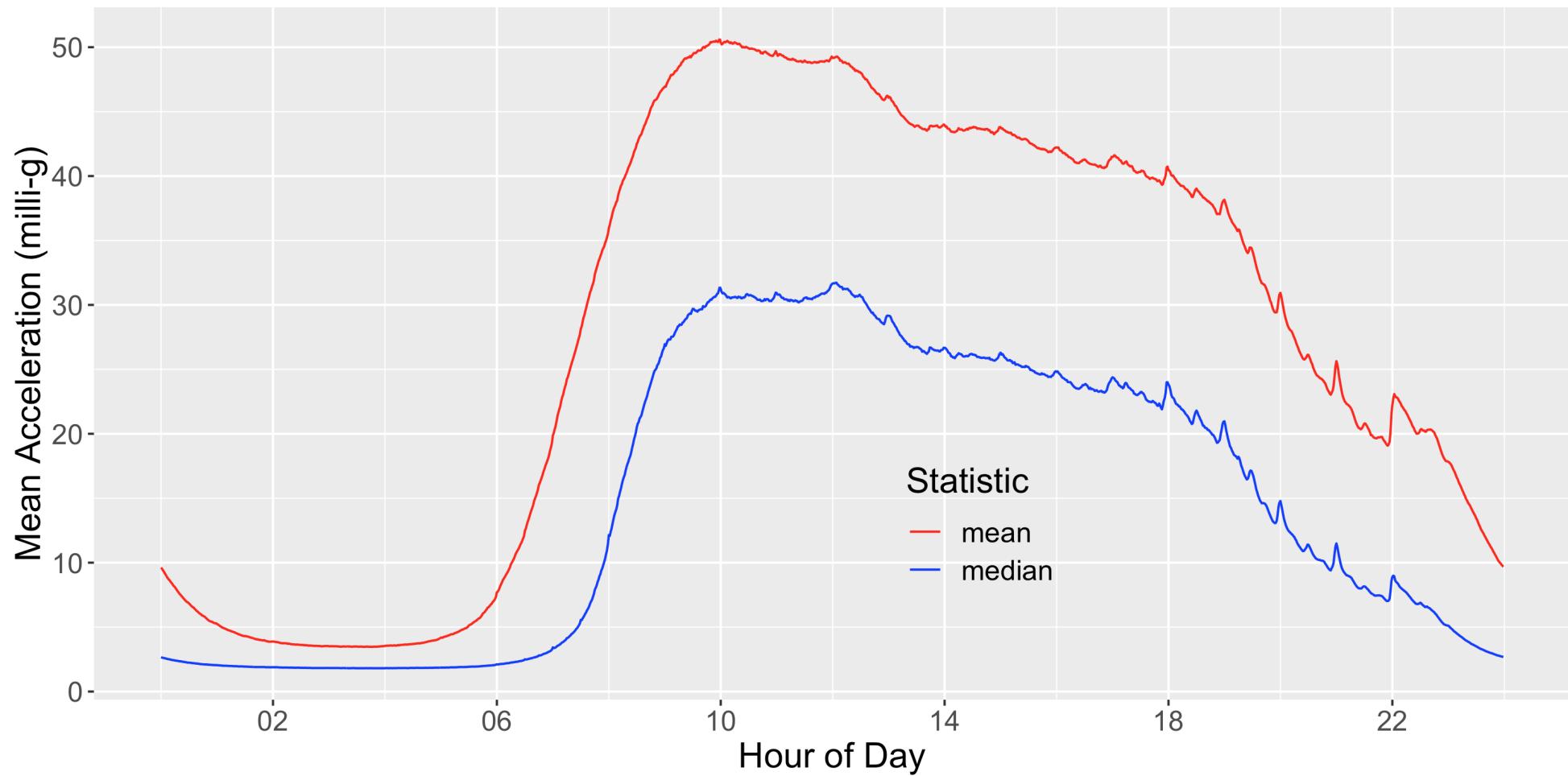
# Removing Day 7

- Average over minute for days 0 - 6



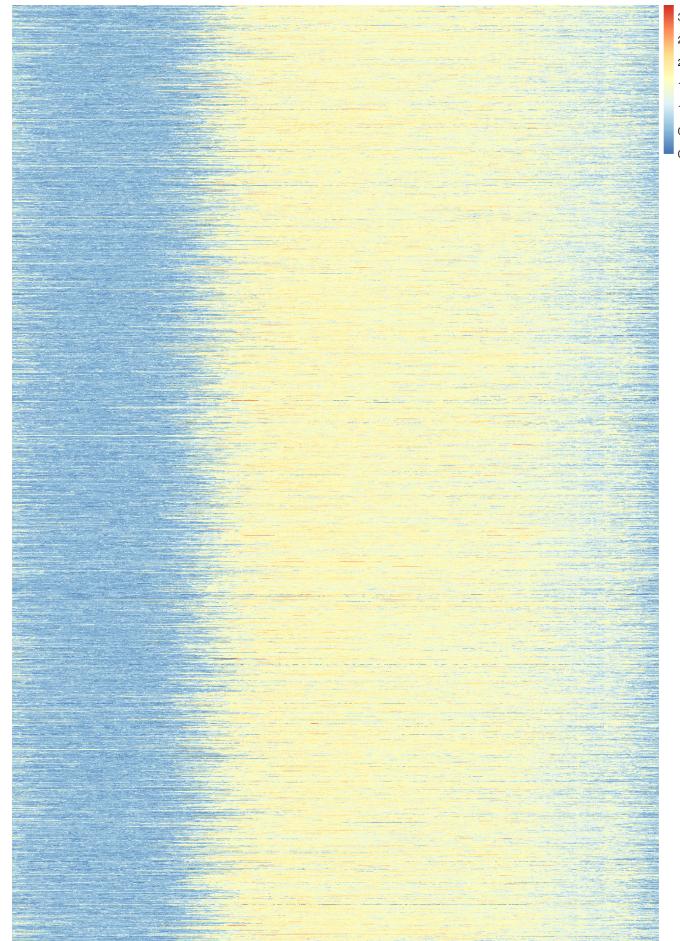
# Lesson #3: Explore days before averaging across individual?

# Well use the MEDIAN then!

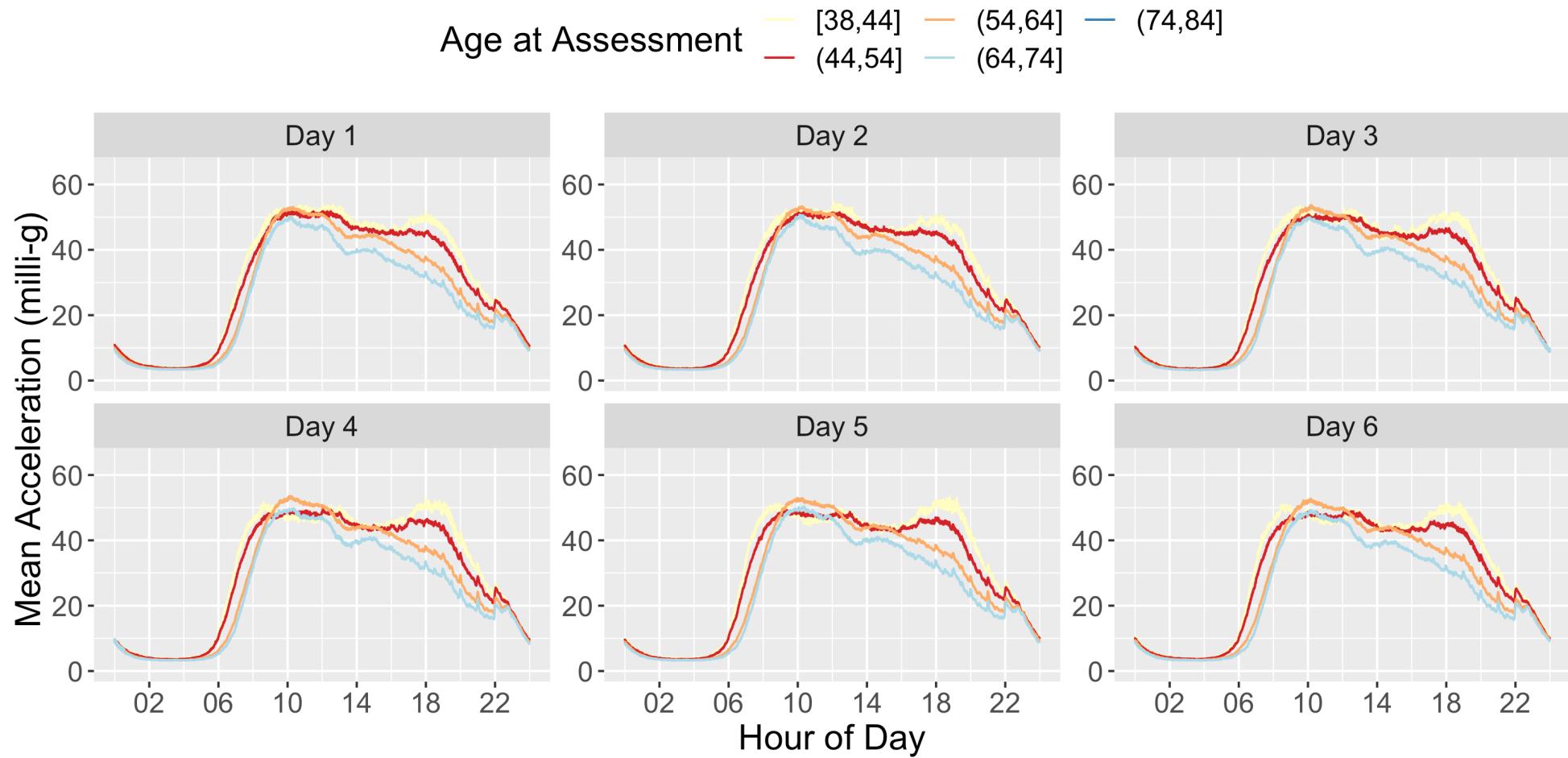


# Maybe it's a “few bad apples”

Heatmap of 2000 randomly sampled people

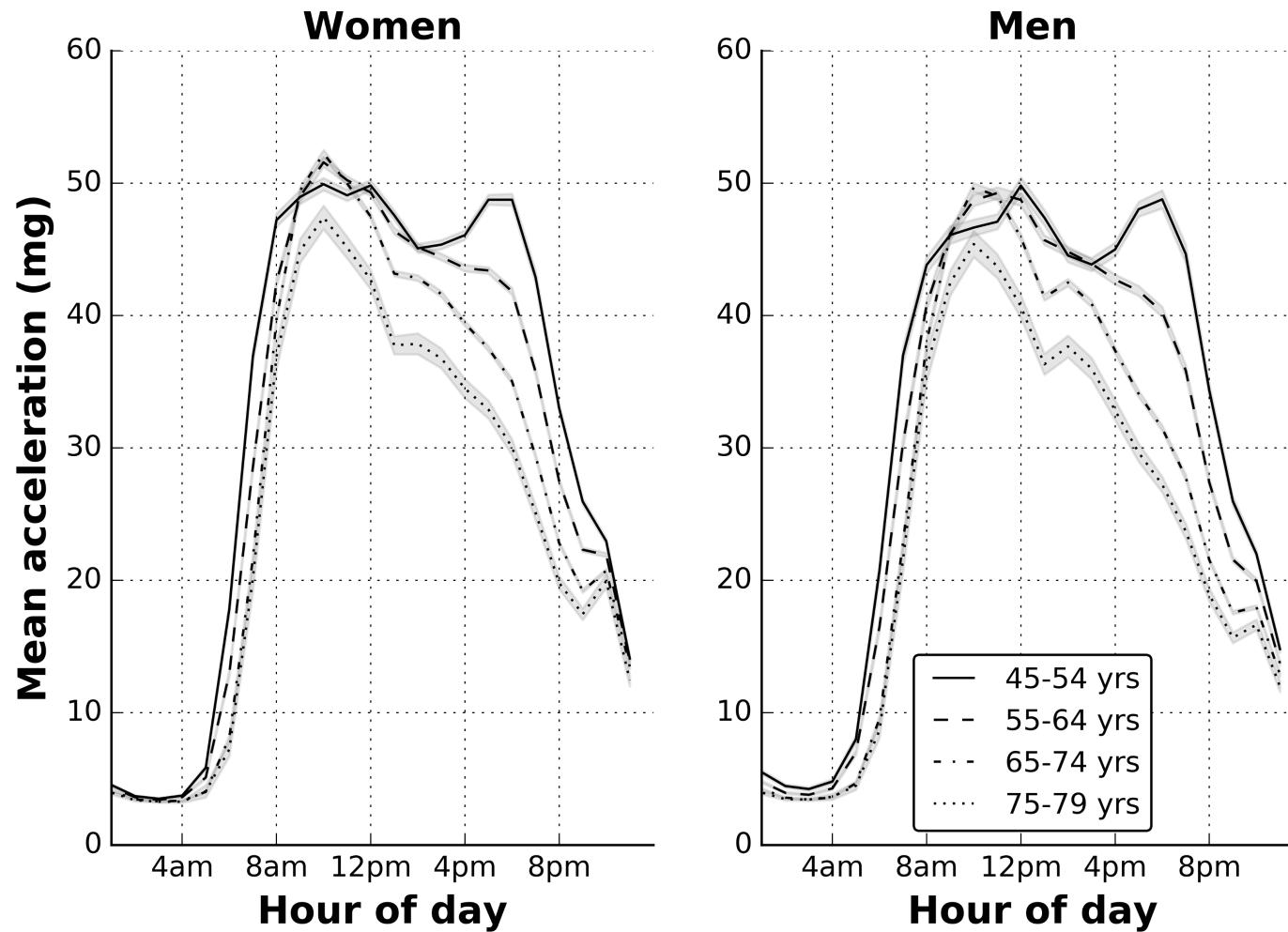


# Using Age at Assessment

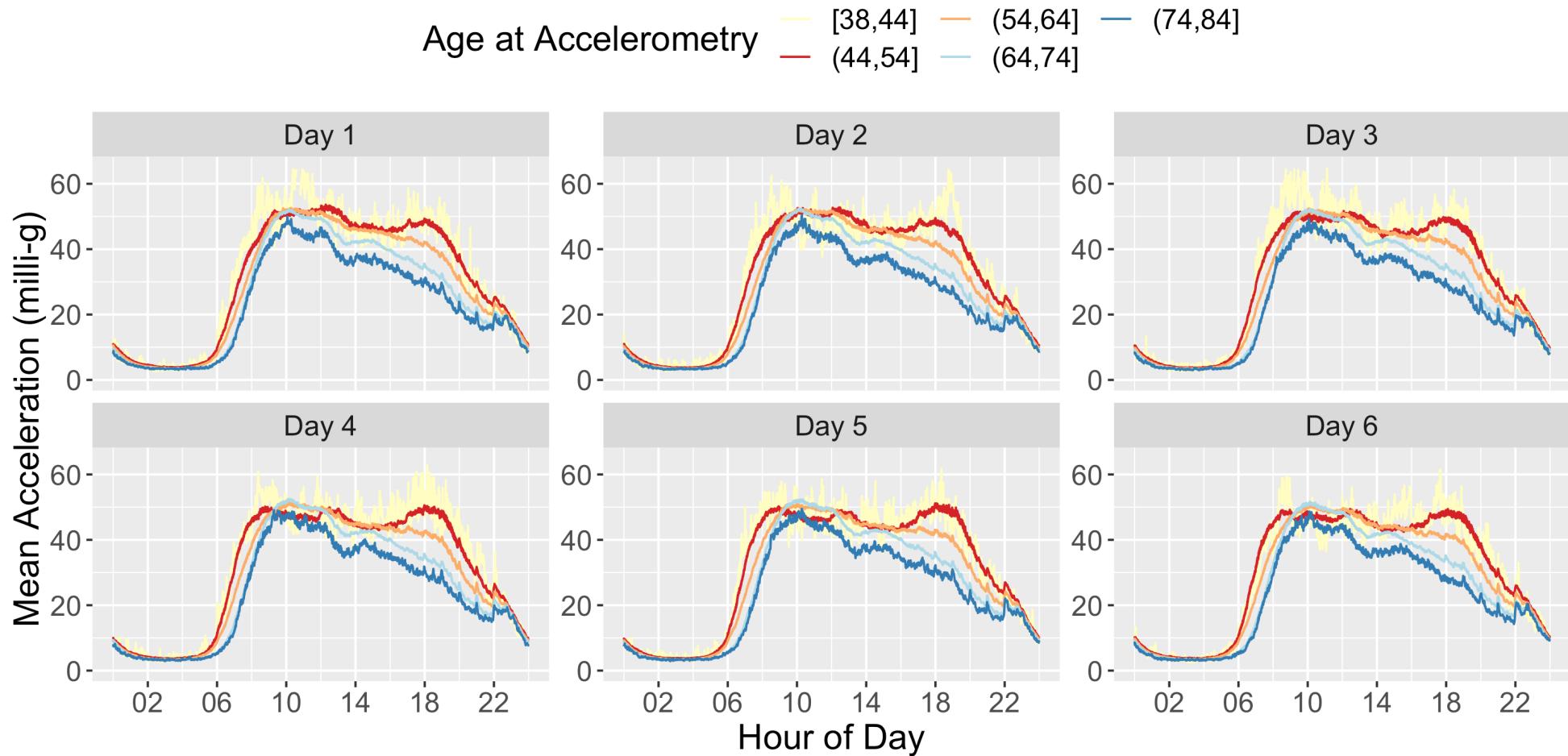


# One result from (Doherty et al. 2017) analysis

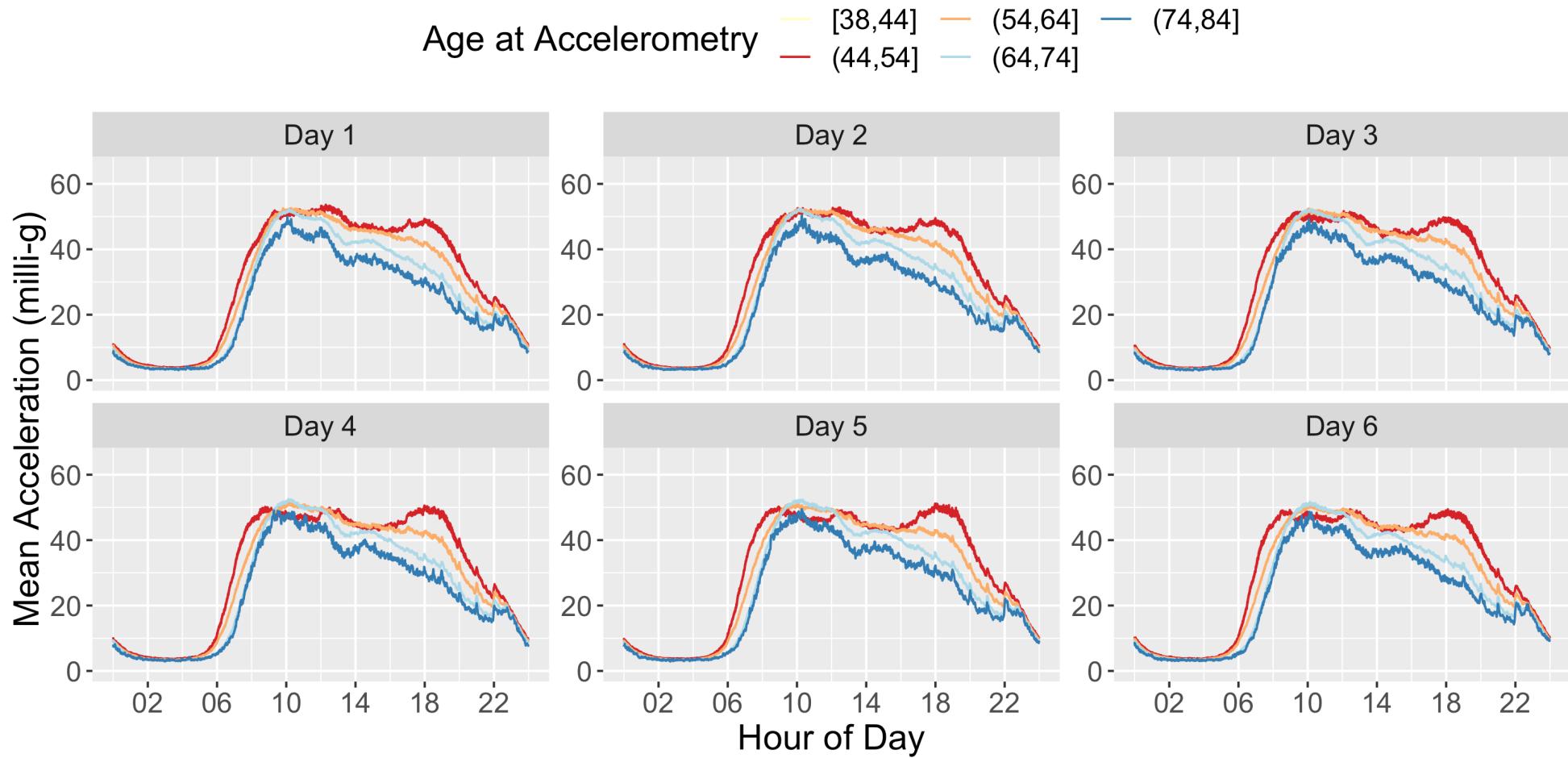
- Look at age range



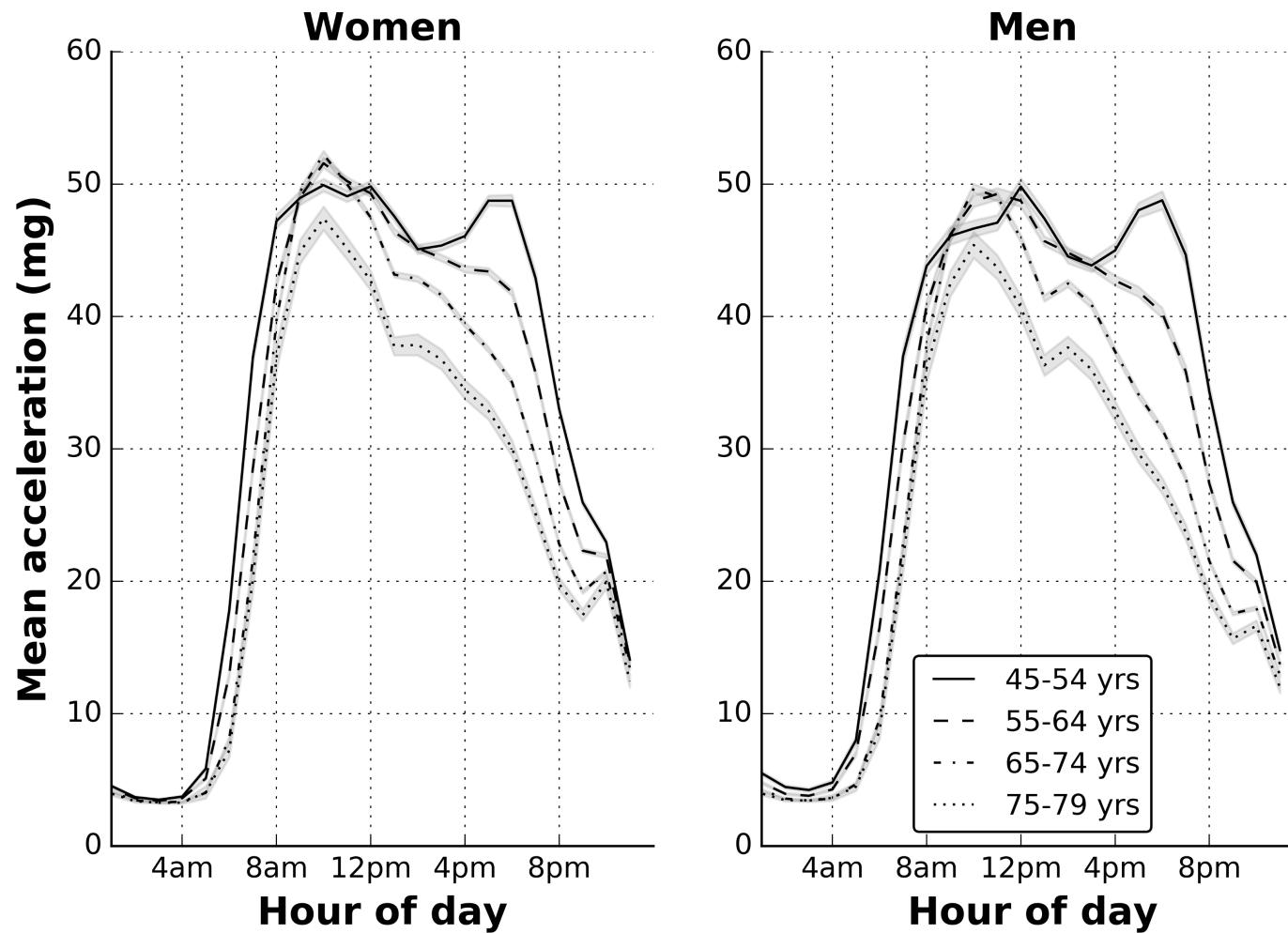
# Using Age at Acceleration



# Using Age at Acceleration - Remove 38-44 y/o



# One result from (Doherty et al. 2017) analysis

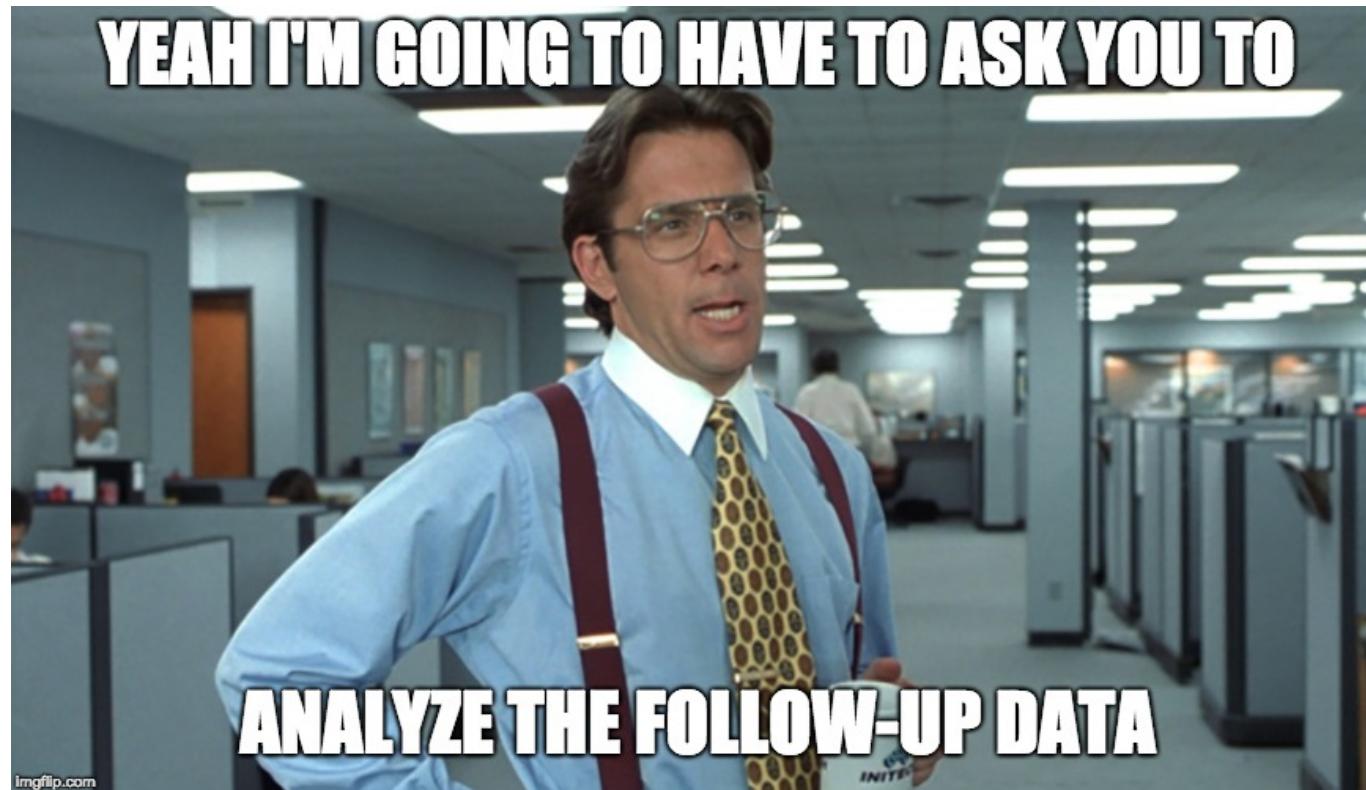


# Takehome Messages

1. Start off smaller than 100K people
2. Inspect the raw(ish) data
3. Processing highly affects results
  - Autocalibration seems to work well on gross features (with 100K people)
  - Artifacts still seem present in the data
4. Inclusion criteria matters (esp. for inference)
5. Back to the 100Hz data we go!

# Next data installment

"We invited some participants to wear an activity monitor for a week, four times a year. ... finished in early 2019."



# Get some data: NHANES

<https://github.com/andrew-leroux/rnhanesdata>

<https://oslerinhealth.org/package/rnhanesdata>

The screenshot shows the oslerinhealth.org website interface. At the top, there is a dark red header bar with the "JOHNS HOPKINS in health" logo on the left, followed by navigation links: "Install", "Submit Package", "List Packages", "Developers", "Help", "About", and "Log in". To the right of these links is a search bar and a "Search" button. Below the header, a breadcrumb navigation bar indicates the current location: "Home / Package rnhanesdata details". The main content area has a light gray background. On the left, a dark sidebar contains links to "Description", "Citation", "Issues", "Versions", "Installation", "Details", and "Documentation". The main content area is divided into sections. The first section, titled "Package Description", contains the title "NHANES Accelerometry Data Pipeline", a description "A data package for processed NHANES accelerometry data with accompanying processing pipeline code.", and the maintainer information "Maintainer: Andrew Leroux <aleroux2 at jhu.edu >". The second section, titled "Citation", contains the instruction "From within R, enter `citation(rnhanesdata)`". A dark blue call-to-action button at the bottom of this section contains the text "To cite package 'rnhanesdata' in publications use:".

JOHNS HOPKINS in health

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Home / Package rnhanesdata details

## Package rnhanesdata details

**Description**

**Citation**

**Issues**

**Versions**

**Installation**

**Details**

**Documentation**

**Package Description**

**NHANES Accelerometry Data Pipeline**

A data package for processed NHANES accelerometry data with accompanying processing pipeline code.

Maintainer: Andrew Leroux <aleroux2 at jhu.edu >

**Citation**

From within R, enter `citation(rnhanesdata)`

To cite package 'rnhanesdata' in publications use:

# References (and Thanks)

- Doherty, Aiden, Dan Jackson, Nils Hammerla, Thomas Plötz, Patrick Olivier, Malcolm H Granat, Tom White, et al. 2017. "Large Scale Population Assessment of Physical Activity Using Wrist Worn Accelerometers: The Uk Biobank Study." 12 (2): e0169649.
- Hees, Vincent T van, Zhou Fang, Joss Langford, Felix Assah, Anwar Mohammad, Inacio CM da Silva, Michael I Trenell, Tom White, Nicholas J Wareham, and Søren Brage. 2014. "Autocalibration of Accelerometer Data for Free-Living Physical Activity Assessment Using Local Gravity and Temperature: An Evaluation on Four Continents." 117 (7): 738-44.