OXFORD POPULATION HEALTH

UNIVERSITY OF OXFORD

Accelerometer data in UK Biobank

Presented by Rosemary Walmsley
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15th September 2022

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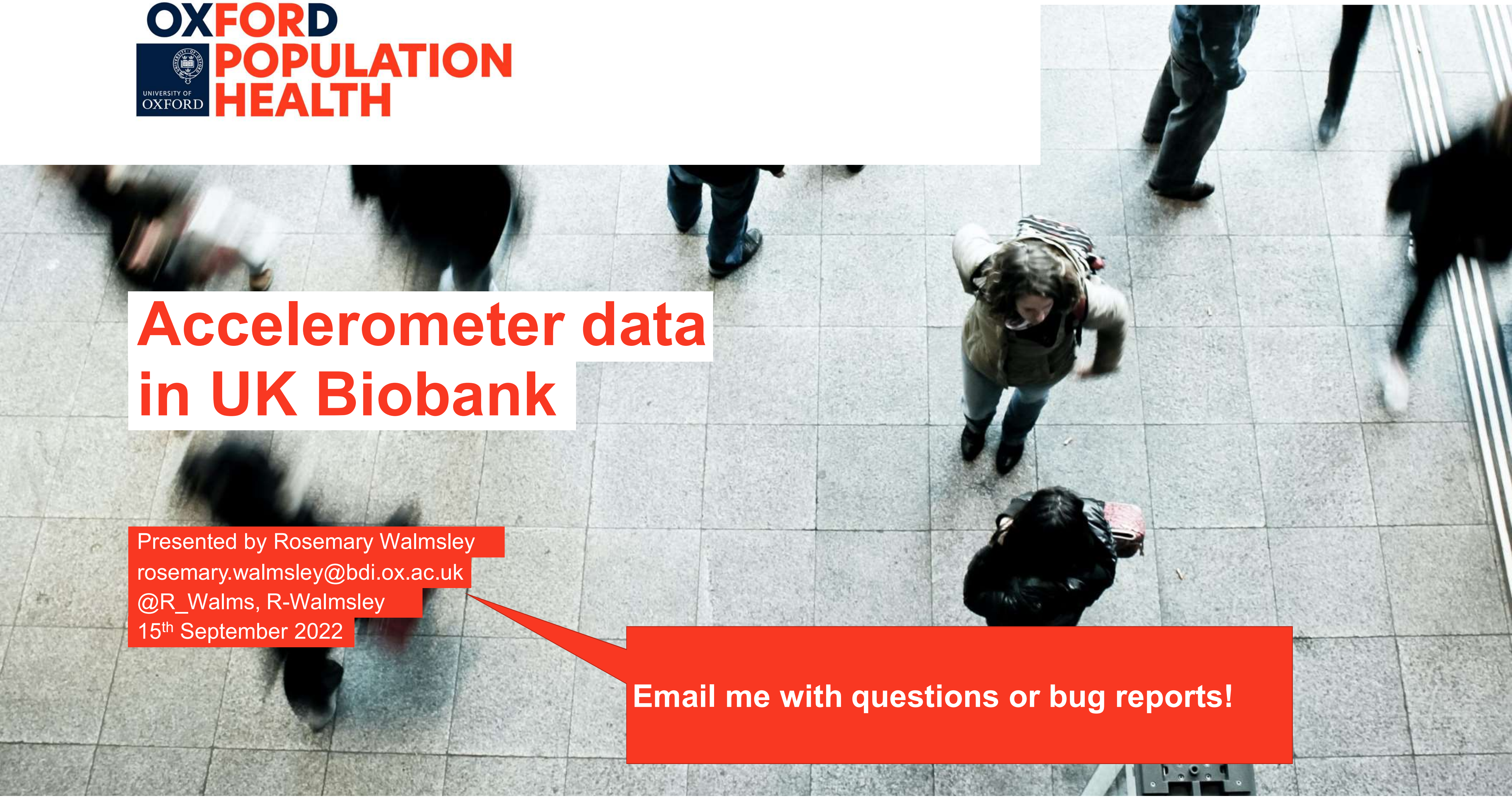

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Email me with questions or bug reports!

Acknowledgements

- Aiden Doherty and the Oxford Wearables group

- DNANexus
- UK Biobank

- Oxford Population Health
- Big Data Institute

- Funders

Outline

- Why wearables?
- What is the UK Biobank accelerometry study?
- How can the accelerometer data be used?
- Where can I find resources?

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- **Why wearables?**
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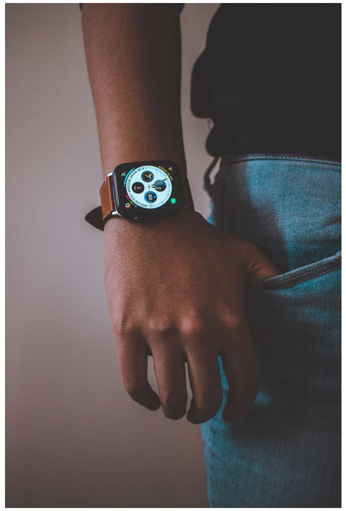
Wearables in health applications



- Acceptable technology: widespread use of consumer wearables

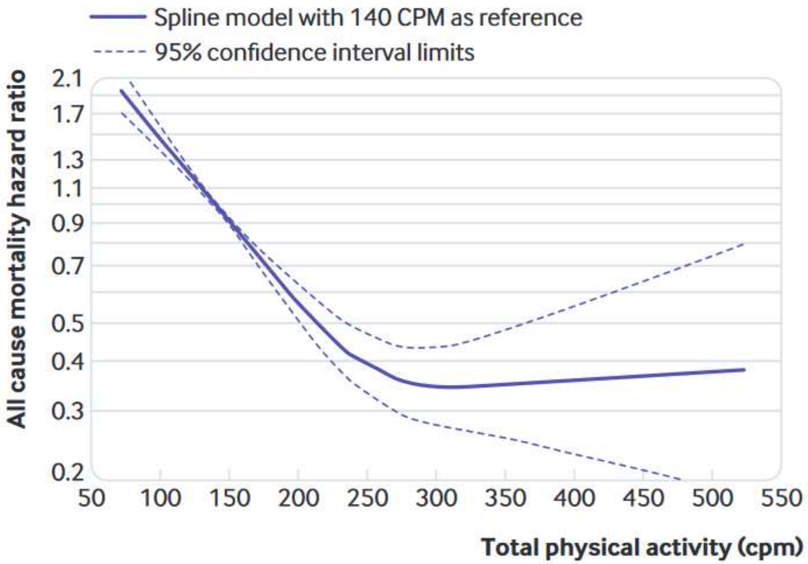
- Rich and detailed measurement in the real-world

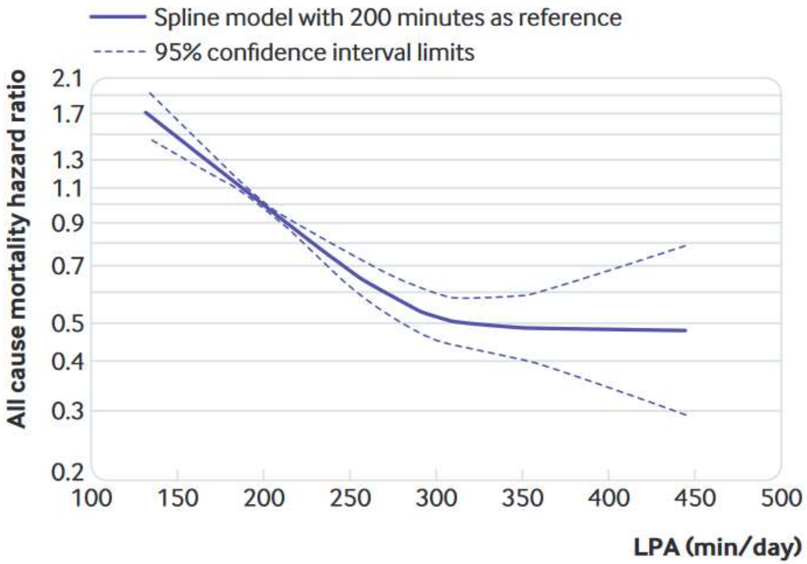
- Diverse applications e.g. studying disease risk factors, clinical trial endpoints, patient monitoring

Images: Unsplash (Nadine Shaabana, Luke Chesser) , UK Biobank

Insights from wearables

- Stronger associations between physical activity and mortality than found with self-report
- Insights into behaviours hard-to-measure with self-report e.g. light physical activity





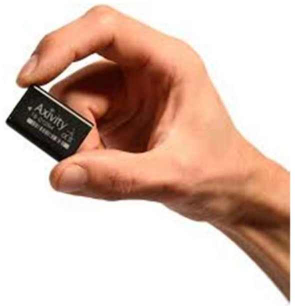
Ekelund et al. ***BMJ,*** (2019).

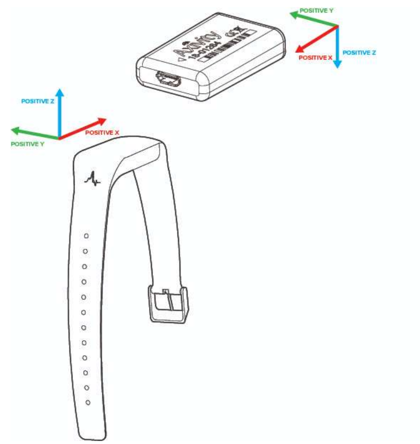
What is an accelerometer?

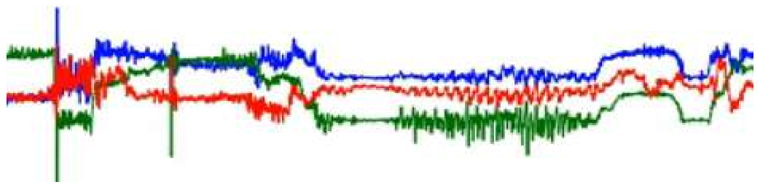
- A device to measure movement objectively

- Typically worn on the body, often on the wrist, hip or thigh

- Modern accelerometers measure in 3 dimensions and record data ~100 times/second (100 Hz)







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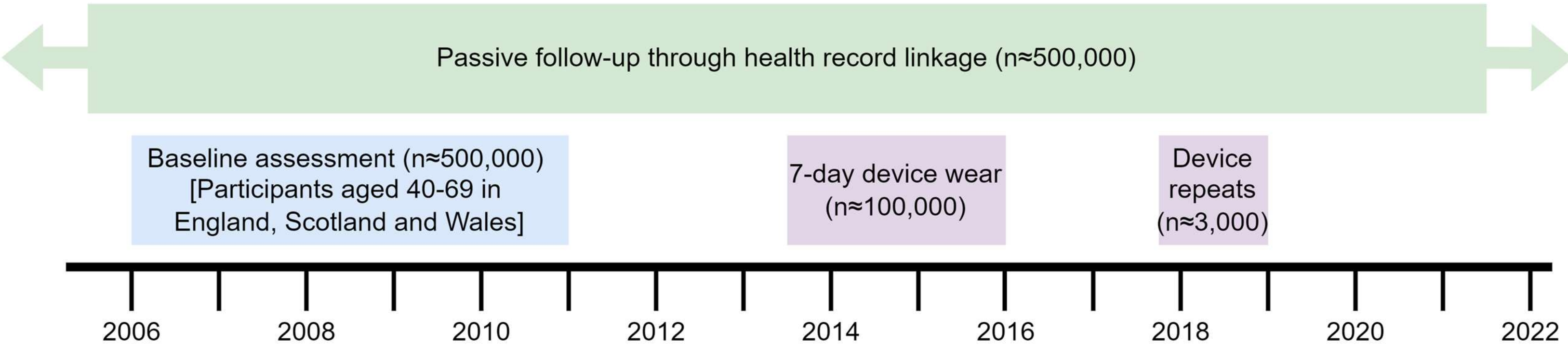
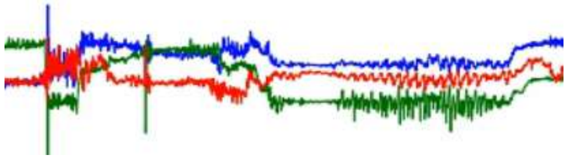
Accelerometry in UK Biobank

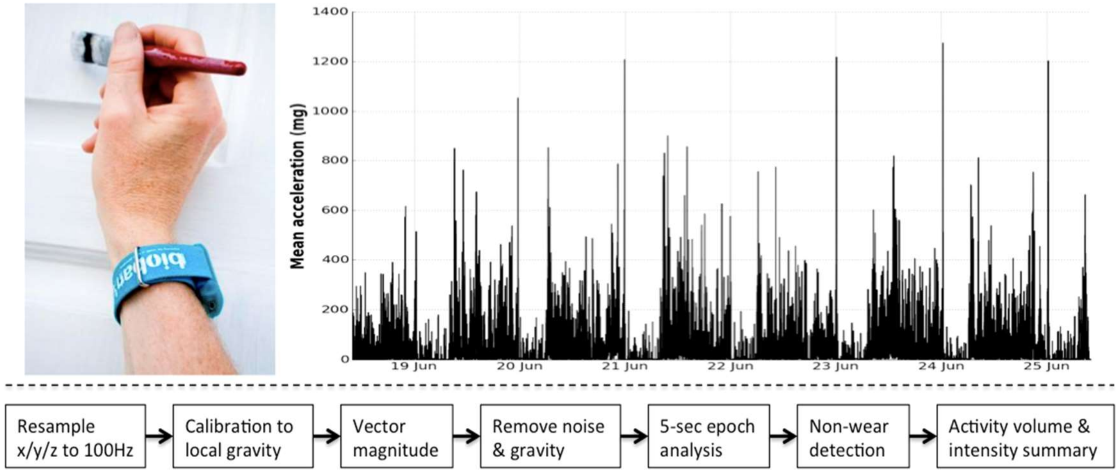
- ~100,000 people
- Axivity AX3 wrist-worn accelerometer
- 7-day 24-hour wear protocol

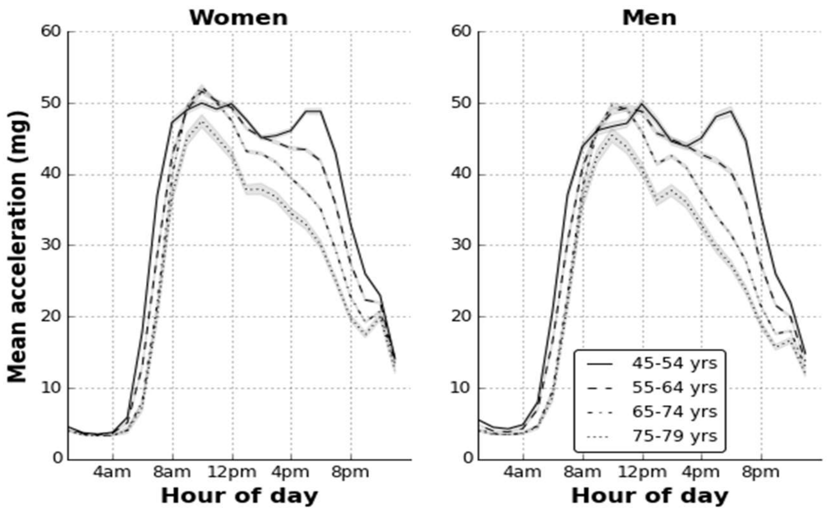


Processing accelerometer data



- Careful data processing e.g. resampling, calibration, non-wear detection
- Use of validated methods e.g validation of overall activity measurement against doubly labelled water





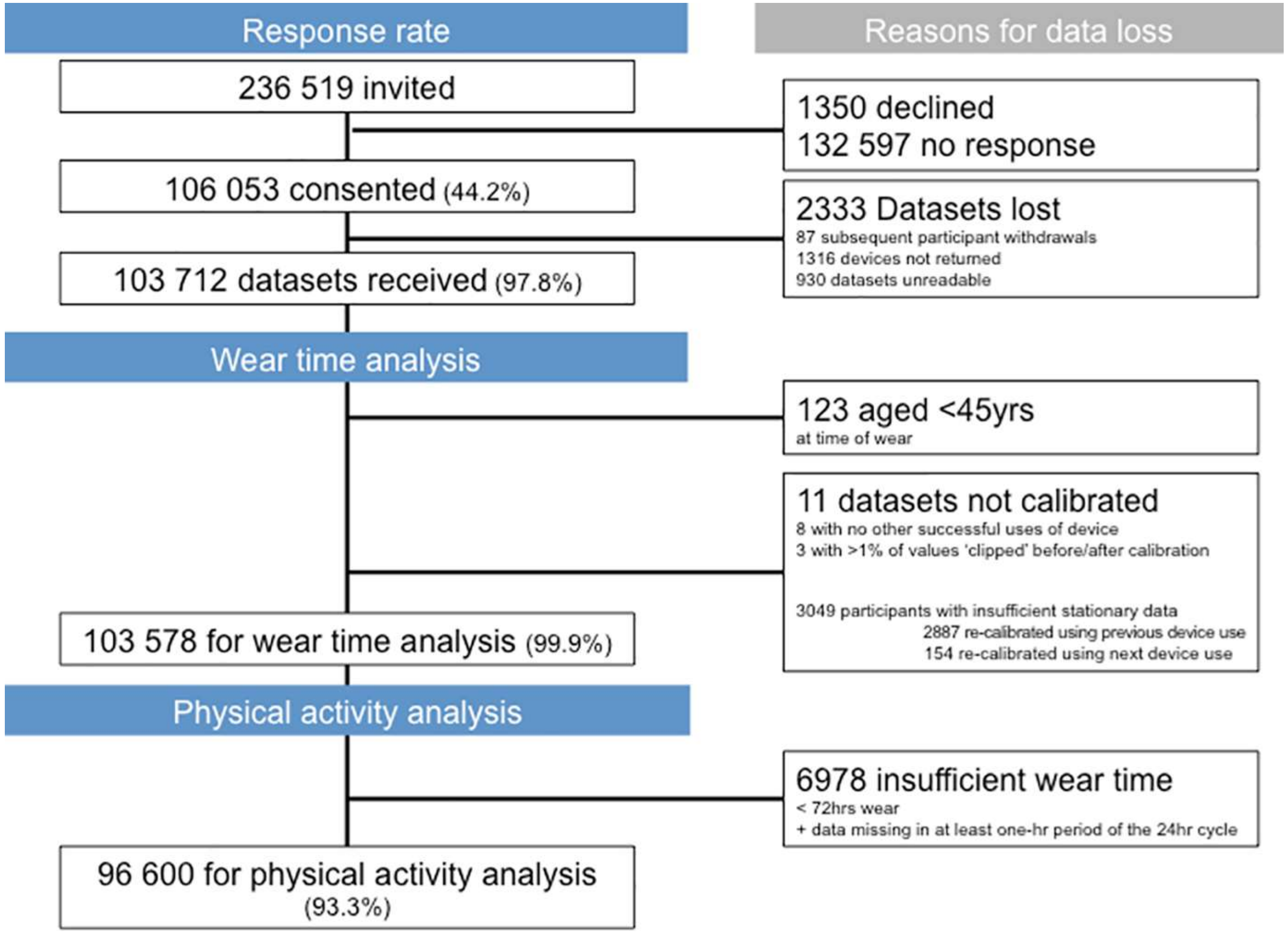
Data processing: Doherty et al. ***PLoS One*** 12, (2017). 12(2):e0169649

Processing methods: van Hees et al. ***J App Physiol,*** *(*2014). 117(7): 738-744

Validation: White et al. ***Intl J. Obesity,*** (2019). 10.1038/s41366-019-0352-x

Quality control

- Pipeline to exclude participants not meeting quality control conditions
- Most exclusions due to insufficient wear time, affecting 7% participants
- Conditions may depend on variables of interest



Doherty et al. ***PLoS One*** 12, (2017). 12(2):e0169649

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Uses of UK Biobank accelerometer data

Used to derive measurements of:

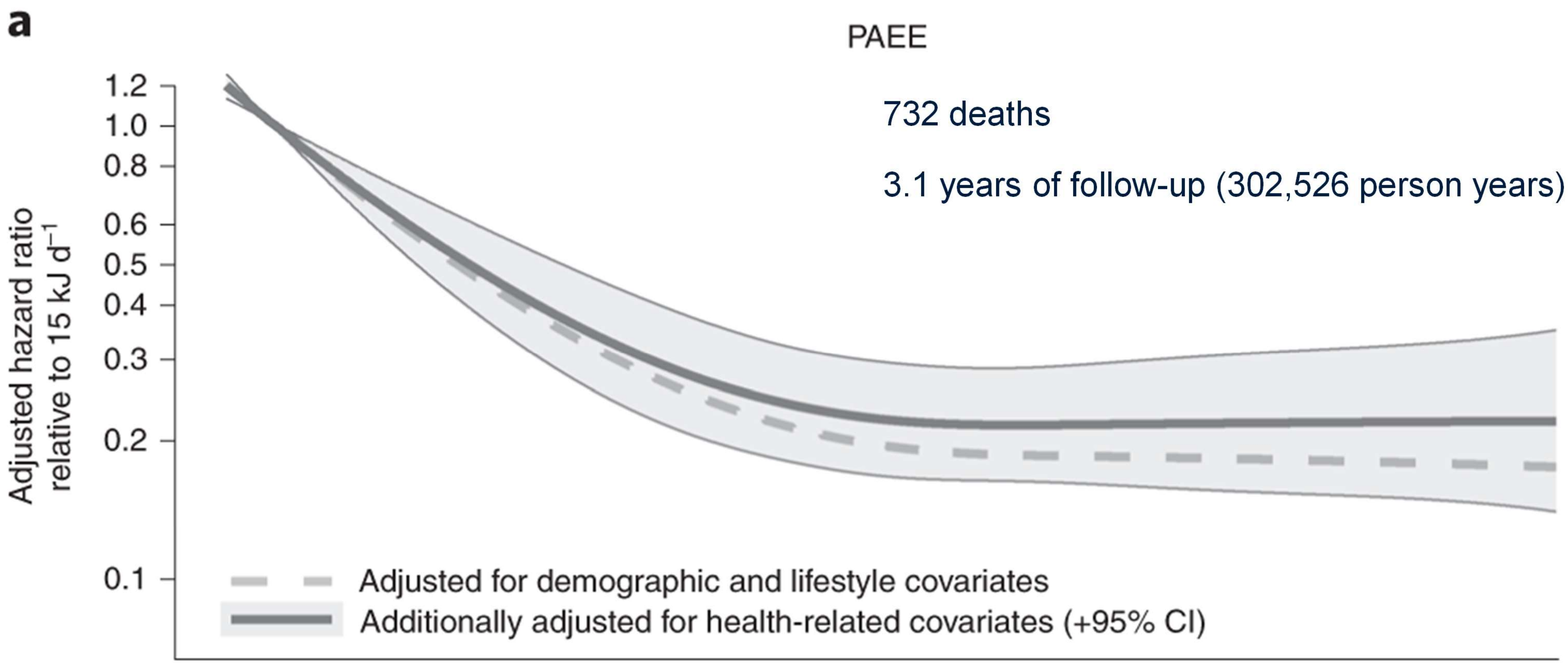
- overall physical activity
- movement behaviours (e.g. sleep, sedentary behaviour, light activity, moderate-to-vigorous activity)
- behavioural patterns
- circadian rhythm
- sleep quality
- step count

Uses of UK Biobank accelerometer data

Used to study:

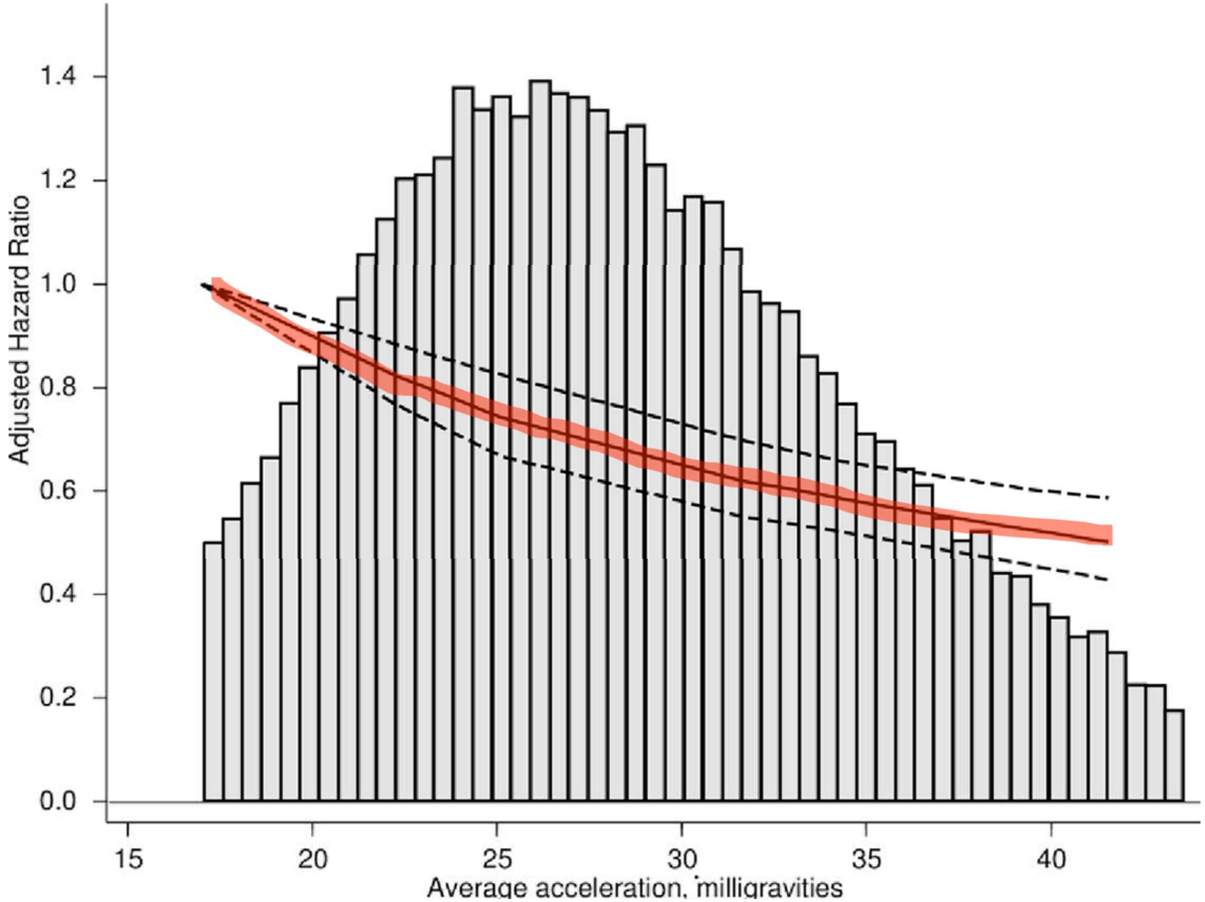
- Associations with incident disease and mortality
- Genetic architecture of movement-related phenotypes
- Associations with other phenotypes e.g. mental health phenotypes

Energy expenditure and mortality



Strain et al. ***Nature Medicine,*** (2020).

Physical activity and cardiovascular disease (CVD)



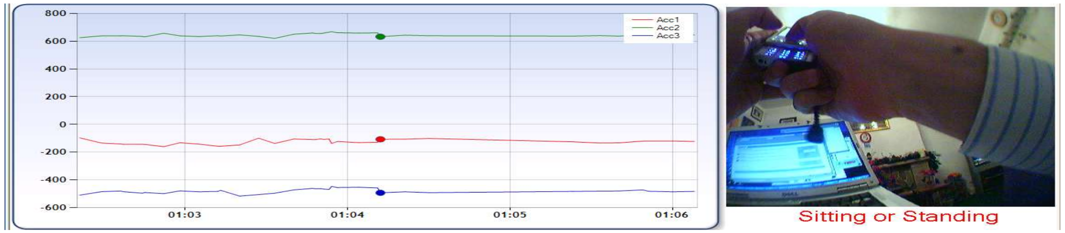
3,617 CVD events

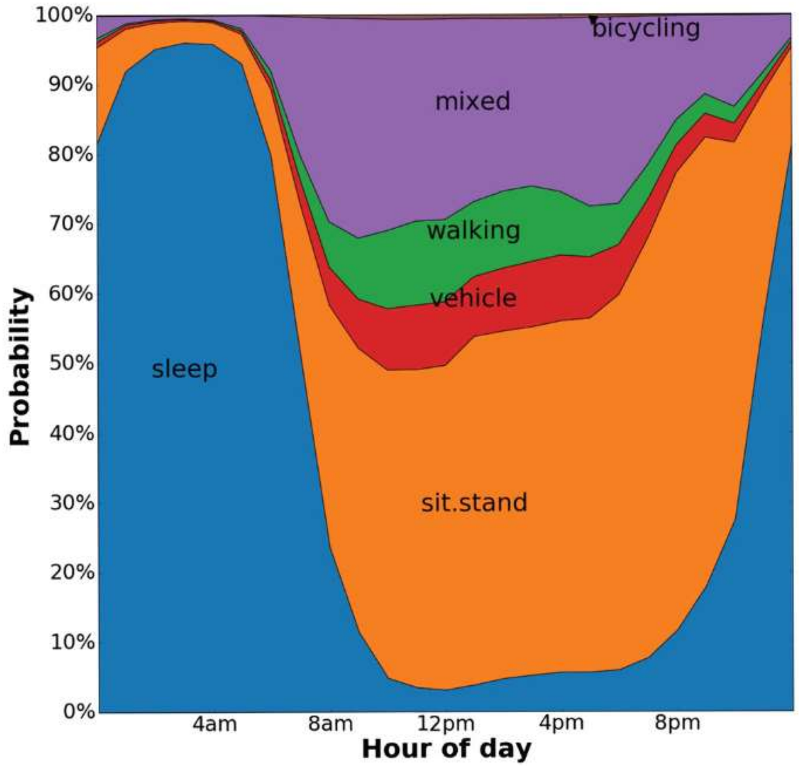
5.2 years of follow-up (440,004 person years)

Ramakrishnan et al. ***PLoS Medicine,*** (2021).

Measuring 24-hour movement behaviours

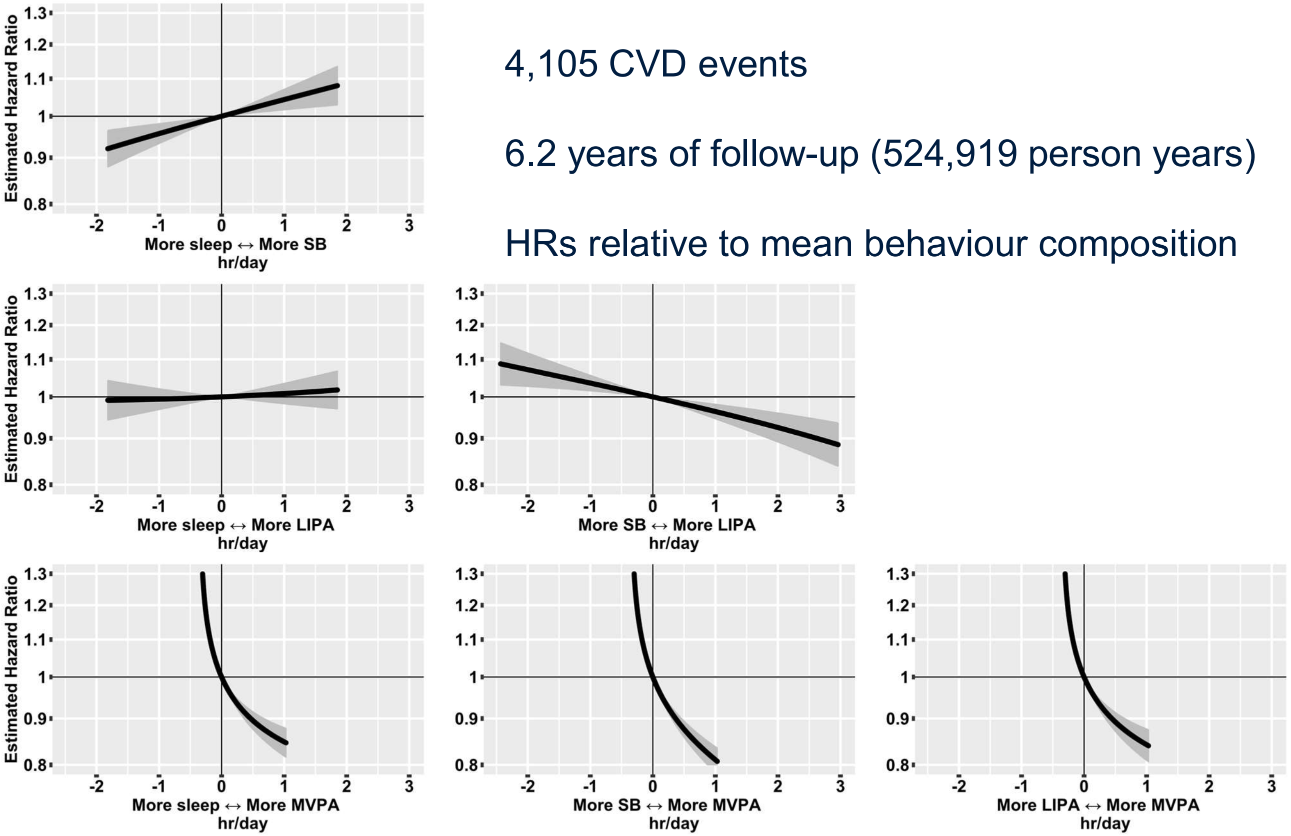
- Developing machine-learning models to classify movement behaviours in accelerometer data
- Models developed in a separate dataset with ground-truth (CAPTURE-24, 10.5287/bodleian:NGx0JOMP5)
- Applied to classify UK Biobank participants' movement behaviours





Willetts et al. ***Scientific Reports,*** (2018).

24-hour movement behaviours and CVD



4,105 CVD events

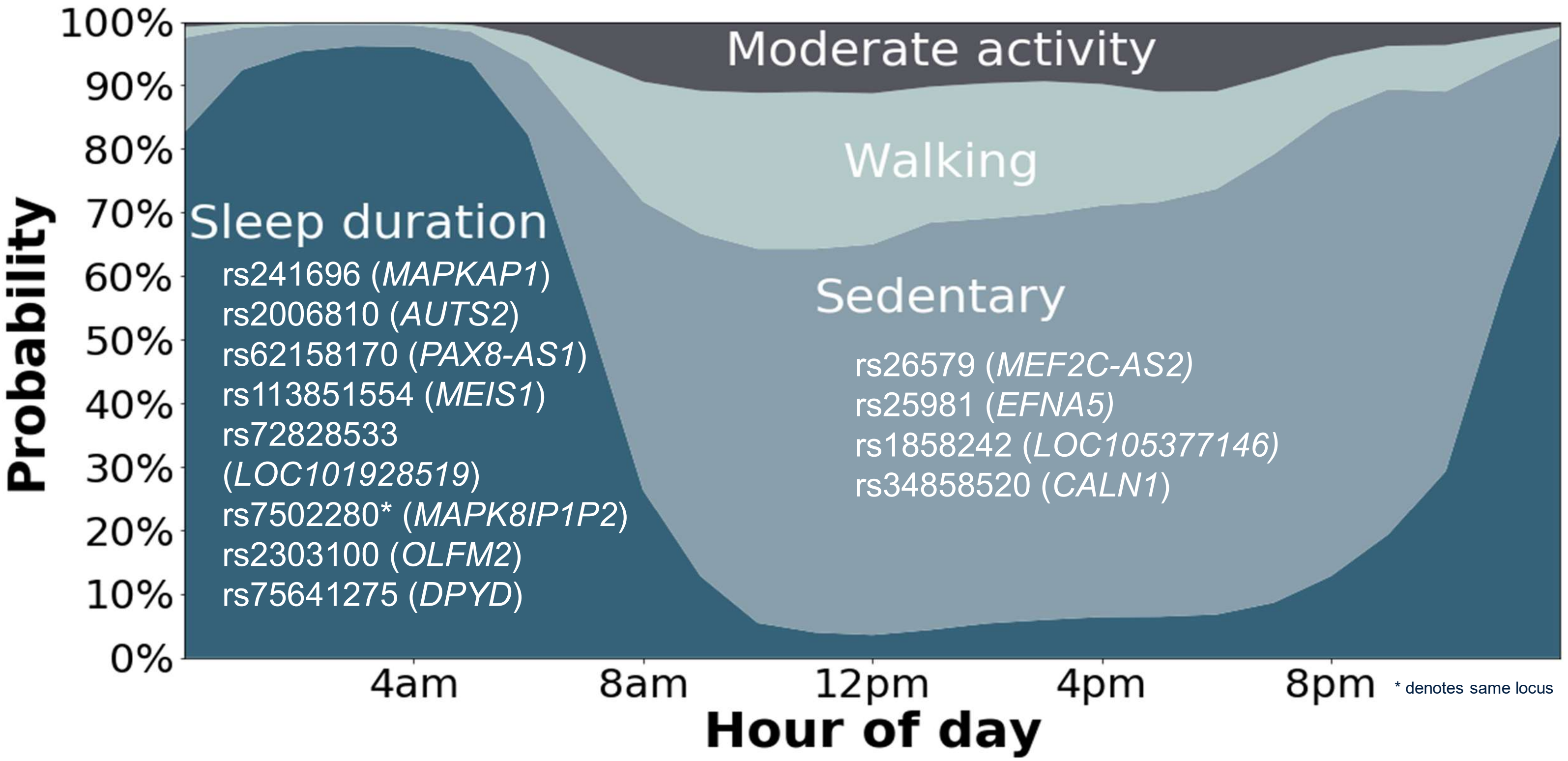
6.2 years of follow-up (524,919 person years)

HRs relative to mean behaviour composition

Walmsley et al. ***British Journal of Sports Medicine,*** (2021), http://dx.doi.org/10.1136/bjsports-2021-104050

Genetics and movement behaviours

Overall activity rs564819152 (*SKIDA1*), rs2696625* (*KANSL1-AS1*), rs59499656 (*SYT4*)



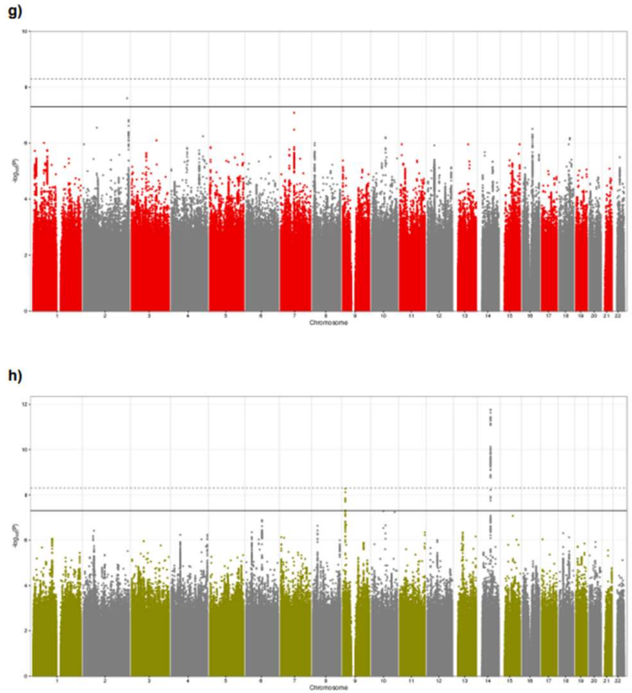
* denotes same locus

Doherty et al. ***Nature Communications*** 9:5257, (2018).

Genetics and sleep/circadian characteristics

Table 2 Heritability estimates of derived sleep variables from BOLT-REML

Sleep variable	h^2	95% CI
Sleep duration	0.190	0.182-0.198
Sleep duration variability (SD)	0.028	0.020-0.036
Number of nocturnal sleep episodes	0.223	0.215-0.231
Sleep efficiency	0.130	0.122-0.138
L5 timing	0.117	0.109-0.125
M10 timing	0.087	0.079-0.095
Sleep midpoint timing	0.101	0.093-0.109
Diurnal inactivity	0.148	0.134-0.161



Supplementary Figure 1. Manhattan plots for the eight accelerometer-derived phenotypes. Plots show GWAS results for a) sleep duration, b) sleep duration variability, c) sleep efficiency, d) number of sleep episodes, e) L5 timing, f) M10 timing, g) sleep midpoint and h) diurnal inactivity.

Jones et al. ***Nature Communications***, 10:1585, (2019).

What’s next?

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Accessing UK Biobank accelerometer data

Off-the-shelf ⟷ Bespoke

Summary accelerometer variables	Processed accelerometer variables from other applications	Intermediate accelerometer time series files	Raw accelerometer data
Summary activity metrics, quality control metrics	E.g. machine-learned behaviours	“Epoch-level” data from device	Raw ~100 Hz data as recorded by the device
Suitable for many analyses	May be appropriate for some analyses	May be suitable for deriving some novel phenotypes (e.g. circadian)	Can be used flexibly to derive novel phenotypes
Tabular	Generally tabular	Medium-sized	Very large
Access in tabular participant data	Access in “returns” datasets	Access as Bulk data	Access as Bulk data

Getting started with accelerometry variables

- github.com/OxWearables/rap_wearables
- Basic pipeline replicating previous papers:

Extract data using the Research Analysis Platform system → Prepare data for analysis → Explore accelerometer variables → Associate accelerometer-measured overall activity with cardiovascular disease risk

- A demo, not a prescription of best-practice
- Start a conversation – GitHub, community.dnanexus.com

Getting started with accelerometry variables

OxWearables/rap_wearables: An ×

github.com/OxWearables/rap_wearables/blob/main/2_Further_Prep_in_R.ipynb

throughout the day (meaning missing data could not be imputed in a way that would account for diurnal bias). See this paper
research questions, you may choose to select different criteria. For example, to study the difference between weekdays and we
both the week and the weekend. If you're interested in finding out more, check out the literature on accelerometer data qualit

We do the accelerometer data quality exclusions:

- Exclude participants whose device could not be calibrated:

In [55]:

```
nb <- nrow(dat)
dat <- dat[dat$quality_good_calibration == "Yes", ]
tab_exc <- rbind(tab_exc, data.frame("Exclusion" = "Poor calibration", "Number_excluded" = nb - nrow(dat), "
```

- Exclude participants for whom >1% of values were clipped (fell outside the sensor's range) before or after calibration:

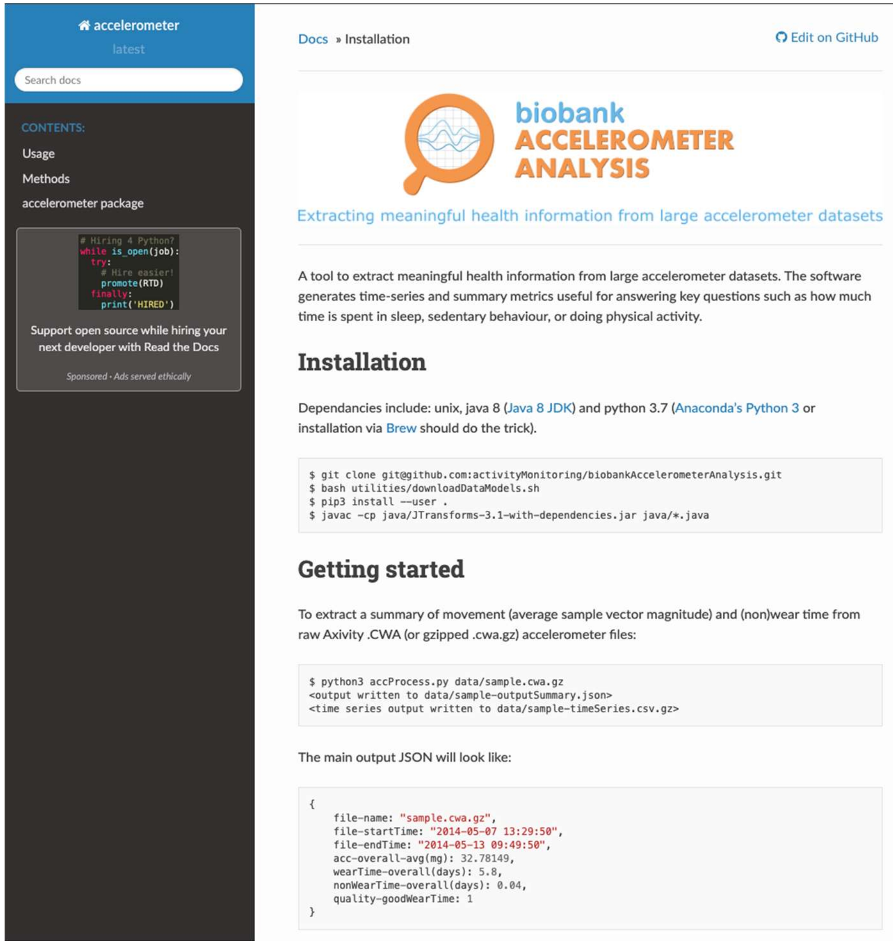
In [56]:

```
nb <- nrow(dat)
dat <- dat[(dat$clips_before_cal < 0.01*dat$total_reads) & (dat$clips_after_cal <0.01*dat$total_reads) , ]
tab_exc <- rbind(tab_exc, data.frame("Exclusion" = "Too many clips", "Number_excluded" = nb - nrow(dat), "Nu
```

Working with raw accelerometer data

- **Processing accelerometer data + applying ML models:** github.com/OxWearables/biobankAccelerometerAnalysis

- **Accelerometer data with ground-truth labels:** (e.g. model development) github.com/OxWearables/capture24



Summary

- Wearables can enhance health research through better phenotype measurement
- In 2013–2015, ~100,000 UKB participants wore an accelerometer, a device to measure movement
- Used to study how movement-related phenotypes are associated with disease, genetics and other health-related phenotypes
- Open-source resources available e.g. introductory repo from this webinar