

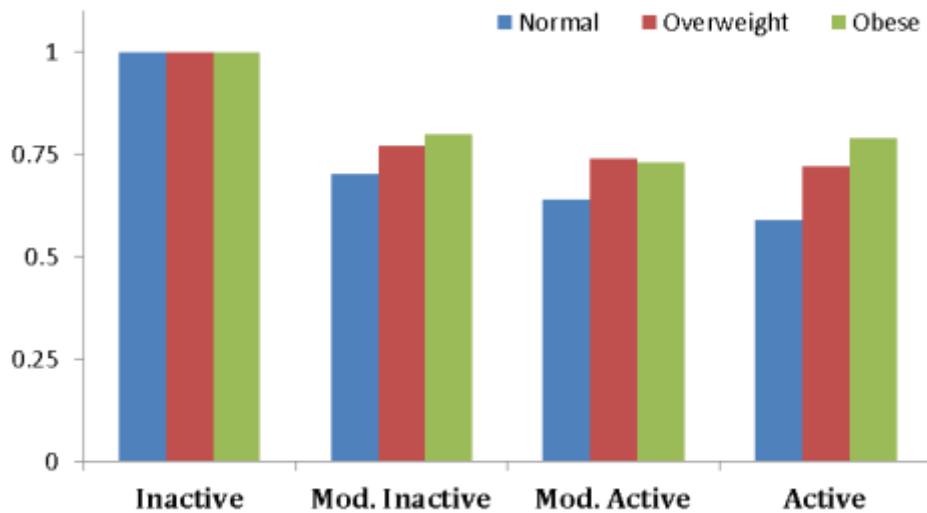
Physical Activity

Soren Brage & Aiden Doherty

on behalf of the Biobank Accelerometry Working Group

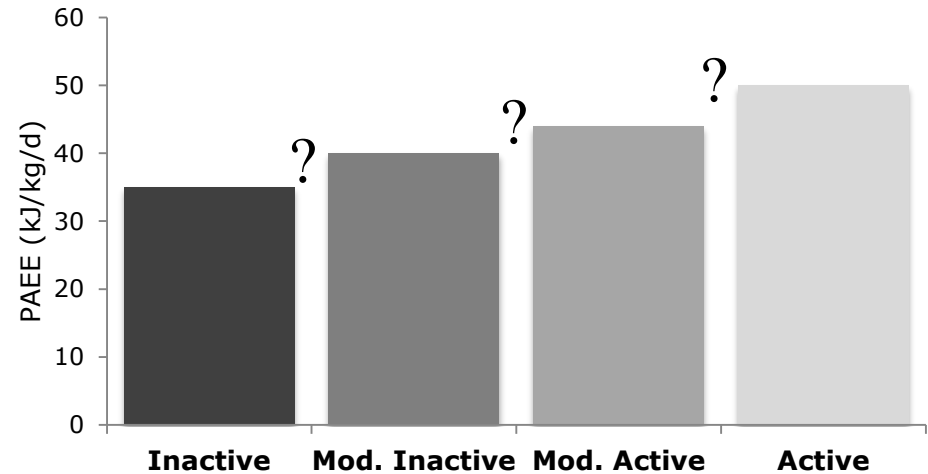
Physical Activity and all-cause mortality

EPIC-Europe; n=500,000,
>20,000 deaths



Ekelund et al, AJCN 2015

Calibration study; n=2000



InterAct Consortium, EJE 2012



**“20 min/day brisk walking
lowers mortality by 25%”**

A new era for Physical Activity Epidemiology

1950 1960 1970 1980 1990 2000 2010 2020

Ecological studies

Moderate sized prospective cohort studies establishing association with major disease outcomes

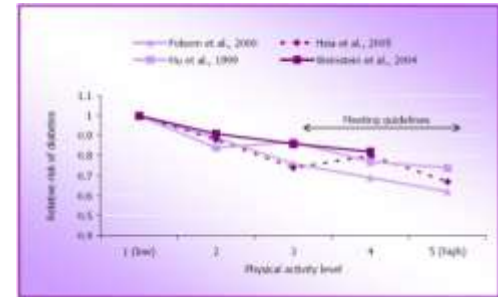
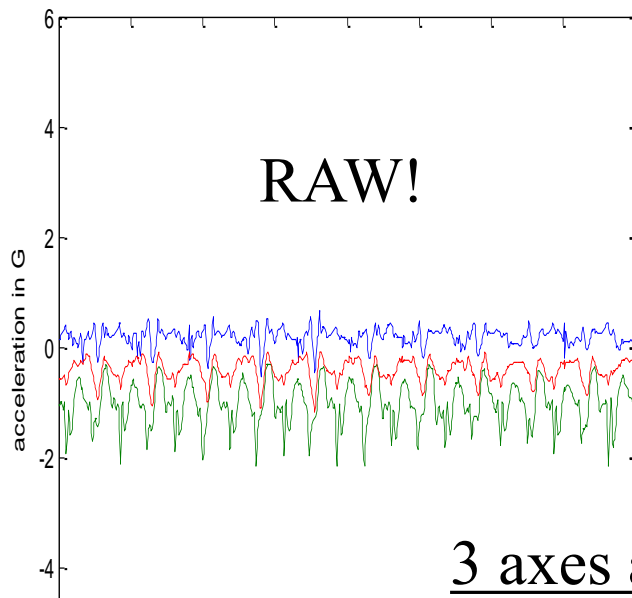
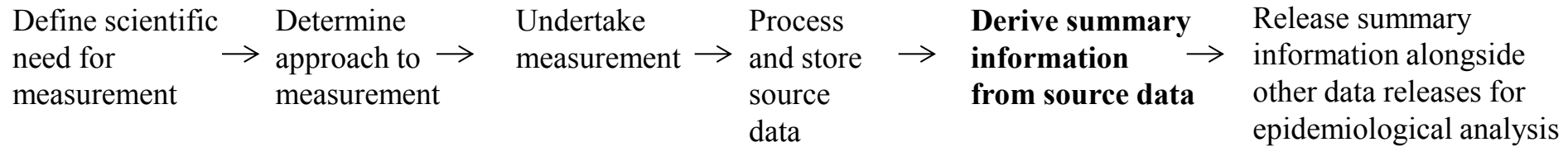
Large prospective cohort studies establishing association with rarer disease outcomes using simple global indices of PA

Smaller studies with detailed measures establishing dose-response relationships with quantitative traits

Large prospective cohort studies with detailed measures establishing dose-response relationships with disease outcomes



Biobank physical activity data processing



3 axes and 3 components

- Activity
- Gravity
- Noise



Response rate

240 000 invited

106 053 consented (44.2%)

103 720 datasets received (97.8%)

Reasons for data loss

1350 declined
132 597 no response

2333 Datasets lost
87 subsequent participant withdrawals
1316 devices not returned
930 datasets unreadable

Wear time analysis

103 586 for wear time analysis (99.9%)

123 aged <45yrs
at time of wear

11 datasets not calibrated
8 with no other successful uses of device
3 with >1% of values 'clipped' before/after calibration

3049 participants with insufficient stationary data
2887 re-calibrated using previous device use
154 re-calibrated using next device use

Physical activity analysis

96 608 for physical activity
analysis (93.3%)

6978 insufficient wear time
< 72hrs wear
+ data missing in at least one-hour period of the 24-hour cycle

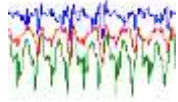
Additional information

e.g. device, location, age, sex, anthropometrics

I. Raw measurement and data storage

Triaxial acceleration waveform (~100Hz)

- Uncalibrated signal
- Variable sampling frequency
- Potentially interrupted signal
- *Page level:* Clock, temperature, interrupts



II. Post-processing

- Sensor calibration to local gravity
 - within-record (or closest)
- Time-stamping and resampling
- Filtering of machine noise (>20Hz)
- Identification of non-worn time

III. Feature extraction

e.g. mean magnitude, standard deviation, pitch, roll, power spectra, wavelets, pattern matching

IV. Prediction

e.g. whole-body movement intensity, activity type, PAEE

Data acquisition level

Time-independent level

..... I N F E R E N C E>

Accelerometer calibration to local gravity

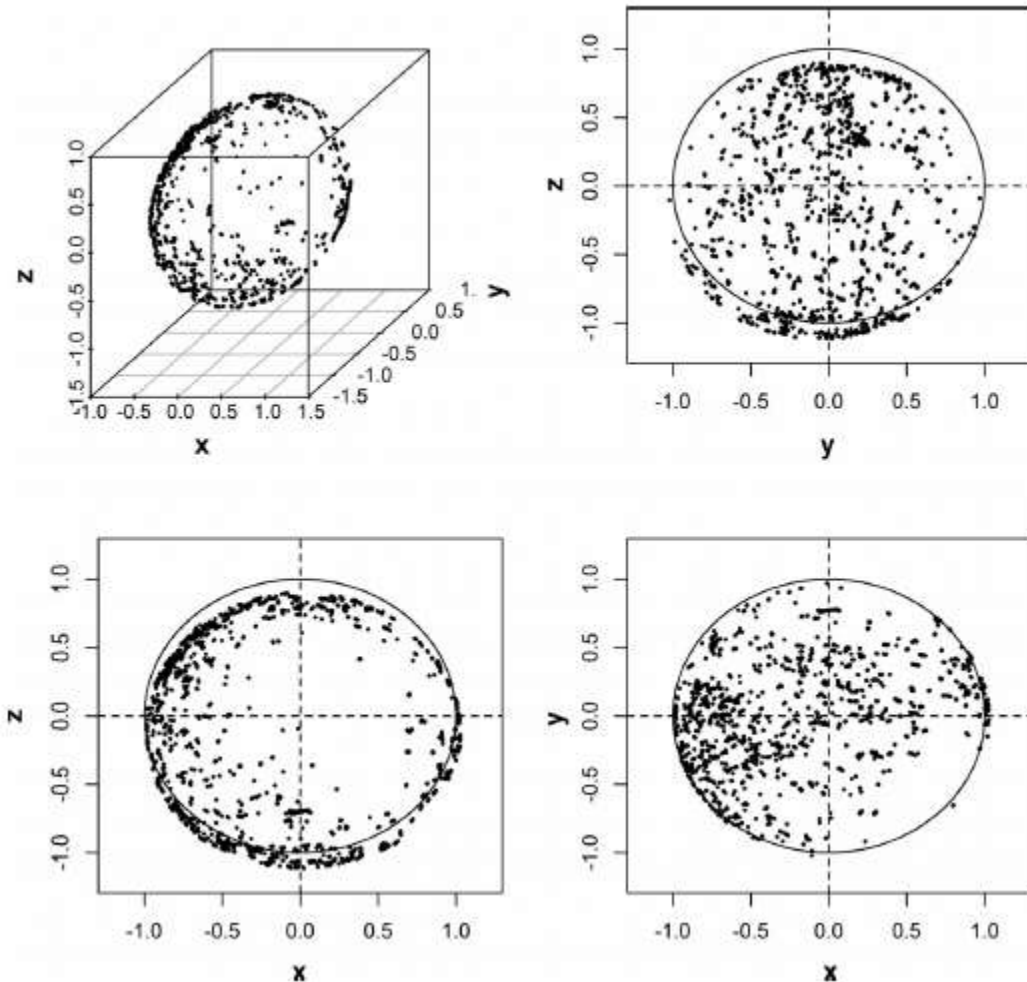


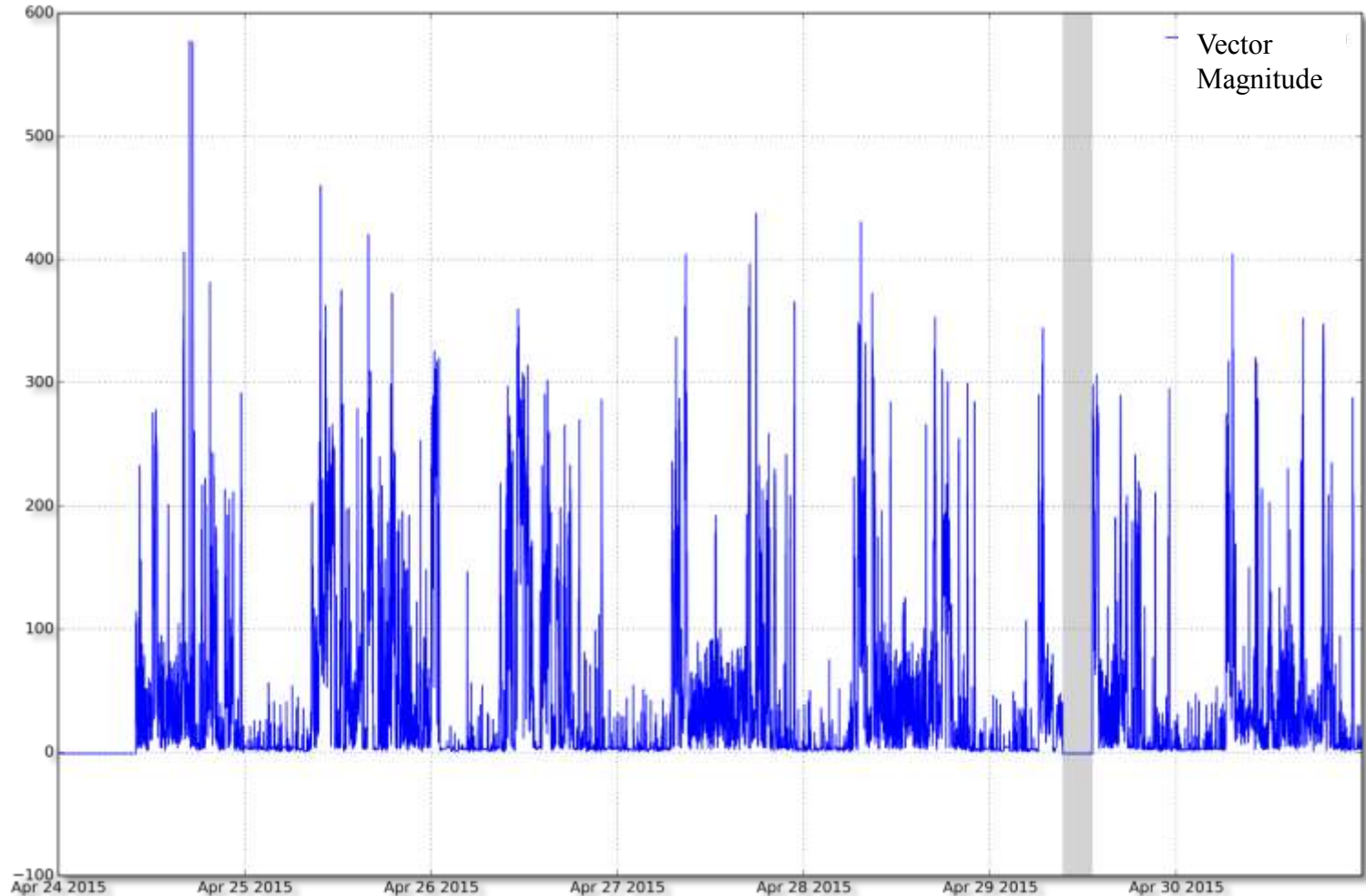
Table 4. Impact of autocalibration on daily wrist acceleration calculated with metric ENMO

Cohort/Metric	C ₀	C ₁	C ₂
UK			
Daily average	34.4 (8.4)	31.8 (11.8)	31.3 (8.3)
P5	6.2 (6.9)	4.5 (1.7)	3.6 (1.8)
P25	13.7 (9.9)	9.4 (3.3)	7.7 (3.5)
P50	27.1 (11.6)	24 (7.4)	23.7 (7.6)
P75	46.4 (14.8)	44.5 (12.2)	44.6 (12.3)
P95	87.4 (29.6)	86.1 (28.4)	86.5 (28.4)
P97.92	113.9 (49)	112.7 (48)	113 (48)
Kuwait			
Daily average	28.6 (8.1)	24.6 (9.3)	24.5 (8.1)
P5	5.7 (4.2)	2.8 (1.0)	2.7 (0.9)
P25	12 (6.2)	6.3 (2.6)	6.1 (2.6)
P50	21.6 (7.8)	17.3 (6.1)	17.3 (6.1)
P75	36.4 (11.5)	33.2 (10.6)	33.2 (10.6)
P95	74.4 (36)	72.2 (35.9)	72.1 (36.0)
P97.92	100.9 (66.4)	99 (66.5)	98.9 (66.6)
Cameroon			
Daily average	53.3 (16.4)	34.5 (18.8)	34.5 (16.4)
P5	18.1 (8.5)	3.6 (0.9)	3.5 (0.9)
P25	32.4 (11.1)	8.4 (3.6)	8.3 (3.7)
P50	45.9 (12.4)	25.3 (7.5)	25.3 (7.6)
P75	65.8 (29.3)	48.8 (28.6)	48.8 (28.5)
P95	112.8 (71.6)	98.9 (72.4)	99 (72.3)
P97.92	143.7 (93.1)	130.7 (93.6)	130.7 (93.6)
Brazil			
Daily average	80.6 (12.5)	39.7 (19.7)	39.5 (12.4)
P5	33.6 (15.3)	4.6 (1.7)	3.7 (1.6)
P25	55.2 (18.6)	11.6 (5.4)	10.4 (5.5)
P50	74.2 (19.7)	29 (10.7)	28.8 (11.0)
P75	96.6 (22.5)	54.3 (17.4)	54.7 (17.8)
P95	148.5 (37.7)	111.1 (37.5)	111.8 (37.4)
P97.92	183.4 (55)	147.7 (55.7)	148.5 (55.7)

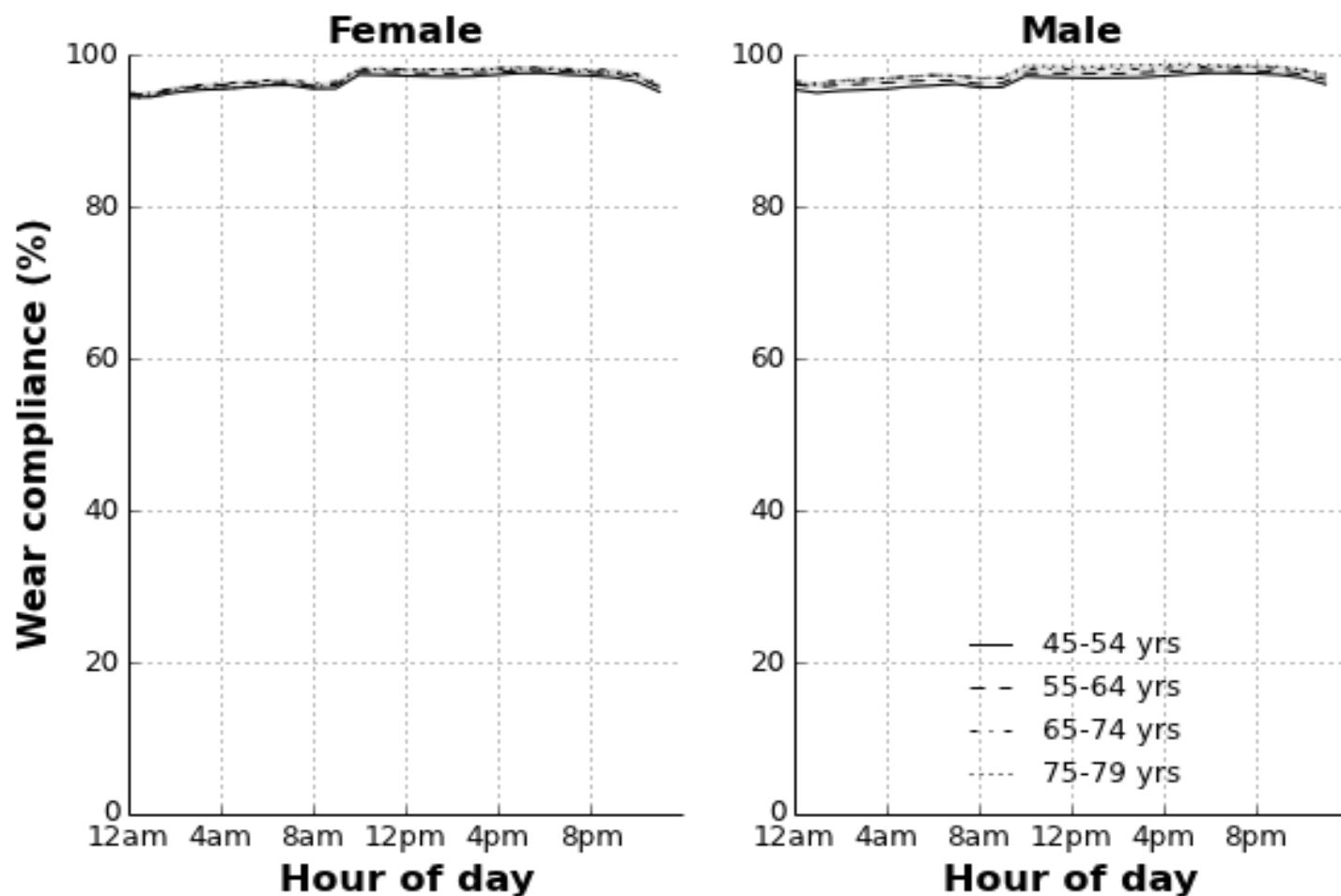
Accelerometer calibration to local gravity

	Un-calibrated Mean (sd)	Gravity-calibrated Mean (sd)
UK	34.4 (8.4)	31.8 (11.8)
Kuwait	28.6 (8.1)	24.6 (9.3)
Cameroon	53.3 (16.4)	34.5 (18.8)
Brazil	80.6 (12.5)	39.7 (19.7)

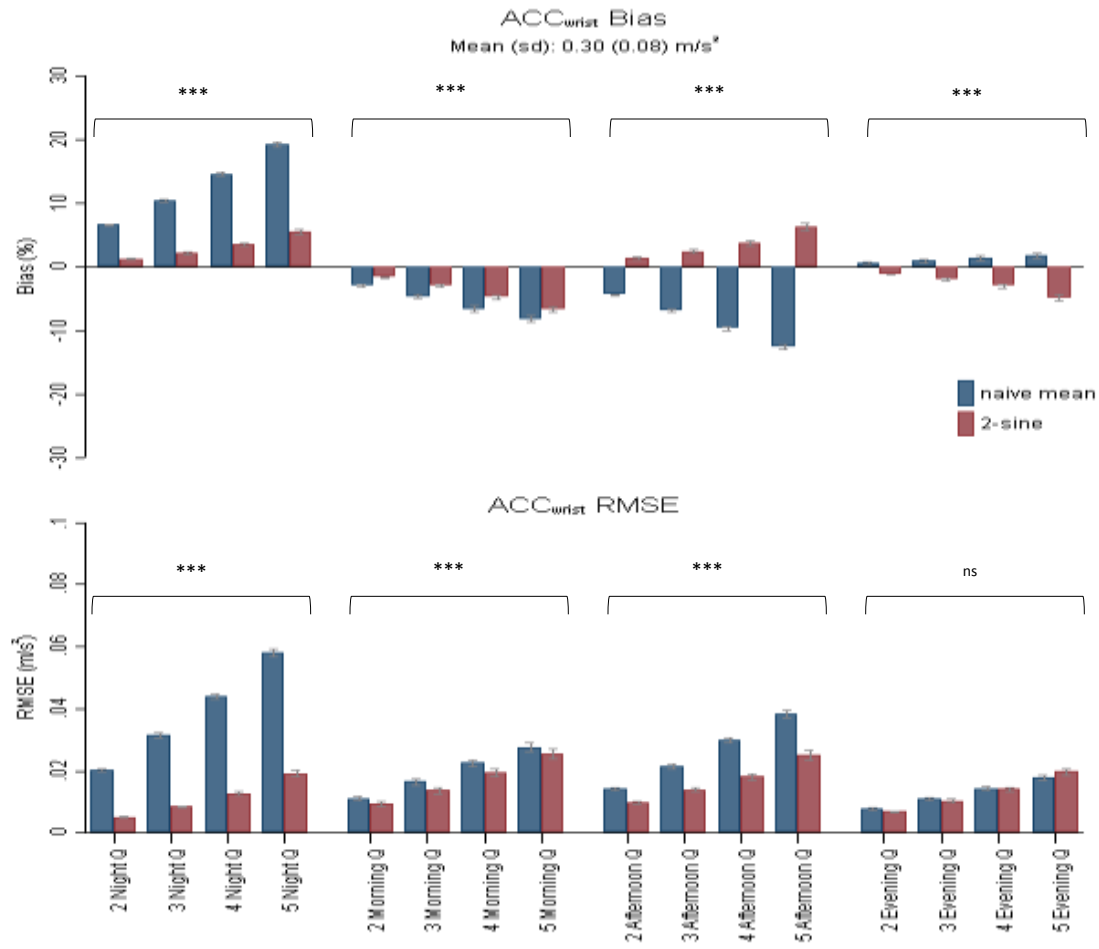
Non-wear detection: 10-sec SD of all 3 axes



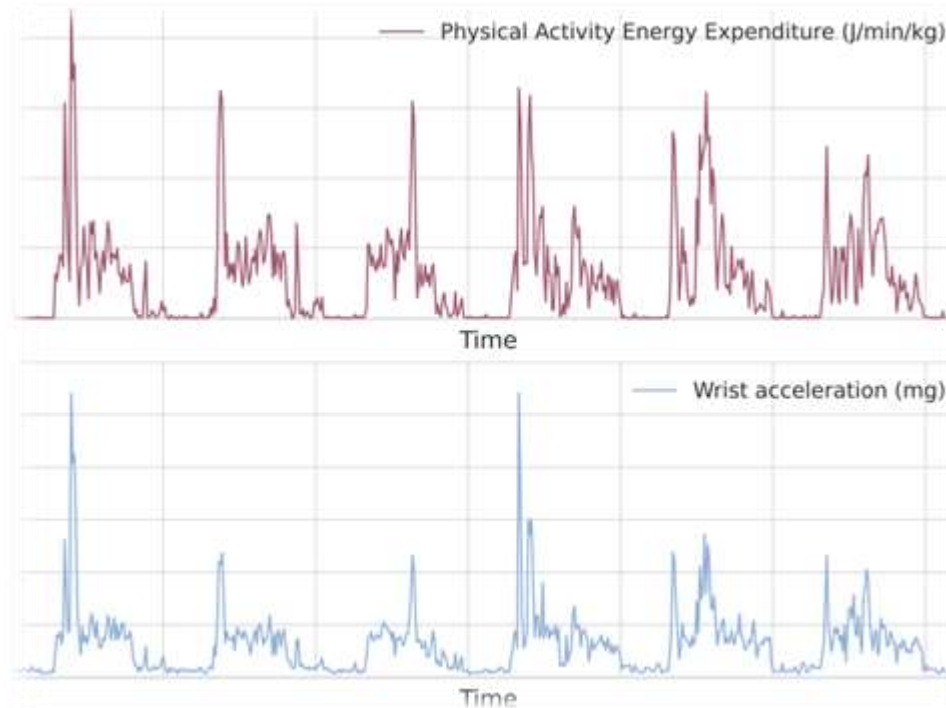
Wear compliance by age, sex and hour of day



Diurnal information bias: Missingness simulation



Comparison with other measures of activity



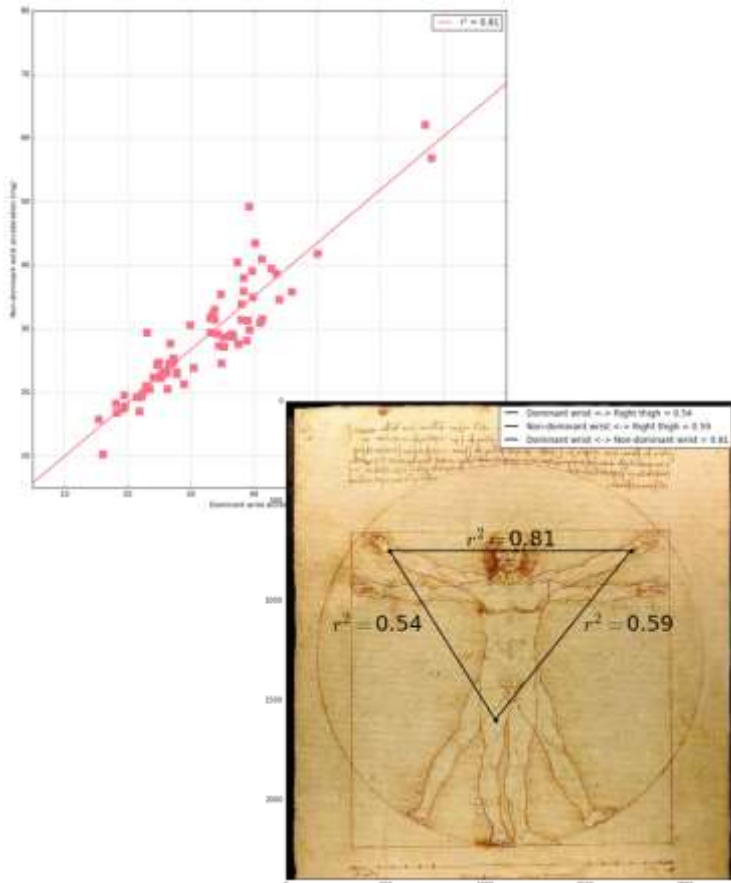
Validity

Vector magnitude \sim AEE_{DLW} (n=63 Swedish women, left or right wrist) : $r=0.61$

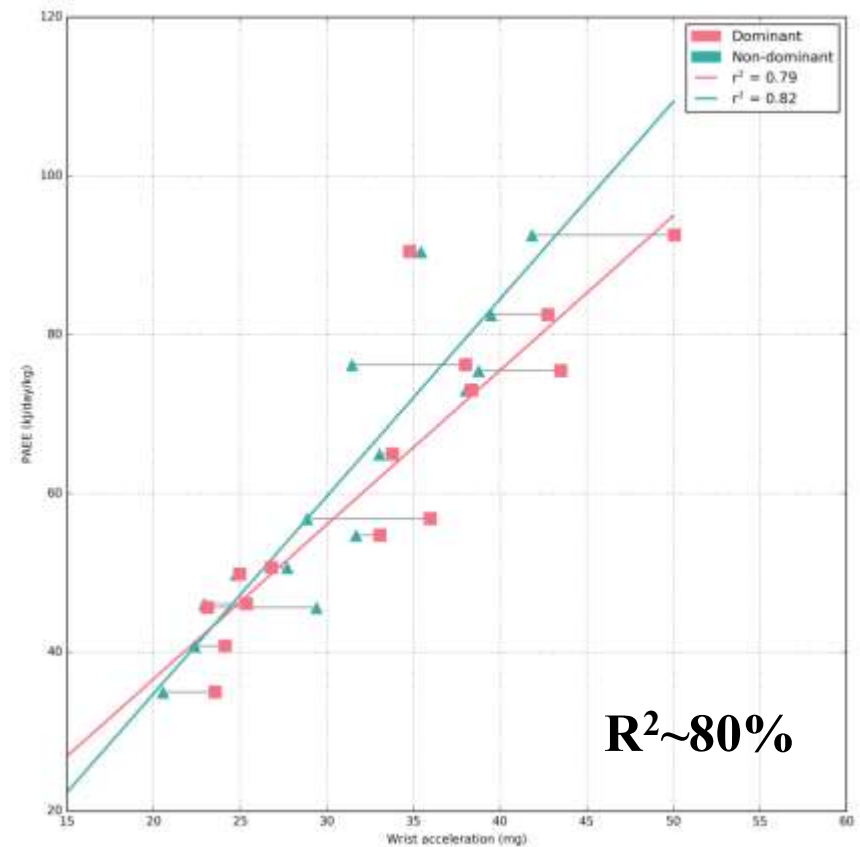
Vector magnitude \sim AEE_{Acc+Hr} (n=2000 UK adults, non-dominant wrist) : $r=0.66$

Further UK validation work (preliminary results)

Non-dominant vs dominant wrist acceleration

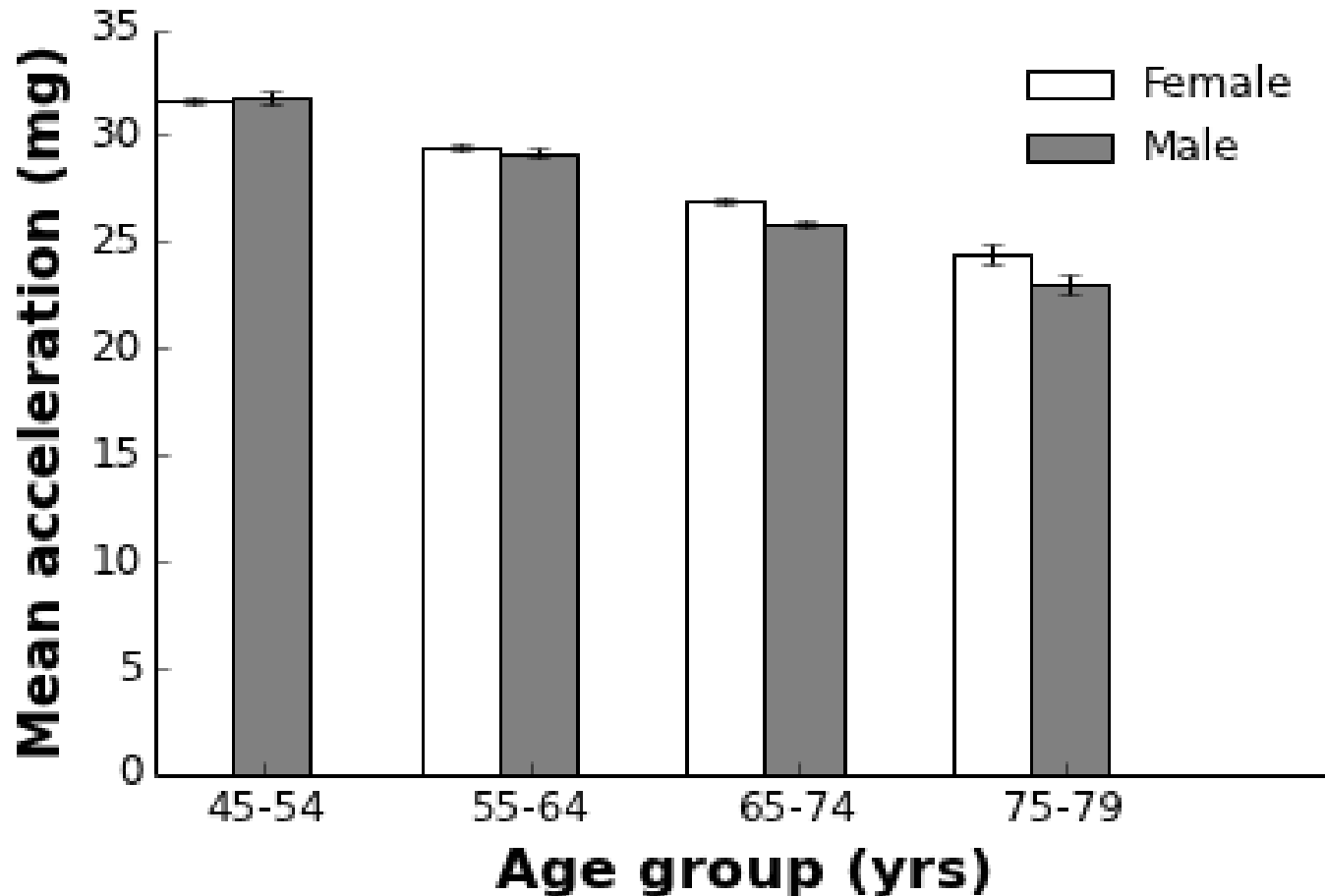


Wrist acc vs PAEE (dlw, n=16)

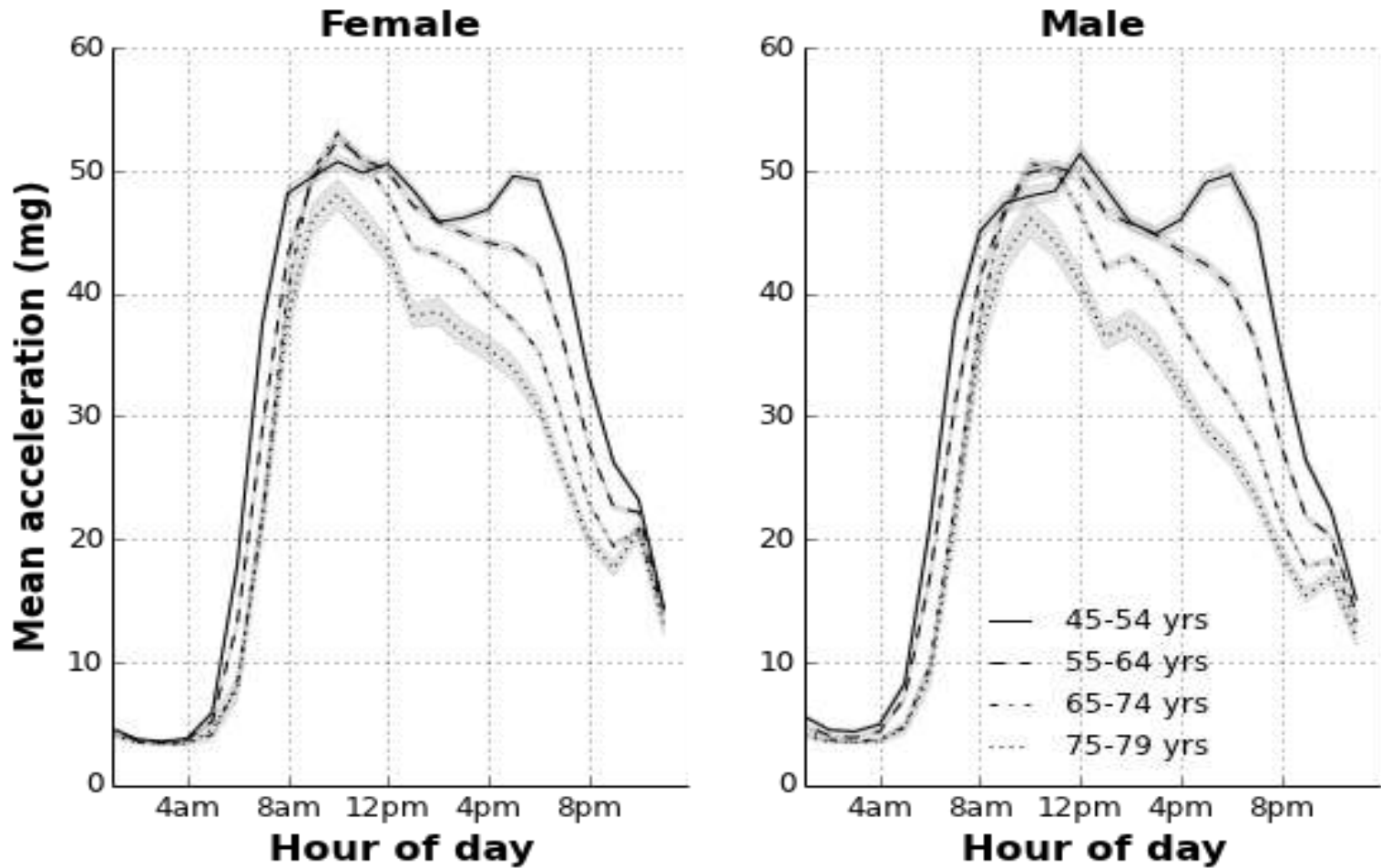


White et al (in preparation)

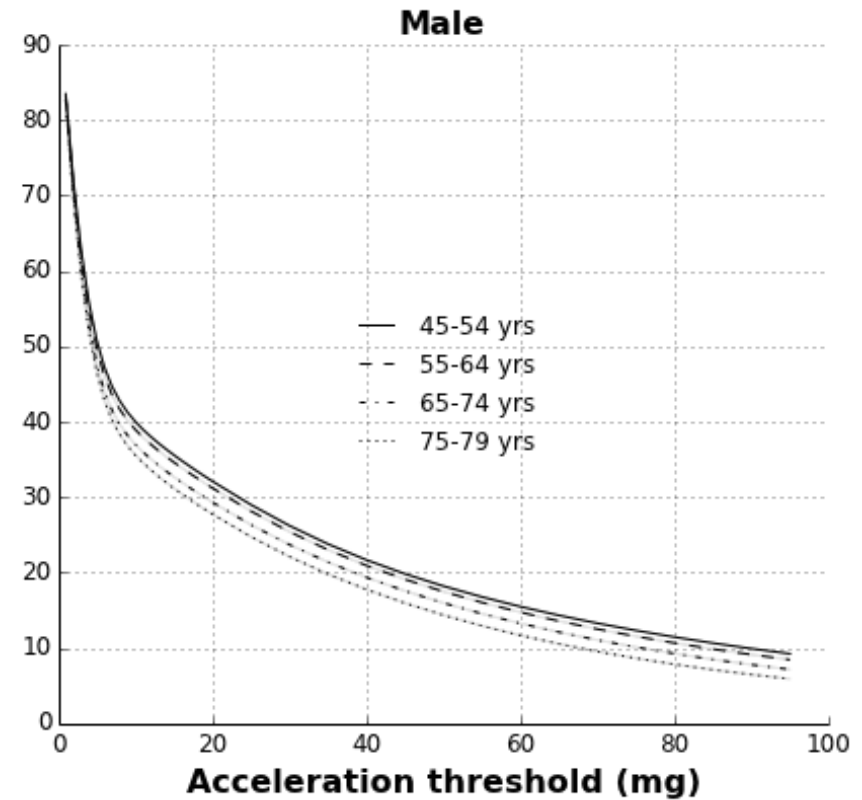
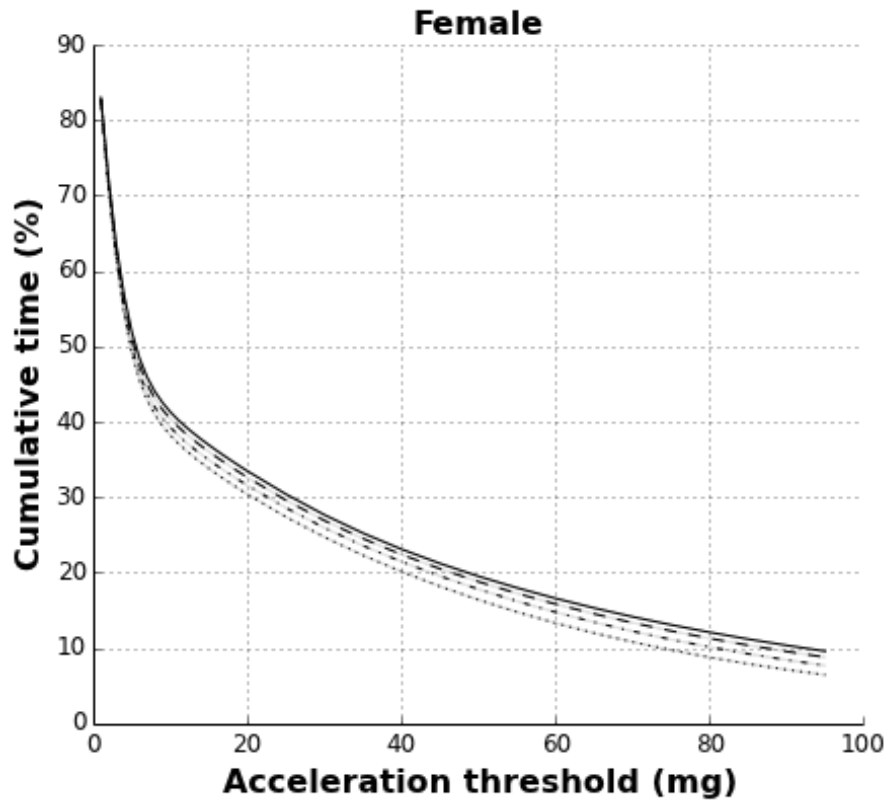
Average vector magnitude by age and sex



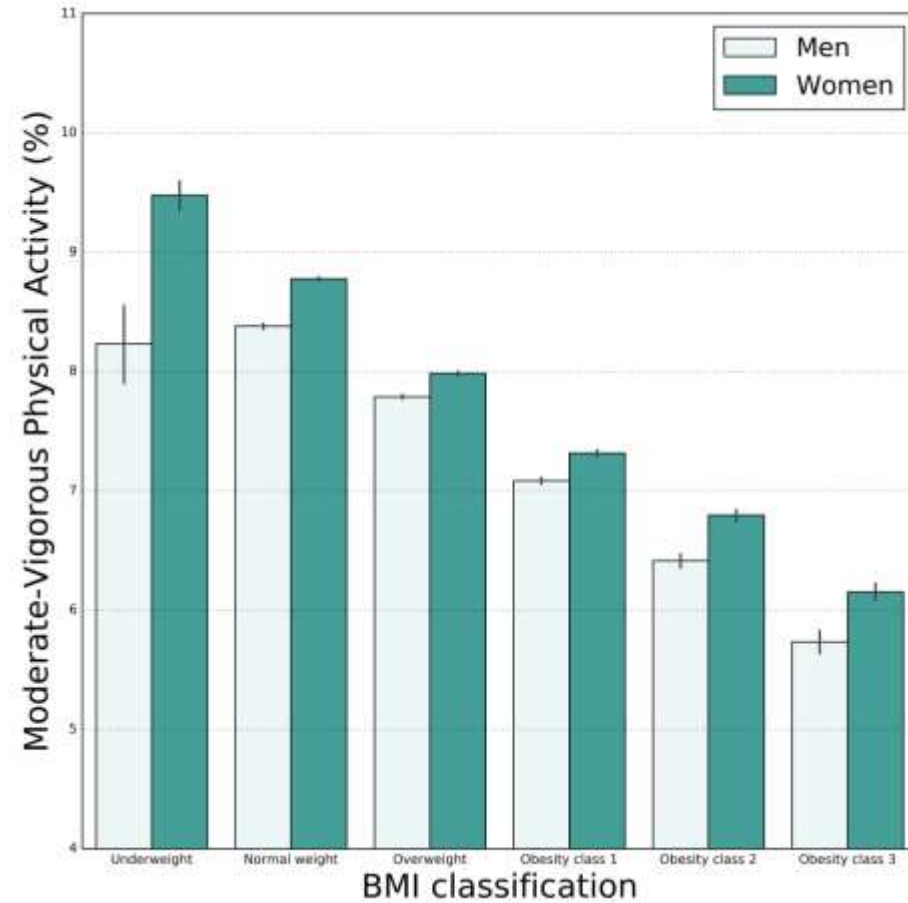
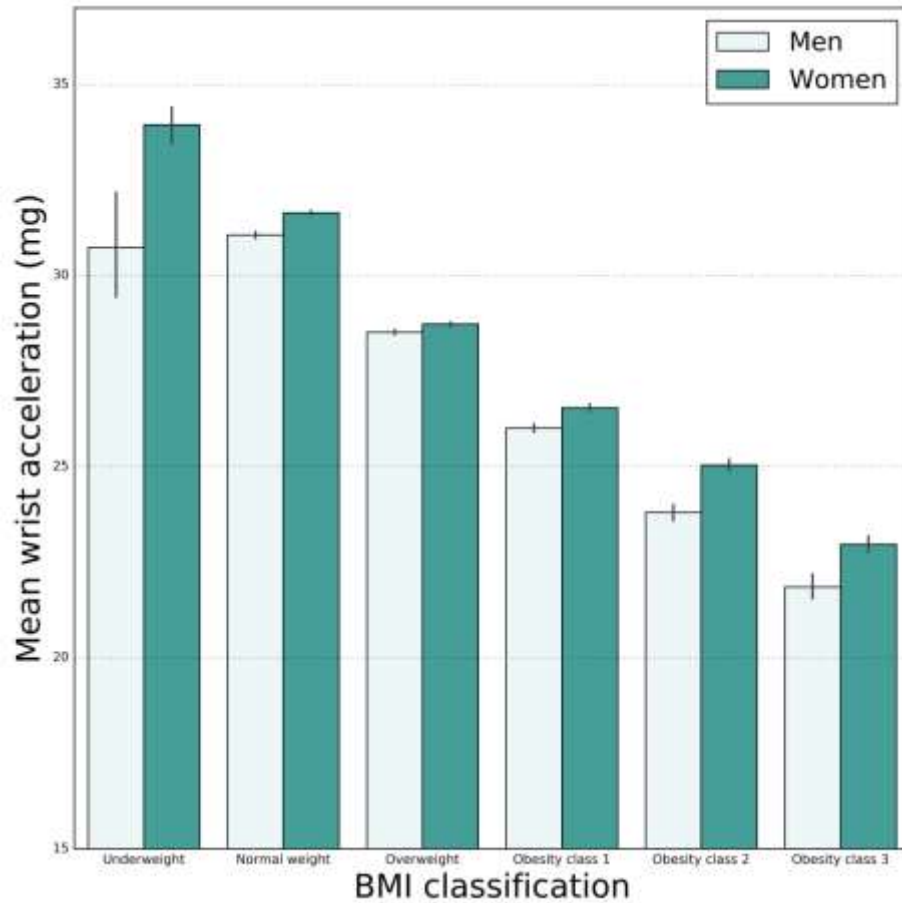
Average vector magnitude by age, sex and hour of day



Movement intensity distribution by age and sex



Associations with weight status



- Consensus summary variables available in the data showcase
 - Use as
 - **exposures**
 - **confounding control**
 - **mediators**
 - **outcomes**
- Post-processed signal data also available (as bulk)
 - e.g. for further inference work
- Raw binary data also available (as bulk)

Biobank Accelerometry Working Group

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Activity Type
Working Group

UK Biobank
Sleep Working
Group

etc