



# Thigh-worn Accelerometer Measurements: Consistency Across Different Positions

Fabio Franzese, Pasan Hettiarachchi, Peter Johansson

4th MASS Workshop

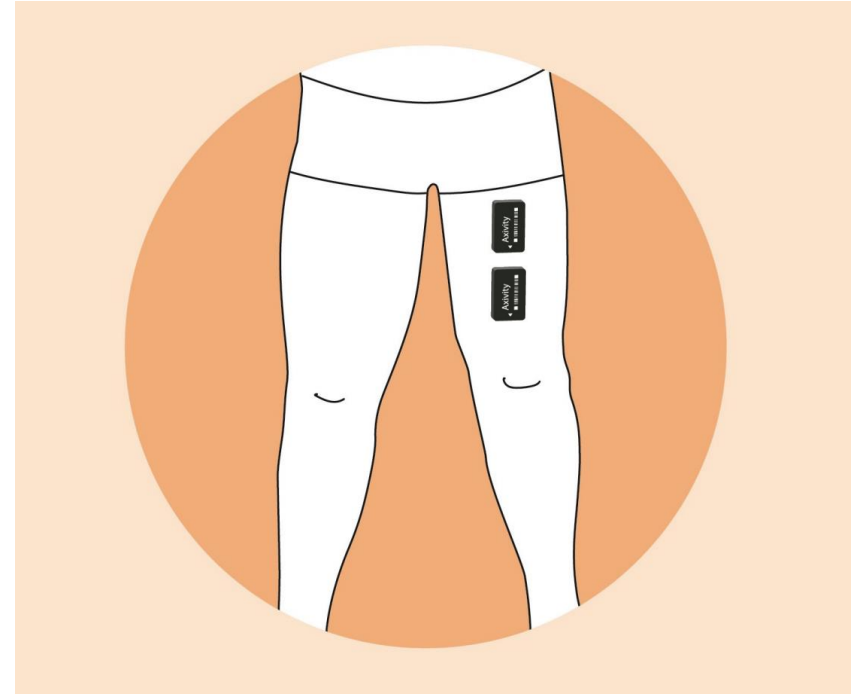
Manchester, 22-23 June 2023

- Thigh-worn accelerometers enable to identify postures and activities
- Exact placement on the thigh is not harmonised across studies/protocols
  - Most studies collected thigh-worn accelerometer data at the **centre of the thigh**. (Crowley et al. 2019)
  - In SHARE “the device should be placed on the **upper half** on the front part” of the participant’s thigh. (Scherpenzeel et al. 2021)
  - The ProPASS protocol instructs to wear the device **10 cm above the patella**.

Do the outcomes of the thigh-worn accelerometer measurement depend on the exact position of the device?

- Implications for comparability between studies
- Implications for designing instructions/protocols

- April-May 2023
- Convenience sample
- **Two** accelerometers were worn **simultaneously** on the same thigh
  - centre and upper thigh
  - for seven days during everyday life
  - Axivity AX3, 50Hz
  - Accompanied by a short Questionnaire



© SHARE ERIC

Sensor Data will be made available

# Sample & Data Processing

## Sample:

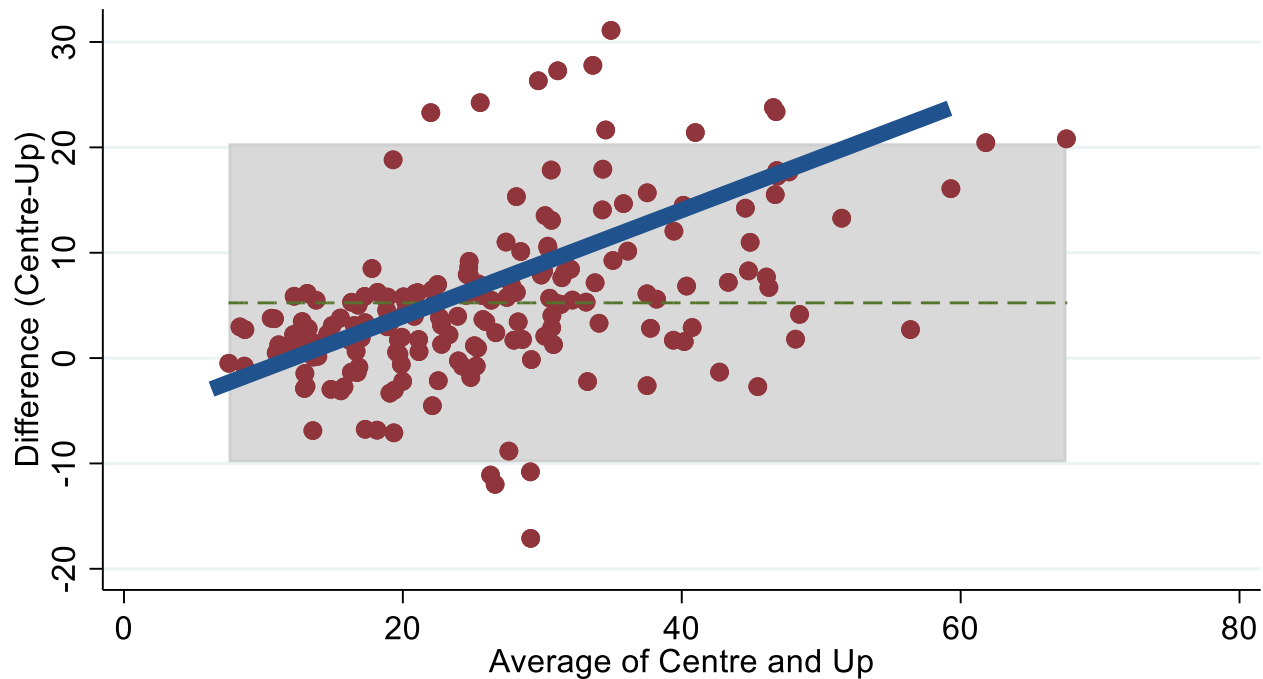
- 34 Participants
  - 184 days
- 59% female, 41% male
- Age 26-72 years (mean 39)
- Gap between devices: 2.5 - 13cm
  
- Preliminary data!
  - Data cleaning is not yet completed

## Sensor data is processed with:

- GGIR 2.9.0 (van Hees et al 2023)
  - ENMO (average acceleration)
- ActiPASS 1.56 Beta (Hettiarachchi & Johansson, 2023)
  - Time walking

# Results: ENMO

ENMO (Average Acceleration)



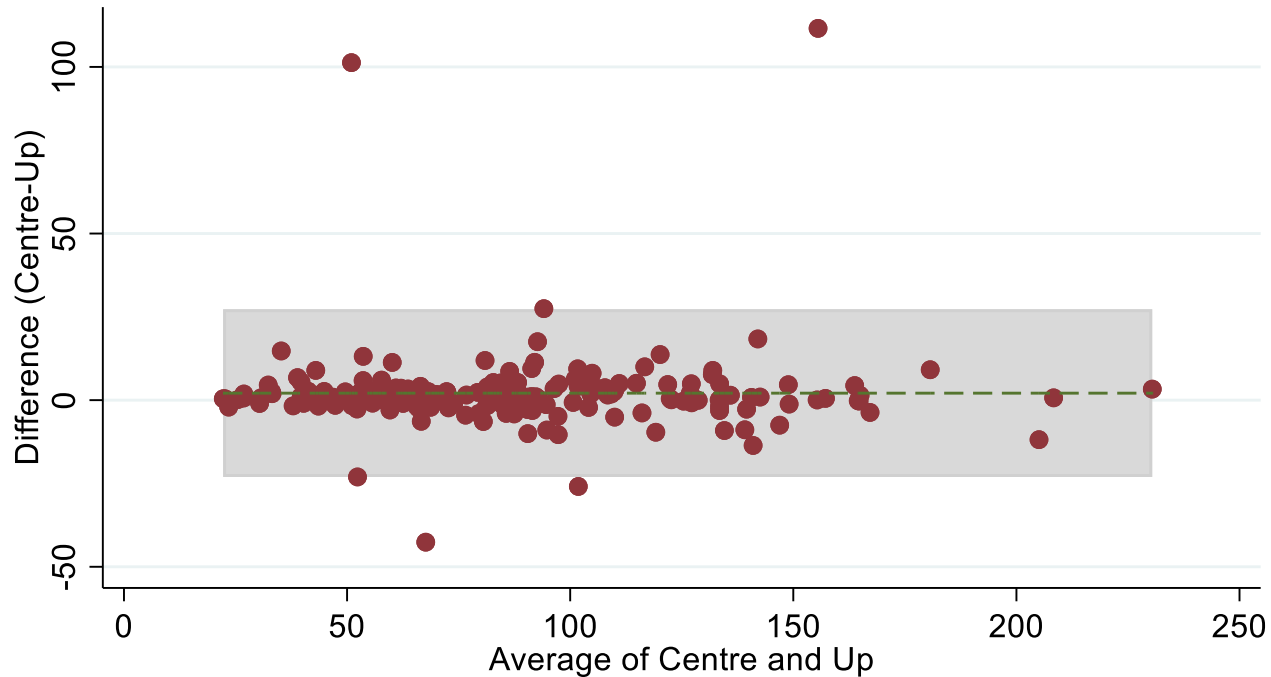
Linear OLS Regression	Difference in ENMO
Mean ENMO	0.34 ***
Device Gap	0.71 *
Height	-0.18
Thigh Length	0.15
Age	0.24 *
Gender	
Male	5.98
Intercept	3.32
R-squared	0.53
Number of observations	184

\*\*\* p<.001, \*\* p<.01, \* p<.05

Preliminary Data & Results

# Results: Time walking

Time spent walking



Linear OLS Regression	Difference in walking time
Mean walk	0.03
Device Gap	-0.21
Height	0.13
Thigh Length	0.21
Age	-0.22
Gender	
Male	0.63
Intercept	-22.77
R-squared	0.05
Number of observations	184

\*\*\* p<.001, \*\* p<.01, \* p<.05

Preliminary Data & Results

## **Average acceleration**

Position on the thigh matters

- Not suitable to compare data from different thigh positions / protocols
- Makes it even harder to define cut-points for light, moderate, and vigorous activities

## **Posture and activities (ActiPASS)**


Less affected by position of sensor

- Better comparability across studies/ protocols
- Participants can attach devices themselves (without introducing a large bias if instructions are not followed perfectly)

Preliminary Data & Results

# Thank You!

## Questions?

Fabio Franzese  
SHARE BERLIN Institute  
Chausseestraße 111, 10115 Berlin  
@ ffranzese@share-berlin.eu  
 @ffranzese\_



# References

- Crowley, Skotte, Stamatakis et al. 2019: Comparison of physical behavior estimates from three different thigh-worn accelerometers brands: a proof-of-concept for the Prospective Physical Activity, Sitting, and Sleep consortium (ProPASS). *Int J Behav Nutr Phys Act* 16, 65.
- Hettiarachchi, P., & Johansson, P. (2023). ActiPASS (Version 1.56) [Computer software]. <https://doi.org/10.5281/zenodo.7701098>
- Scherpenzeel, Angleys, Franzese, Weiss. 2021: Measuring physical activity in SHARE: The SHARE accelerometer study. In: Bergmann and Börsch-Supan (Eds.) *SHARE Wave 8 Methodology: Collecting Cross-National Survey Data in Times of COVID-19*. 183-193.
- van Hees, Fang, Zhao, Heywood, Mirkes, Sabia, Migueles (2023). GGIR: Raw Accelerometer Data Analysis. doi:10.5281/zenodo.1051064, R package version 2.9-0, <https://CRAN.R-project.org/package=GGIR>.

# Appendix

# Sample

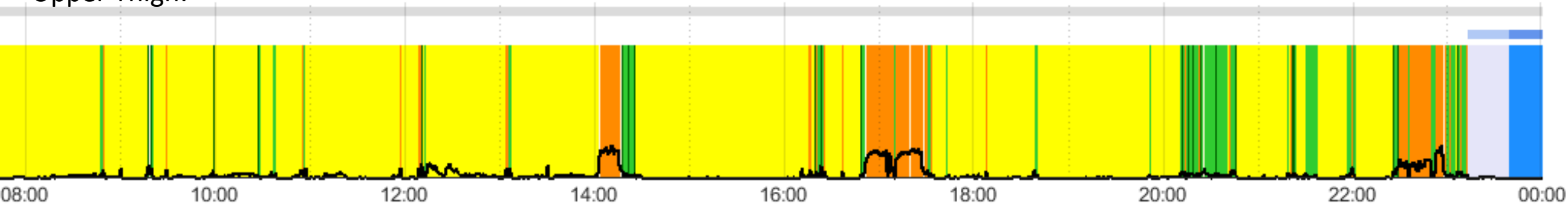
<i>Participants</i>	Obs	Mean	Std. dev.	Min	Max
Age	34	39.2	11.3	26	72
Valid days	34	5.4	2.1	1	7
Device Gap (cm)	34	7.4	2.1	2.5	13
Height (cm)	34	172.4	9.6	155	193.6
Thigh Length (cm)	34	46.0	3.9	36	55

<i>Days</i>		Obs	Mean	Std. dev.	Min	Max
<b>ENMO</b>	Centre	184	29.0	13.8	7.3	78.0
	Upper	184	23.7	10.3	6.8	57.2
	Difference	184	5.2	7.71	-17.1	31.1
<b>Walking</b>	Centre	184	88.4	39.9	22.4	232.1
	Upper	184	86.2	39.5	0.3	228.8
	Difference	184	2.1	12.8	-42.6	111.6
<b>Number of steps</b>	Centre	184	11698.2	5657.7	2710	31118
	Upper	184	11393.1	5544.2	2602	28560
	Difference	184	305.1	507.0	-577	373

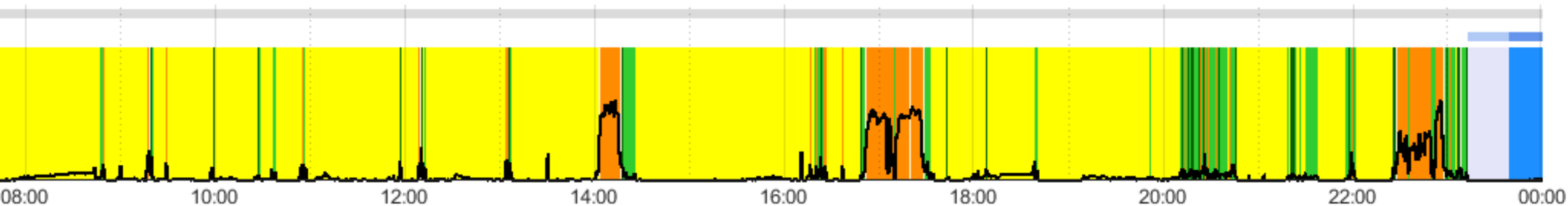
# Example: ActiPASS Output

- Colors indicate detected activities: yellow = sitting; orange = walking; green = standing; grey = lying; blue = sleeping
- Black line indicates acceleration

Upper Thigh:

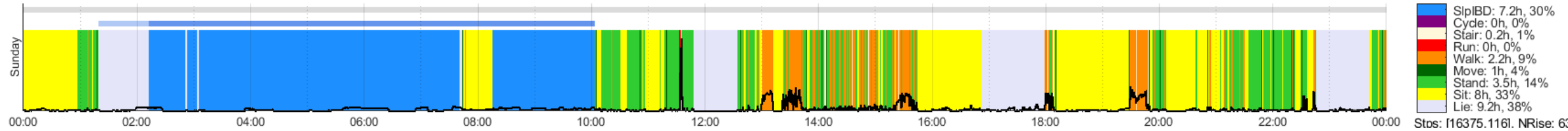


Mid-Thigh:

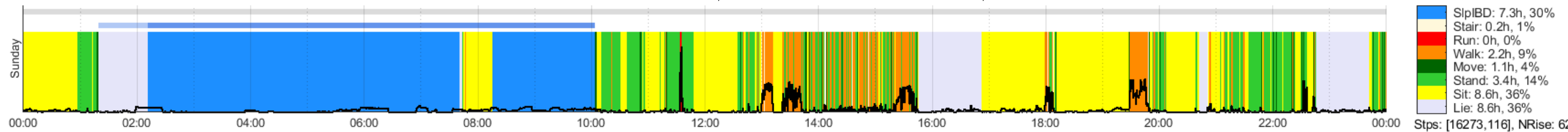


# Example ActiPASS Inconsistency: Sitting vs. Lying

Upper thigh:



Mid-thigh:

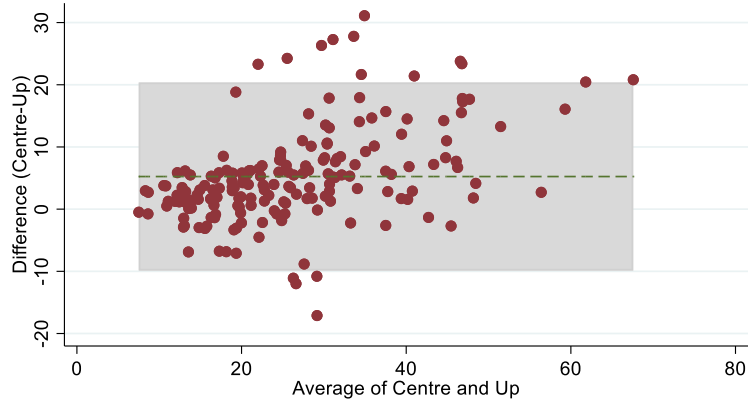


sitting in train

- Analysis by day (N=184)
- Bland-Altman-Plot
  - Plot mean and difference of two measurements
  - Agreement between measurements
  - Identify systematic bias
- Linear OLS Regression to control for other factor
  - Clustered standard errors (by participant)

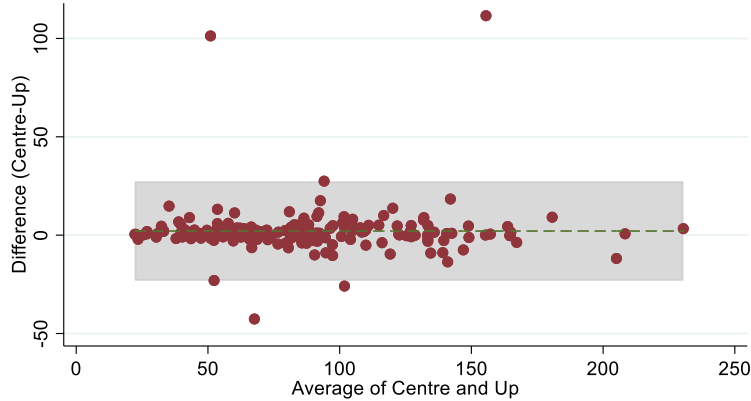
### ENMO (Average Acceleration)

16/184 = 8.70% outside the limits of agreement  
Mean difference 5.243  
95% limits of agreement (-9.874,20.361)  
Averages lie between 7.512 and 67.577



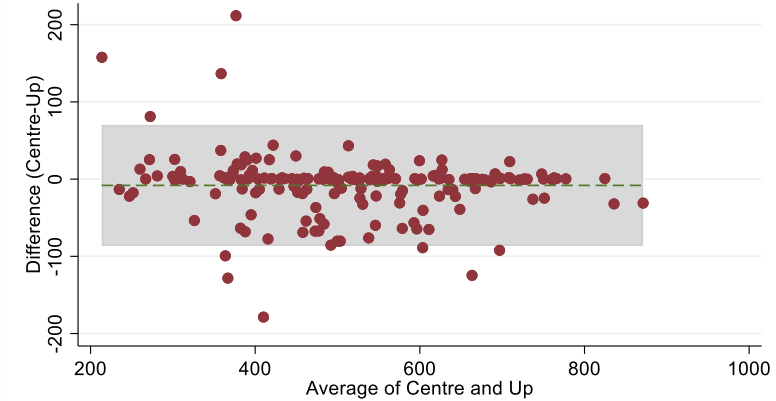
### Time spent walking

5/184 = 2.72% outside the limits of agreement  
Mean difference 2.113  
95% limits of agreement (-23.052,27.278)  
Averages lie between 22.235 and 230.425



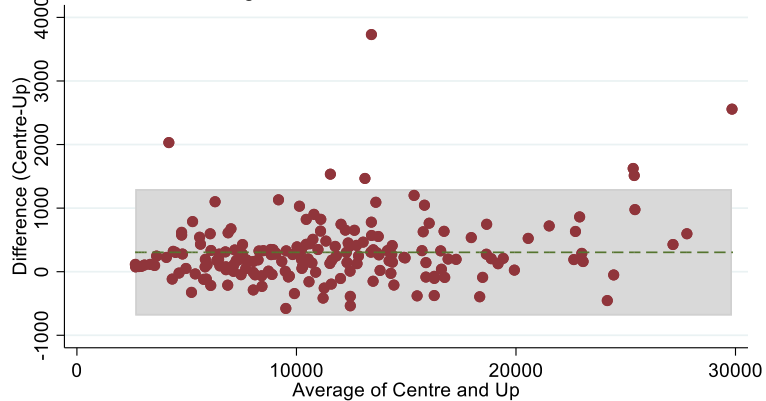
### Time spent sitting

10/184 = 5.43% outside the limits of agreement  
Mean difference -8.155  
95% limits of agreement (-86.484,70.174)  
Averages lie between 213.725 and 871.150



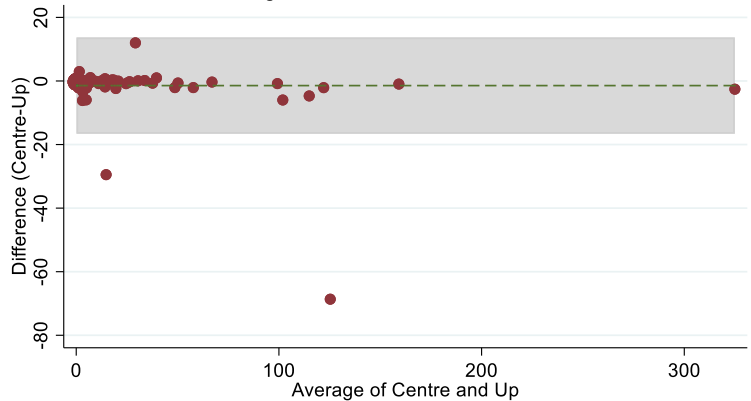
### Number of steps

7/184 = 3.80% outside the limits of agreement  
Mean difference 305.065  
95% limits of agreement (-688.724,1298.855)  
Averages lie between 2660.000 and 3.0e+04



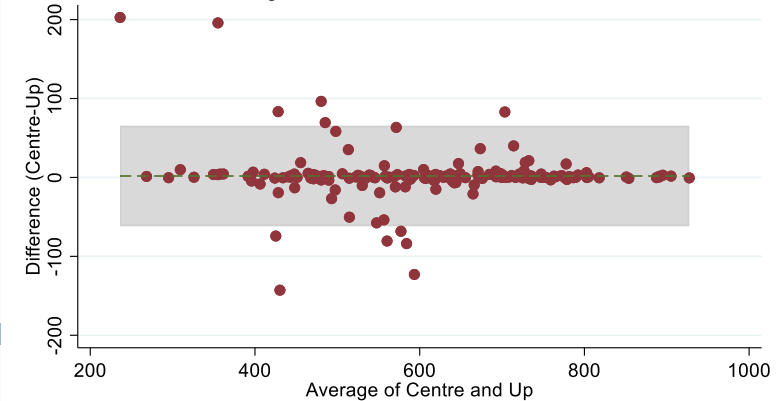
### Cycling

2/97 = 2.06% outside the limits of agreement  
Mean difference -1.449  
95% limits of agreement (-16.590,13.693)  
Averages lie between 0.135 and 324.935



### Sitting & Lying

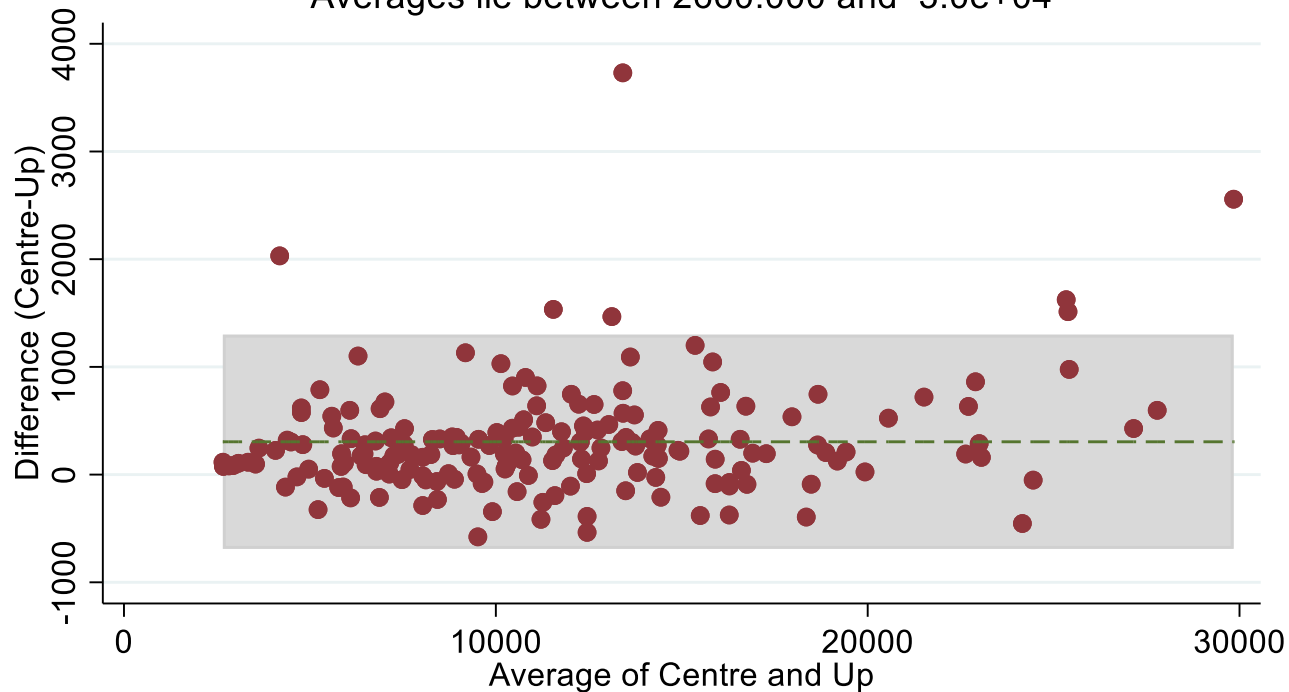
12/184 = 6.52% outside the limits of agreement  
Mean difference 1.845  
95% limits of agreement (-61.747,65.438)  
Averages lie between 236.190 and 927.285



# Results: Number of Steps

## Number of steps

7/184 = 3.80% outside the limits of agreement  
 Mean difference 305.065  
 95% limits of agreement (-688.724, 1298.855)  
 Averages lie between 2660.000 and 3.0e+04



Linear OLS Regression	Difference in number of steps
Mean numsteps	0.02 *
Device Gap	23.16
Height	3.08
Thigh Length	4.24
Age	1.65
Gender	
Male	-21.32
Intercept	-896.76
R-squared	0.06
Number of observations	184

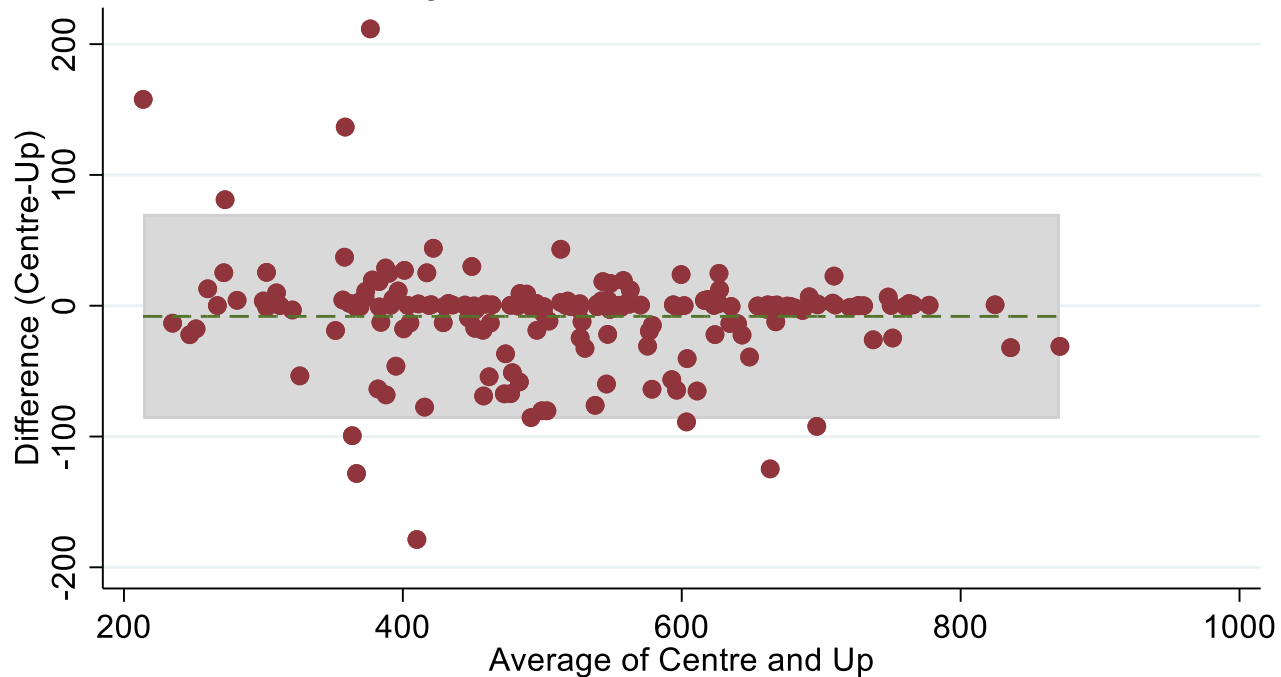
\*\*\* p<.001, \*\* p<.01, \* p<.05



# Results: Time sitting

## Time spent sitting

10/184 = 5.43% outside the limits of agreement  
 Mean difference -8.155  
 95% limits of agreement (-86.484, 70.174)  
 Averages lie between 213.725 and 871.150



Linear OLS Regression	Difference in sitting time
Mean sit	-0.03
Device Gap	-4.45 ***
Height	-1.54 ***
Thigh Length	2.46 **
Age	-0.87 ***
Gender	
Male	11.96
Intercept	221.21 ***
R-squared	0.09
Number of observations	184

\*\*\* p<.001, \*\* p<.01, \* p<.05