Impact of Lower-Back Sensor Height Variability on Stride Length Estimation

- Daniel Nicoll[1], Claire Brockett[1], Oliver Bandmann[2], Tecla Bonci[1]

1. School of Mechanical, Aerospace and Civil Engineering & INSIGNEO Institute for in silico Medicine, The University of Sheffield
2. Sheffield Institute for Translational Neuroscience, University of Sheffield

FACTS & FIGURES

Start date:	01 Apr 2019
End date:	30 Jun 2024
IMI / EU funding:	€25.40 million
EFPIA + other contribution:	€24.52 million
Total Cost:	€49.91 million
Grant agreement:	No. 820820
Project website:	mobilise-d.eu
Social media:	LinkedIn / X: Mobilise-D

CHALLENGE

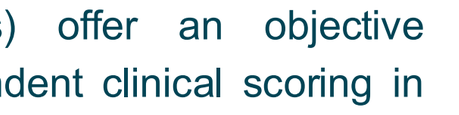
Digital mobility outcomes (DMOs) offer an objective alternative to subjective, rater-dependent clinical scoring in Parkinson's Disease[1,2]. While Mobilise-D validated DMOs using a single lower-back sensor and the mobgap pipeline[3], **sensor height** remains a critical yet **vulnerable parameter**. Essential for biomechanically estimating spatial parameters, sensor height naturally varies due to attachment methods like elastic belts. However, neither the **extent** of this **variability** nor its **impact** has been quantified, and **robust solutions** for missing, altered, or unrecorded height metadata remain unexplored.

APPROACH & METHODOLOGY

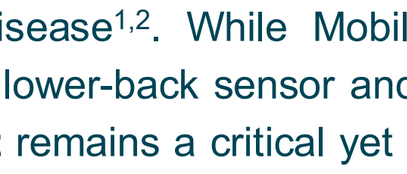
Healthy Adults (HA): n=20 71.7±5.8yrs 11M / 9F [4]

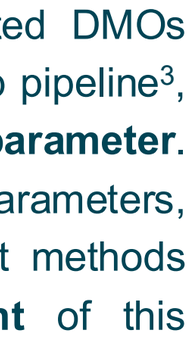
Parkinson's Disease (PD): n = 20 69.8±7.1yrs 16M / 4F
UPDRSIII $\bar{x}$=28.35±13.6 H&Y 1-3 [4]

Straight walk (Comfortable, slow, fast):

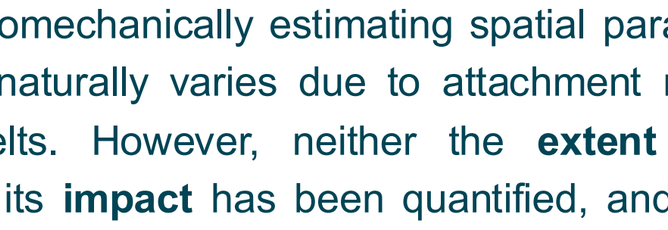


Surface test:

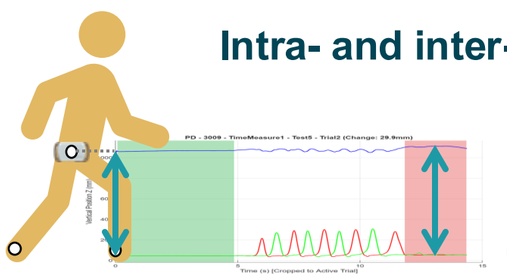




Hallway test:



Variability:



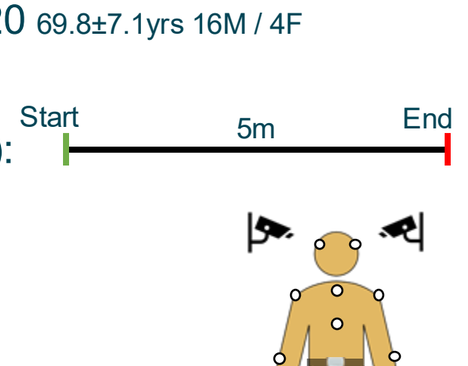
Intra- and inter-trial changes in sensor height.

Calculated using gold-standard motion capture and identification of stationary regions of gait tests.

Simulation:

For each participant (p), based on their relevant reported sensor height $(h_{R,p})$, sensor height changes have been simulated $(h_{S,p})$ as:

$$h_{S,p}(cm) = h_{R,p} - 10{:}\,0.5{:}\,h_{R,p} + 10$$



Anthropometric Approximations:



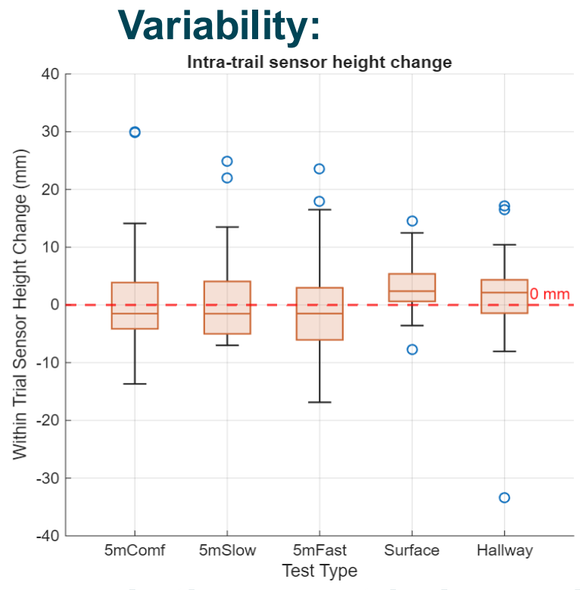
Linear regression methods for anthropometric proportion estimation for height of the upper pelvis for sensor height:

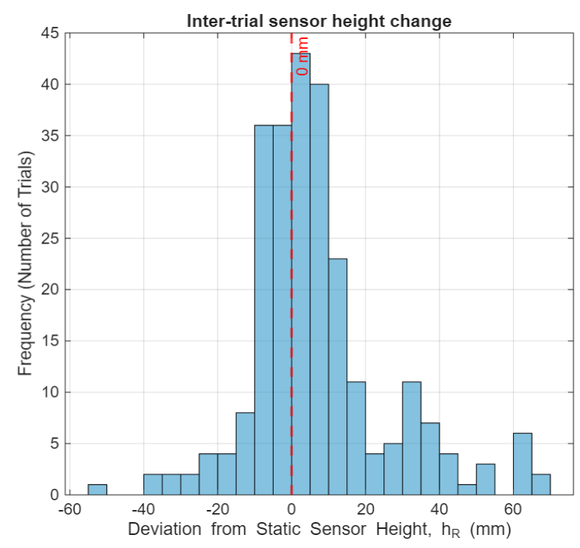
De Leva[5] vs Ha Hoang[6]

This work has received support from the EU/EFPIA Innovative Medicines Initiative 2 Joint Undertaking (MOBILISE-D grant no. 820820).

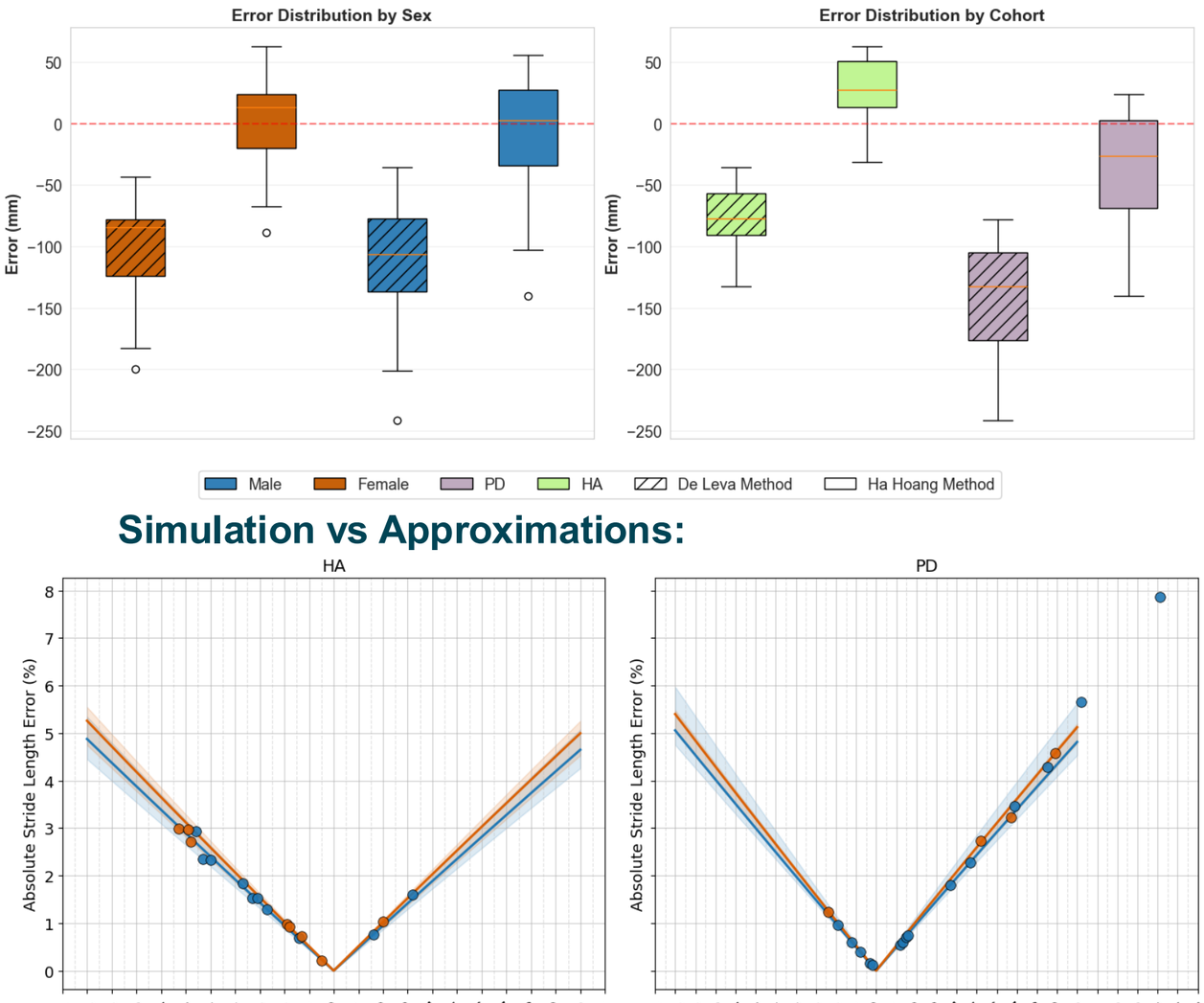
RESULTS

Variability:





Anthropometric Approximations:



Simulation vs Approximations:

VALUE OF IMI COLLABORATION

Research enabled by the MOBILISE-D collaboration provides access to open-source technical validation datasets and a validated algorithmic pipeline for processing digital mobility outcomes (DMOs). Building on this foundation, this study aims to enhance the robustness of the standardised processing framework by **understanding the impact of sensor height** variability, while introducing an approximation method to **resolve sensor height metadata discrepancies**. Findings suggest variability and approximation techniques to fall below the 5-7% clinically significant[7] impacts to stride length in Parkinson's disease patients.

CAREER IMPACT

The IMI project bridged the gap between **engineering** and **clinical healthcare**, shaping the analytical approach to digital mobility biomarkers. It developed robust technical proficiencies in data analysis and biomechanical modelling using sensor data. Beyond technical skills, this study instilled a critical perspective on **validation and error propagation**. This multidisciplinary foundation provided the skillsets, resources and findings for future PhD investigations and projects in this field of research.

1. Kirk C et al. *Sci Rep*. 2024;
2. Micó-Amigo M.E. et al. *J NeuroEng Rehabil*. 2023;.
3. Küderle A et al. MobGap [Software]. GitHub; 2024.
4. Küderle A. Mobilise-D TVS Dataset [Data set]. Zenodo; 2024.
5. de Leva P. *J Biomech*. 1996;
6. Ho Hoang KL, Mombaur K. *J Biomech*. 2015;
7. Baudendistel ST et al. *Gait Posture*. 2024;