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Capturing real-world walking speed in a lab-based protocol: validation in younger and older healthy adults

As part of the project:

Validation of a tool for digital assessment of mobility in the real world

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Background

- Wearable sensors offer the potential to quantify real-world walking and subsequent adoption in healthcare to better diagnose, classify and predict pathologies related to a loss of mobility. However, validation of the accuracy and precision of the sensor's calculated outputs, referred to as digital mobility outcomes (DMOs), including walking speed, is crucial.
- A gold-standard for assessment of gait outputs, an optoelectronic stereophotogrammetric (SP) system, can be used to validate wearable sensors and calculated outputs, however this system is restricted to a laboratory space, which may limit the ability to capture the variation of the sensor's calculated outputs expected in real-world walking. In response, a task protocol that includes variation in walking conditions and complexity has been designed.

This study aims to:

1. **Assess if the variation in walking speed calculated by the SP system for two cohorts, younger healthy adults (YHA, 18 - 65 years old) and older healthy adults (OHA, > 65 years old), is representative of that reported for real-world.**
2. **Assess if the walking speed data for the YHA and OHA cohorts is normally distributed to allow for parametric analysis of walking speed between the two cohorts.**
3. **Assess the difference in walking speed between the YHA and OHA cohorts in easier and more complex walking tasks with normally distributed data.**

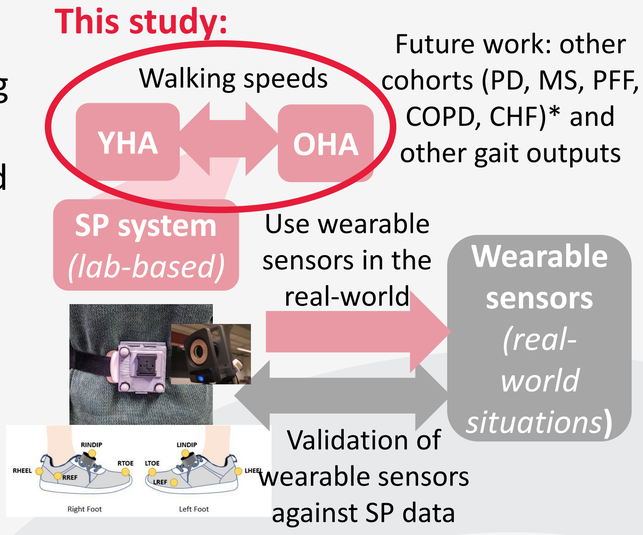

Figure 1. From lab to real-world assessment of mobility: the need for validation of wearable sensors

*PD = Parkinson's disease, MS = multiple sclerosis, PFF= proximal femur fracture, COPD = chronic obstructive pulmonary disorder, CHF = congestive heart failure

Methods

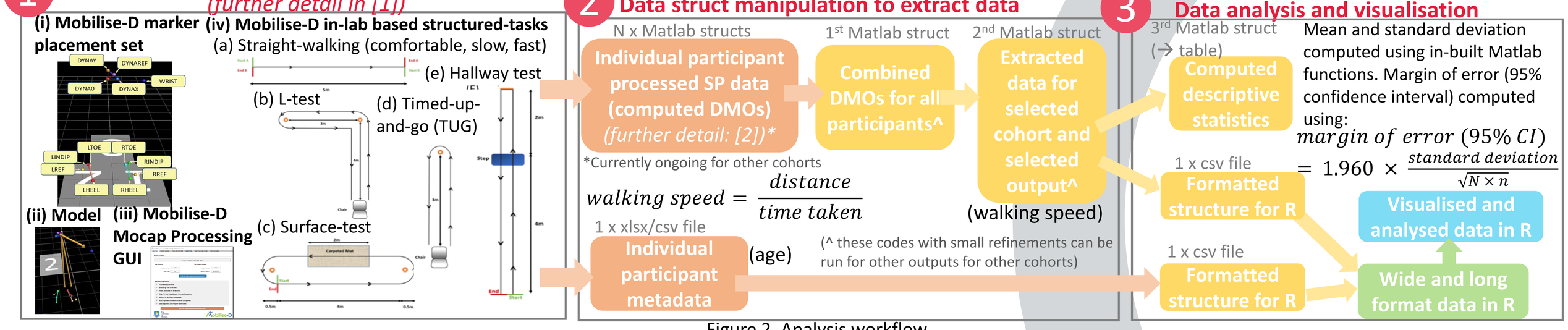

Figure 2. Analysis workflow

For each of YHA and OHA cohorts: N = 20, n=1 for all activities except for each of the three conditions of straight-walking (SWalk) where N=20, n=2 (N = number of participants, n = number of repeats); with further exceptions resulting in: N x n = SWalk_Comf OHA (28), LTest OHA (19), SWalk_Slow OHA (38), SWalk_Fast OHA (21) and SWalk_Fast YHA (19)

Software used: Matlab 2020b (MathWorks Inc.) and R Studio (version 1.4.1717)

Results

Aim 1

Table 1. Mean, standard deviation and margin of error (95% confidence interval) of the calculated walking speed for all tasks

	Mean (m/s)		SD (m/s)		Margin of error (95% CI) (m/s)	
	YHA	*OHA*	*YHA*	*OHA*	*YHA*	*OHA*
SWalk_Comf	1.24	1.06	0.15	0.15	0.07	0.07
L-Test	1.05	0.90	0.13	0.16	0.06	0.07
Surface-test	1.08	0.99	0.11	0.15	0.05	0.07
Hallway test	1.04	0.92	0.11	0.17	0.05	0.08
SWalk_Slow	0.80	0.69	0.18	0.13	0.08	0.06
SWalk_Fast	1.61	1.30	0.17	0.16	0.07	0.07
TUG	1.32	1.05	0.17	0.26	0.08	0.11

Aim 2

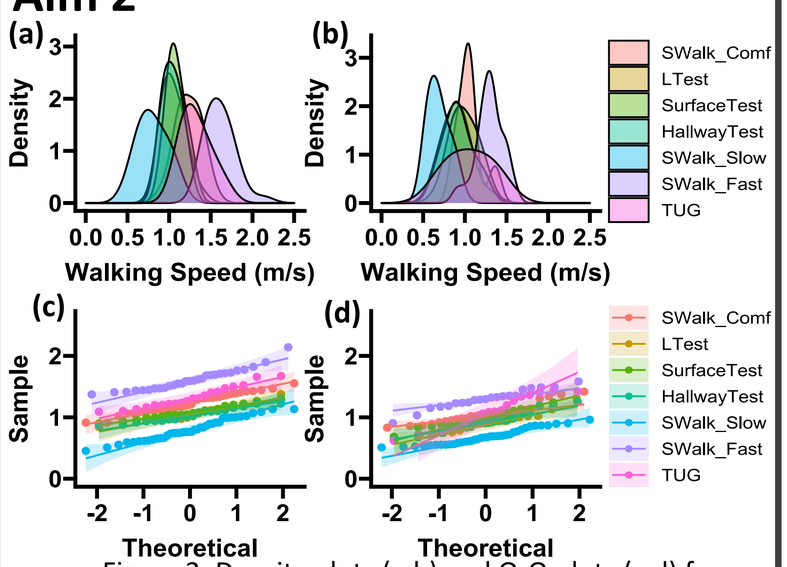

Figure 3. Density plots (a,b) and Q-Q plots (c,d) for YHA (a,c) and OHA (b,d) cohorts

Table 2. p-values for Shapiro-Wilk test and F-test

	Shapiro-Wilk (normality test)		F-test (variance test)
	YHA	OHA	
SWalk_Comf	0.51	*0.01	0.96
L-Test	0.15	0.52	0.38
Surface-test	0.72	0.50	0.14
Hallway test	0.36	0.62	0.06
SWalk_Slow	0.37	*0.02	*0.04
SWalk_Fast	*0.04	0.69	0.77
TUG	0.19	0.23	0.09

* Indicates statistical significance of p < 0.05 which Shapiro-Wilk on its own would indicate as non-parametric data

Aim 3

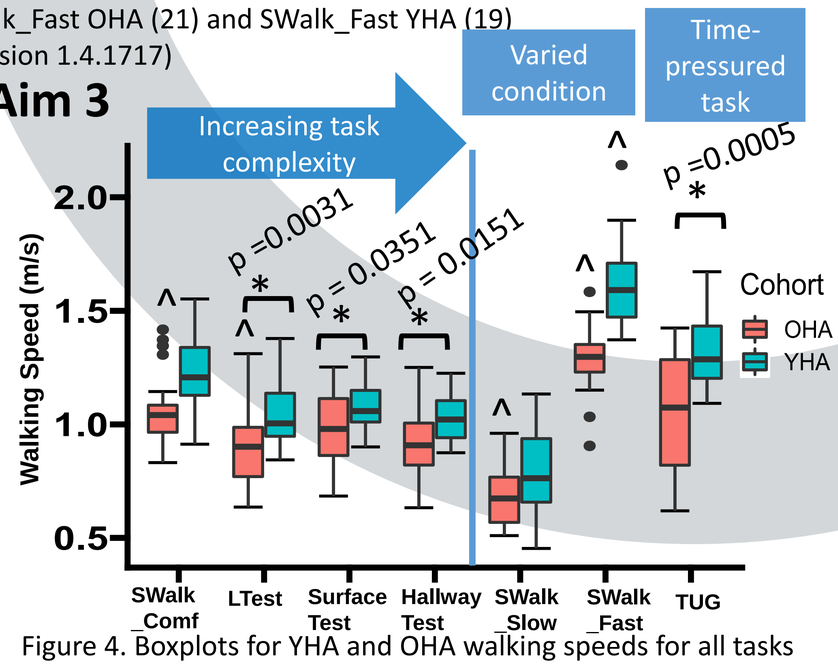

Figure 4. Boxplots for YHA and OHA walking speeds for all tasks

* Unpaired, two-sided student's t-test, 95% CI, unequal variances computed for normally distributed data. Further analyses required for non-parametric data (SWalk: Comf OHA, SWalk_Slow OHA and SWalk_Fast YHA)

^ Aforementioned exceptions to sample size (N x n) indicated = 28, 19, 38, 21, 29

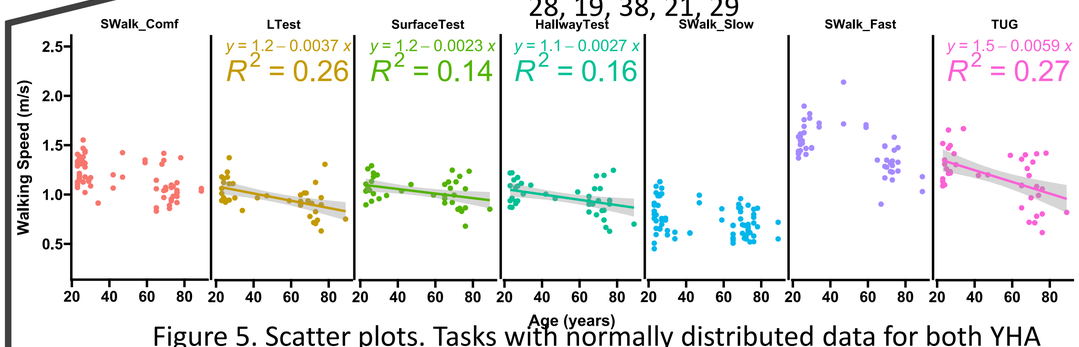

Figure 5. Scatter plots. Tasks with normally distributed data for both YHA and OHA, fitted with linear model showing equation and R-squared value

R-squared value of 16 - 27% contribution of age to walking speed for tasks with normally distributed data, few data points exist for middle range of ages (Figure 5).

Conclusions

Upon initial analysis for the YHA and OHA cohorts:

- ***Aim 1:*** **Variation in walking speed of 0.69 - 1.61 m/s (Table 1) consistent with real-world walking speed range reported in the literature ([2]).**
- ***Aim 2:*** **Walking speeds for most tasks are normally distributed (Figure 3) except those marked in Table 2, Shapiro-Wilk test.**
- ***Aim 3:*** **Significant differences ($p < 0.05$) in walking speeds between YHA and OHA cohorts were found for all normally distributed tasks (Figure 3).**

Future work

In order to determine the ages of participants required for validating the wearable sensors, further analysis is required for:

1. **In-lab tasks with non-parametric data (Figure 3, 4, Table 1)**
2. **Middle-range age groups and confounding variables such as height and mass to produce a model with stronger fit to the data points (Figure 5)**
3. **Time-varying walking speeds across the full gait cycle**
4. **Different disease cohorts**

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Mobilise-D imi innovative medicines initiative efpia

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