Translating intervention effects to real-world

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LAB VS REAL-WORLD

- Broad range of non-pharmacological interventions
- Effectiveness typically assessed in the lab under supervised conditions

- But: Effectiveness in real-world?

LAB VS REAL-WORLD

- Disparity between lab and real-world
- Gait quality worse in real-world settings (slower, higher variability,…)[1]

[1]Del Din et al., 2016

LAB VS REAL-WORLD

Free-living gait characteristics in ageing and Parkinson's disease: impact of environment and ambulatory bout length

Silvia Del Din*, Alan Godfrey, Brook Galna, Sue Lord and Lynn Rochester

Table 2 Laboratory based and free-living gait characteristics.

Domain/gait characteristic	BWM Lab			BWM free-living		
	CL ($n = 50$)	PD ($n = 47$)	p	CL ($n = 50$)	PD ($n = 47$)	p
Pace						
Step Velocity (m/s)	1.393 ± 0.207	1.254 ± 0.211	**0.002**	1.097 (0.48)	1.017 (0.426)	**<0.001**
Step Length (m)	0.726 ± 0.095	0.667 ± 0.073	**0.001**	0.601 (0.183)	0.578 (0.243)	**<0.001**
Swing Time Var (s)	0.018 (0.113)	0.025 (0.103)	0.051	0.147 (0.125)	0.151 (0.134)	0.014
Variability (SD)						
Step Velocity Var (m/s)	0.073 (0.301)	0.081 (0.223)	0.253	0.383 (0.494)	0.362 (0.221)	0.070
Step Length Var (m)	0.033 (0.096)	0.039 (0.094)	0.050	0.151 (0.079)	0.152 (0.091)	0.660
Step Time Var (s)	0.019 (0.109)	0.028 (0.085)	0.037	0.175 (0.156)	0.181 (0.179)	0.037
Stance Time Var (s)	0.022 (0.109)	0.029 (0.092)	0.088	0.188 (0.161)	0.196 (0.249)	0.034
Rhythm						
Step Time (s)	0.525 ± 0.047	0.539 ± 0.058	0.206	0.593 (0.144)	0.605 (0.318)	0.017
Swing Time (s)	0.371 ± 0.040	0.388 ± 0.055	0.092	0.449 (0.113)	0.458 (0.252)	**0.008**
Stance Time (s)	0.679 ± 0.061	0.689 ± 0.069	0.450	0.741 (0.166)	0.756 (0.434)	0.035

LAB VS REAL-WORLD

Article

Multidisciplinary Intensive Rehabilitation Program for People with Parkinson's Disease: Gaps between the Clinic and Real-World Mobility

Moriya Cohen [1,2], Talia Herman [1], Natalie Ganz [1], Inbal Badichi [2], Tanya Gurevich [3,4,5] and Jeffrey M. Hausdorff [1,4,6,7,*]

Lab based parameters
Real world parameters

		Pre intervention	Post intervention	P-value
Gait Quantity				
Steps per day (average)		4496.50 [2513.00-7501.25]	4502.5 [2456.7-7384.0]	0.429
Gait Quality				
Rhythm	Cadence (step/min)	102.85 [97.68-109.48]	102.02 [97.30-110.43]	0.413
	Stride Time (sec)	1.16 (±0.11)	1.17 (±0.13)	0.359
	Gait Speed (cm/sec)	89.00 (±18.49)	87.70 (±19.16)	0.389

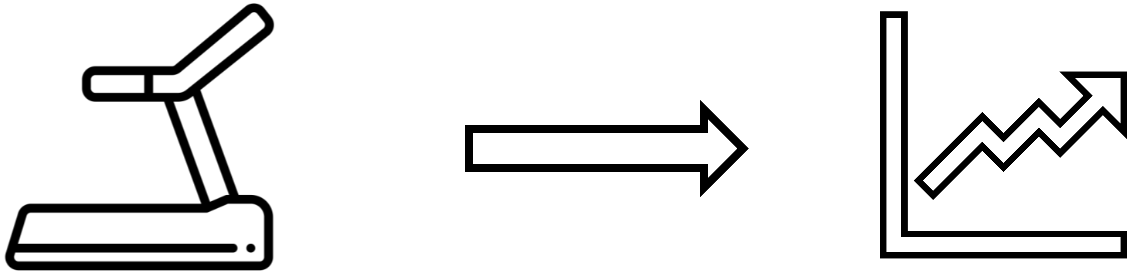
LAB VS REAL-WORLD

- Disparity between lab and real-world
- Gait quality worse in real-world settings (slower, higher variability,…)[1]

- Translation of intervention effects possible?

[1]Del Din et al., 2016

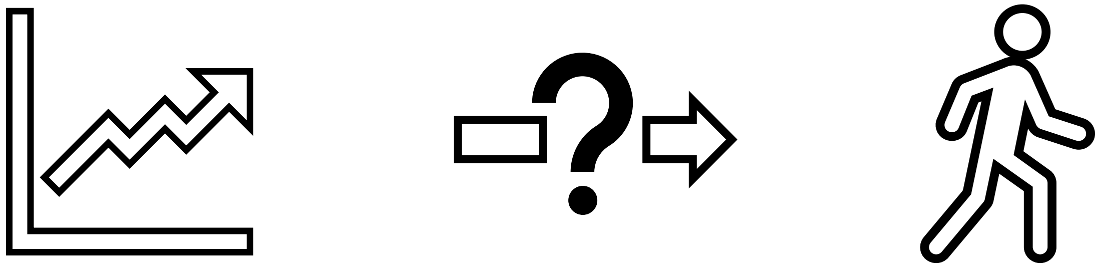
TRANSLATION



Lab-based interventions e.g. treadmill training

Improvement of gait quality in the lab

TRANSLATION

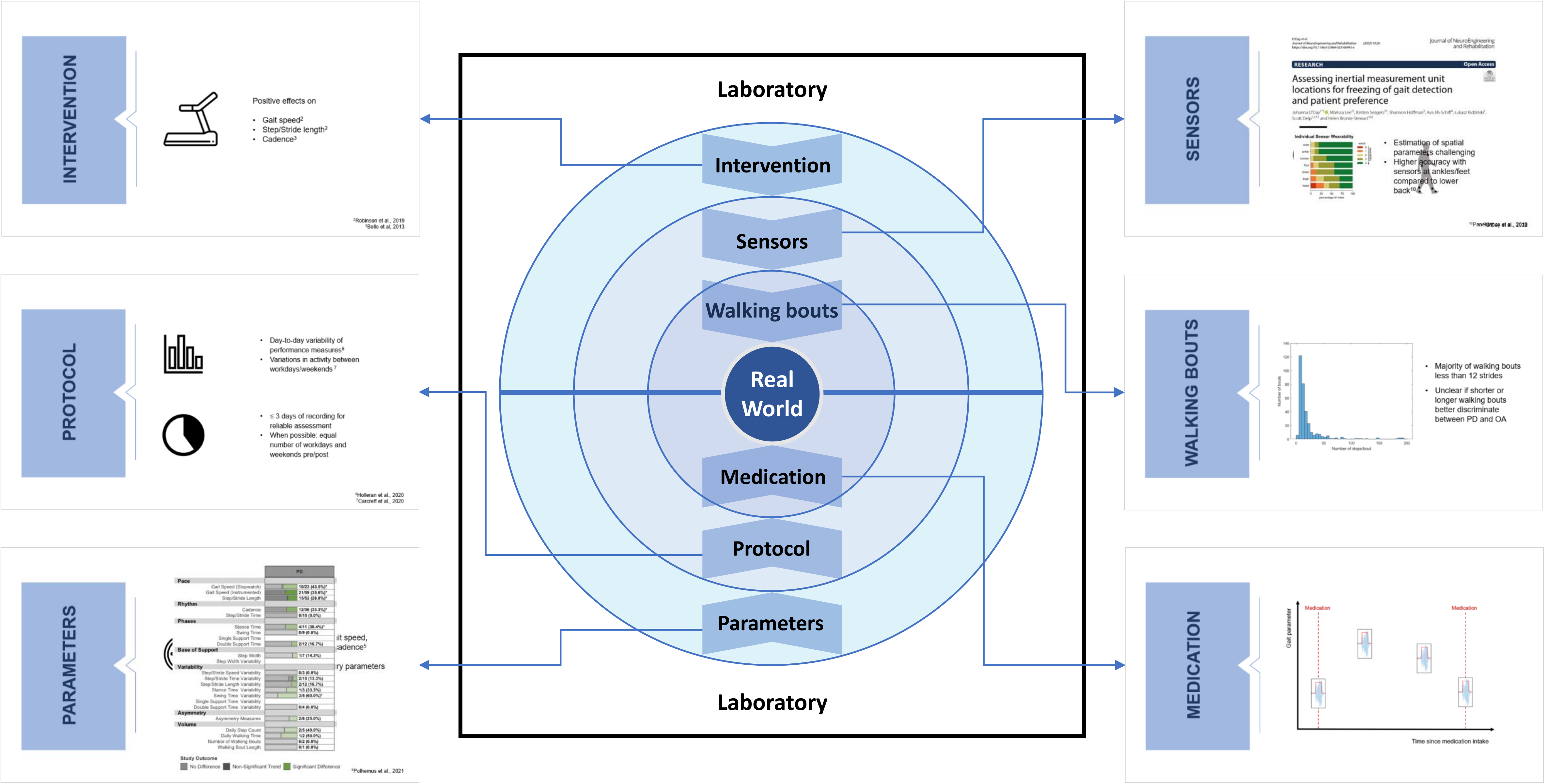


Improvement of gait quality in the lab

Same improvements in real-world gait

How can we achieve translation of lab-based improvements to real-world gait?

Intervention → Parameter → Protocol → Sensors → Walking bouts → Medication



Laboratory
Intervention
Sensors
Walking bouts
Real World
Medication
Protocol
Parameters
Laboratory
INTERVENTION
Positive effects on
• Gait speed[2]
• Step/Stride length[2]
• Cadence[3]
[2]Robinson et al., 2019
[3]Bello et al, 2013
PROTOCOL
• Day-to-day variability of performance measures[6]
• Variations in activity between workdays/weekends[7]
• ≤ 3 days of recording for reliable assessment
• When possible: equal number of workdays and weekends pre/post
[6]Holleran et al., 2020
[7]Carcreff et al., 2020
PARAMETERS
Pace
Rhythm
Phases
Base of Support
Variability
Asymmetry
Volume
Study Outcome
No Difference
Non-Significant Trend
Significant Difference
[5]Polhemus et al., 2021
SENSORS
Assessing inertial measurement unit locations for freezing of gait detection and patient preference
Estimation of spatial parameters challenging
Higher accuracy with sensors at ankles/feet compared to lower back[10]
WALKING BOUTS
Majority of walking bouts less than 12 strides
Unclear if shorter or longer walking bouts better discriminate between PD and OA
MEDICATION
Medication
Gait parameter
Time since medication intake

INTERVENTION

Positive effects on

- Gait speed[2]
- Step/Stride length[2]
- Cadence[3]

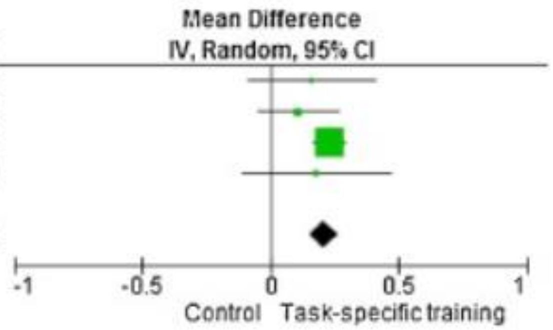
[2]Robinson et al., 2019
[3]Bello et al, 2013

INTERVENTION

Comfortable walking speed

Study or Subgroup	Task-specific training Mean	SD	Total	Control Mean	SD	Total	Weight	Mean Difference IV, Random, 95% CI
Canning 2012	1.39	0.32	9	1.23	0.2	9	5.0%	0.16 [-0.09, 0.41]
Fisher 2008	1.52	0.19	10	1.41	0.17	10	12.2%	0.11 [-0.05, 0.27]
Ganesan 2015	0.71	0.1	20	0.48	0.1	20	79.2%	0.23 [0.17, 0.29]
Protas 2005	1.45	0.37	9	1.27	0.25	9	3.6%	0.18 [-0.11, 0.47]
Total (95% CI)			**48**			**48**	**100.0%**	**0.21 [0.15, 0.27]**

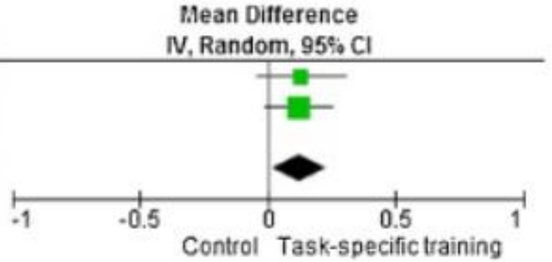
Heterogeneity: $Tau^2 = 0.00$; $Chi^2 = 2.14$, $df = 3$ ($P = 0.54$); $I^2 = 0\%$
Test for overall effect: $Z = 7.46$ ($P < 0.00001$)



Stride length

Study or Subgroup	Task-specific training Mean	SD	Total	Control Mean	SD	Total	Weight	Mean Difference IV, Random, 95% CI
Fisher 2008	1.54	0.16	10	1.41	0.23	10	36.7%	0.13 [-0.04, 0.30]
Protas 2005	0.73	0.17	9	0.61	0.11	9	63.3%	0.12 [-0.01, 0.25]
Total (95% CI)			**19**			**19**	**100.0%**	**0.12 [0.02, 0.23]**

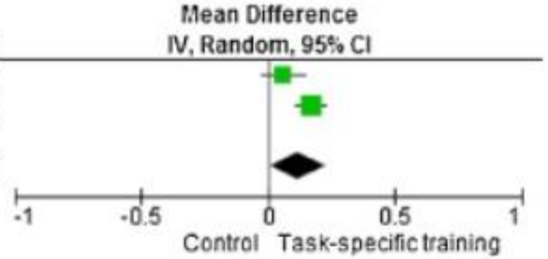
Heterogeneity: $Tau^2 = 0.00$; $Chi^2 = 0.01$, $df = 1$ ($P = 0.93$); $I^2 = 0\%$
Test for overall effect: $Z = 2.30$ ($P = 0.02$)



Step length

Study or Subgroup	Task-specific training Mean	SD	Total	Control Mean	SD	Total	Weight	Mean Difference IV, Random, 95% CI
Fisher 2008	0.77	0.08	10	0.71	0.11	10	46.5%	0.06 [-0.02, 0.14]
Ganesan 2015	0.54	0.1	20	0.37	0.1	20	53.5%	0.17 [0.11, 0.23]
Total (95% CI)			**30**			**30**	**100.0%**	**0.12 [0.01, 0.23]**

Heterogeneity: $Tau^2 = 0.00$; $Chi^2 = 4.25$, $df = 1$ ($P = 0.04$); $I^2 = 76\%$
Test for overall effect: $Z = 2.17$ ($P = 0.03$)



[2]Robinson et al., 2019

INTERVENTION

Positive effects on

- Gait speed
- Step length
- Cadence

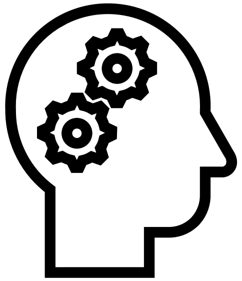
But…

… TT does not reflect typical demands of natural environment

INTERVENTION

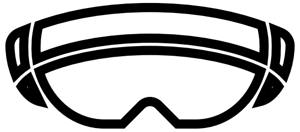
INTERVENTION

To approach daily life more closely add..



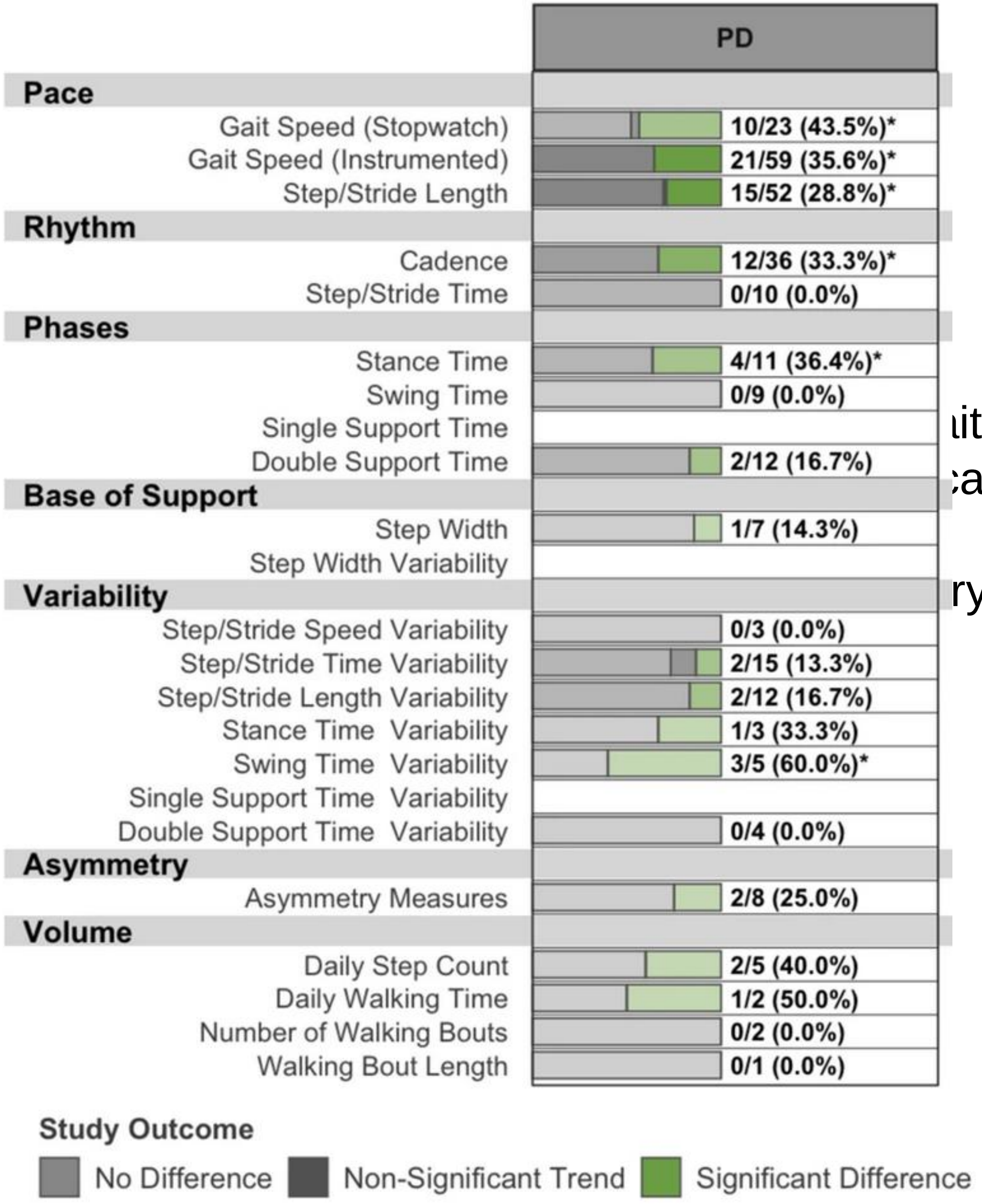
…dual task

…perturbations



…AR/VR

PARAMETERS



it speed,
adence[5]

ry parameters

[5]Polhemus et al., 2021

PARAMETERS

- Most commonly: gait speed, step/stride length, cadence[5]
- Less frequent: variability/asymmetry parameters

- Determine: which parameter targeted by intervention?
- Gait stability parameters might be useful to achieve translation

[5]Polhemus et al., 2021

PROTOCOL

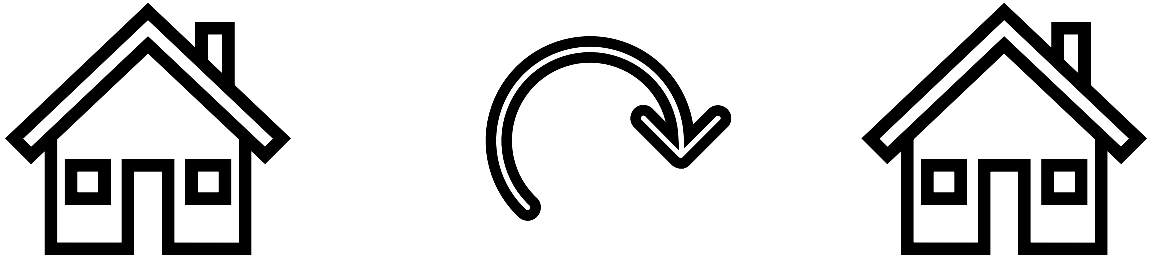
- Day-to-day variability of performance measures[6]
- Variations in activity between workdays/weekends [7]

- ≤ 3 days of recording for reliable assessment
- When possible: equal number of workdays and weekends pre/post

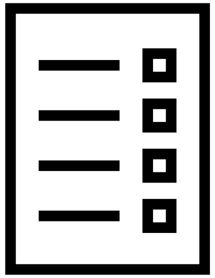
[6]Holleran et al., 2020
[7]Carcreff et al., 2020

PROTOCOL

Similar environment pre/post assessment



T1 **T2**



Questionnaire assessing…

… special activities (running, etc.)
… use of walking aids

PROTOCOL

7-day activity diary [8]

1 How long did you ride a bike?

	mo	tu	we	th	fr	sa	su
0 minutes							
1–15 minutes							
16–30 minutes							
31–60 minutes							
61–120 minutes							
longer than 2 hours							

[8]Stel et al., 2004

PROTOCOL

LASA physical activity questionnaire (LAPAQ)[8]

16. Which sport did you do most time during the past two weeks?
Sometimes it happens that a respondent does a sport, which is not on the list. This should be recorded:

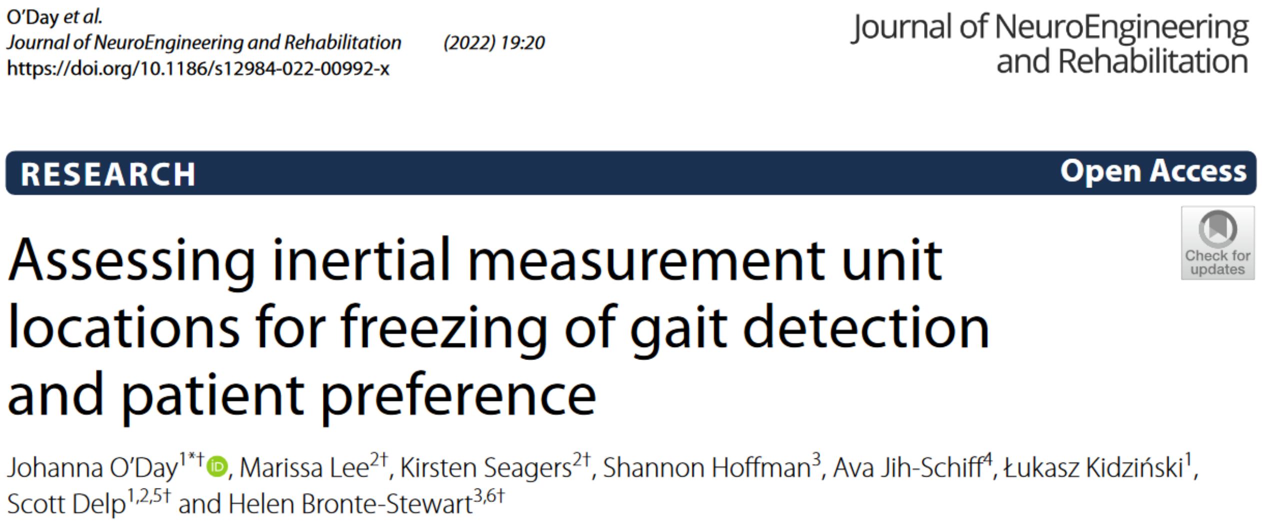
1. Distance walking
2. Distance cycling
3. Gymnastics
4. Cycling on hometrainer
5. Swimming
6. Dancing
7. Bowling
8. Tennis, badminton
9. Running, fast walking
10. Rowing
11. Sailing
12. Playing billiards
13. Fishing
14. Playing soccer/basketball/hockey
15. Playing volleyball/baseball
16. Skiing
17. Else, ……………………….

27. Do you do heavy household tasks?
Explanation: with heavy household tasks we mean window cleaning, changing the bed, beating the mat, vacuuming, washing or scrubbing the floor, and chores with sawing, carpeting, repairing or painting.

1. no (go to question 30)
2. yes

[8]Stel et al., 2004

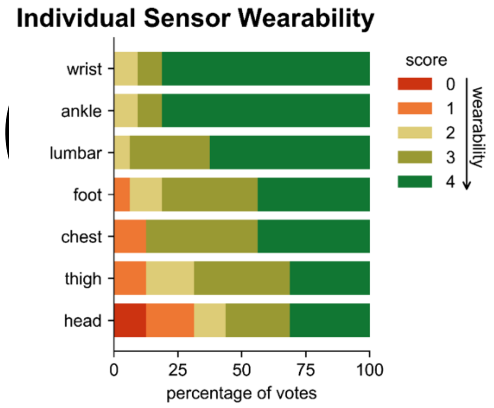
SENSORS

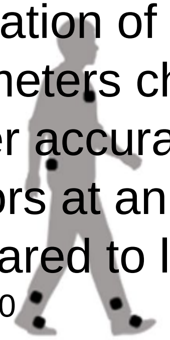

O'Day *et al. Journal of NeuroEngineering and Rehabilitation* (2022) 19:20
https://doi.org/10.1186/s12984-022-00992-x
Journal of NeuroEngineering and Rehabilitation

RESEARCH **Open Access**

Assessing inertial measurement unit locations for freezing of gait detection and patient preference

Johanna O'Day[1*†], Marissa Lee[2†], Kirsten Seagers[2†], Shannon Hoffman[3], Ava Jih-Schiff[4], Łukasz Kidziński[1], Scott Delp[1,2,5†] and Helen Bronte-Stewart[3,6†]

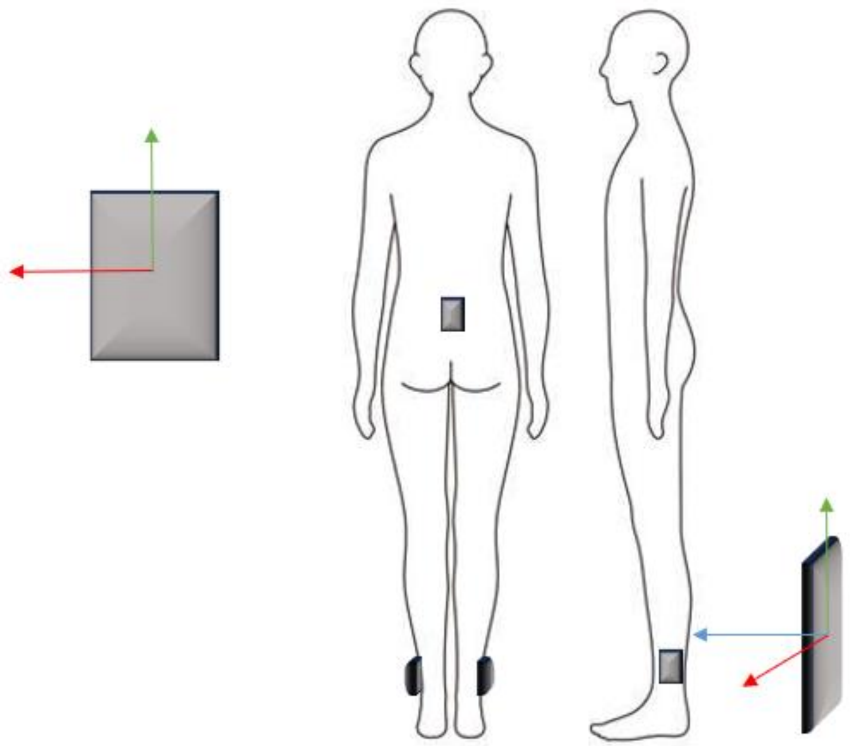




- Estimation of spatial parameters challenging
- Higher accuracy with sensors at ankles/feet compared to lower back[10]

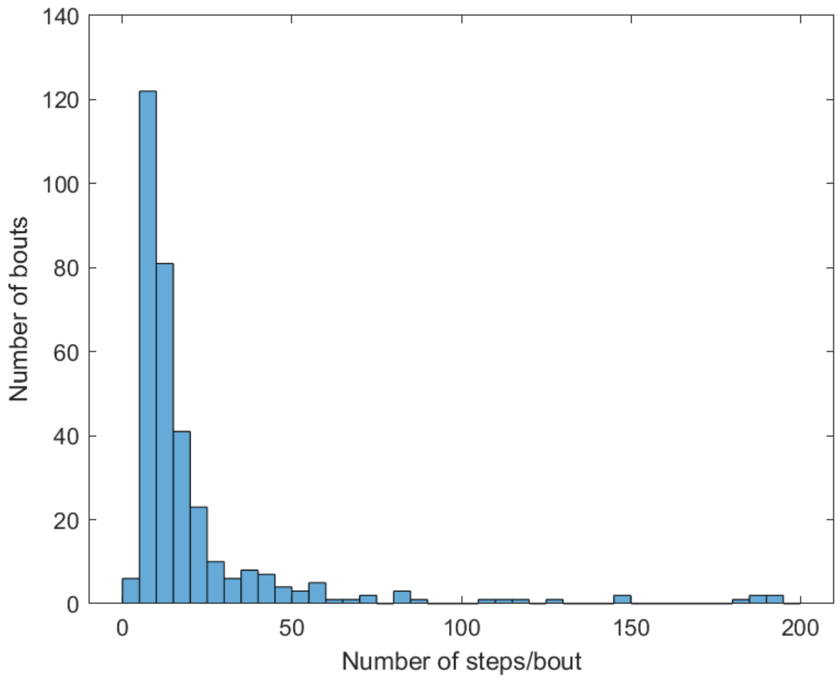
[10]Panebianco et al., 2018 [9]O'Day et al., 2022

SENSORS



- 3-sensor system
- 1x lower back, 2x ankles
- Enhanced accuracy
- Might be able to facilitate translation

WALKING BOUTS



- Majority of walking bouts less than 12 strides
- Unclear if shorter or longer walking bouts better discriminate between PD and OA

WALKING BOUTS

Del Din *et al. Journal of NeuroEngineering and Rehabilitation* (2016) 13:46
DOI 10.1186/s12984-016-0154-5

Journal of NeuroEngineering and Rehabilitation

RESEARCH **Open Access**

Free-living gait characteristics in ageing and Parkinson's disease: impact of environment and ambulatory bout length

Silvia Del Din*, Alan Godfrey, Brook Galna, Sue Lord and Lynn Rochester

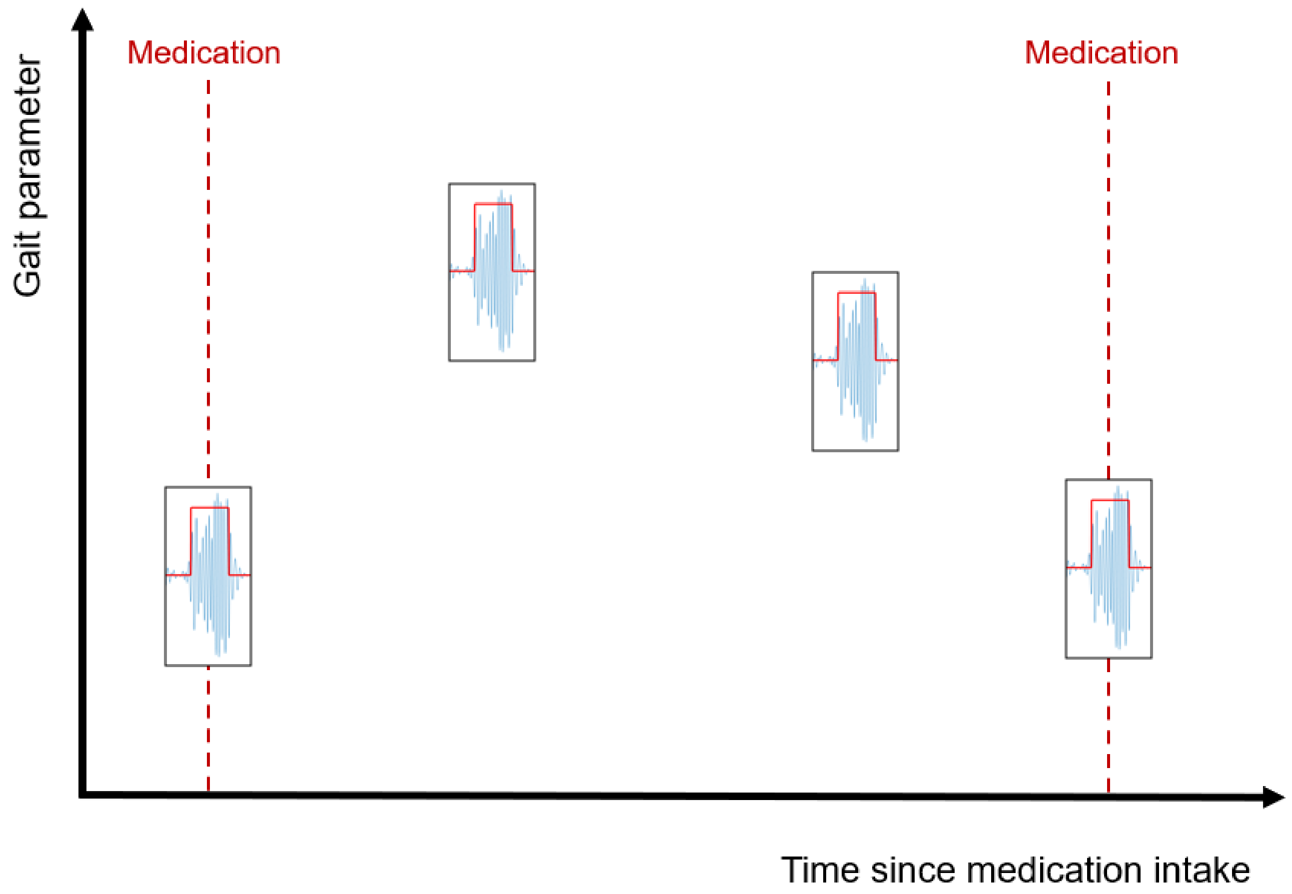
sensors MDPI

Article

Effect of Bout Length on Gait Measures in People with and without Parkinson's Disease during Daily Life

Vrutangkumar V. Shah [1,*], James McNames [2], Graham Harker [1], Martina Mancini [1], Patricia Carlson-Kuhta [1], John G. Nutt [1], Mahmoud El-Gohary [3], Carolin Curtze [4] and Fay B. Horak [1]

MEDICATION


Medication
Medication
Gait parameter
Time since medication intake

MEDICATION

Day/ Time	**6:00 7:00**	**7:00 8:00**	**8:00 9:00**	**9:00 10:00**	**10:00 11:00**	**11:00 12:00**	**12:00 13:00**	**13:00 14:00**	**14:00 15:00**	**15:00 16:00**	**16:00 17:00**	**17:00 18:00**	**18:00 19:00**	**19:00 20:00**	**20:00 21:00**	**21:00 22:00**	Comments
Monday																	
Tuesday																	
Wednesday																	
Thursday																	
Friday																	
Saturday																	
Sunday																	

[11]Debelle et al., 2023
[12]Hauser et al., 2000

DISCUSSION

1. Documentation of medication intake feasible?
2. Is gait speed as outcome parameter enough?

List of references

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