ETH zürich

LABORATORY FOR MOVEMENT BIOMECHANICS

Real-world assessment in PD: Daily life outcomes based on IMUs

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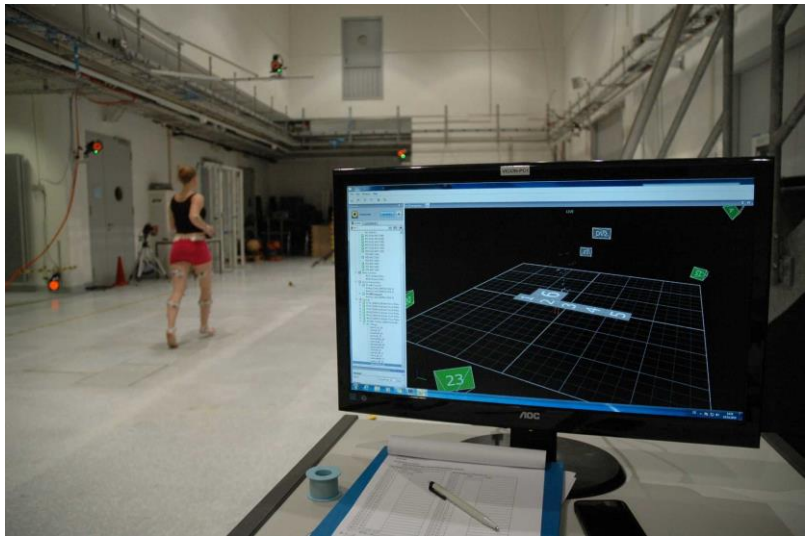
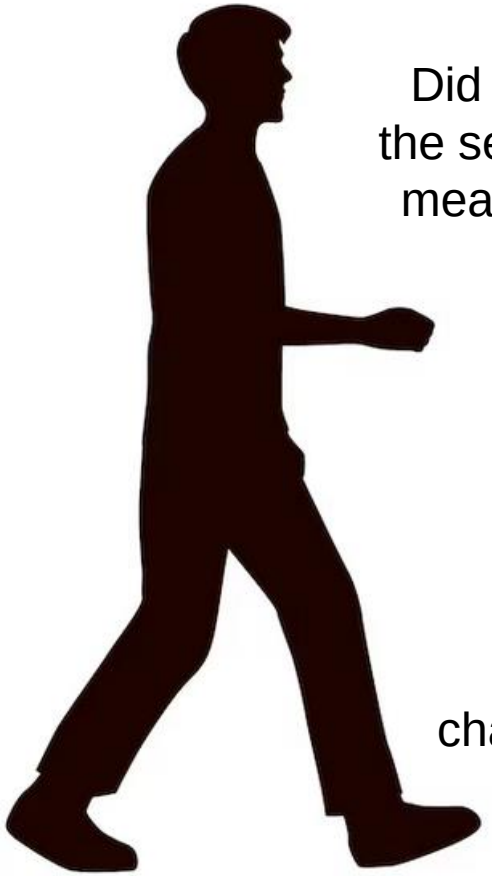
29 November 2024

Moving from lab to real-world



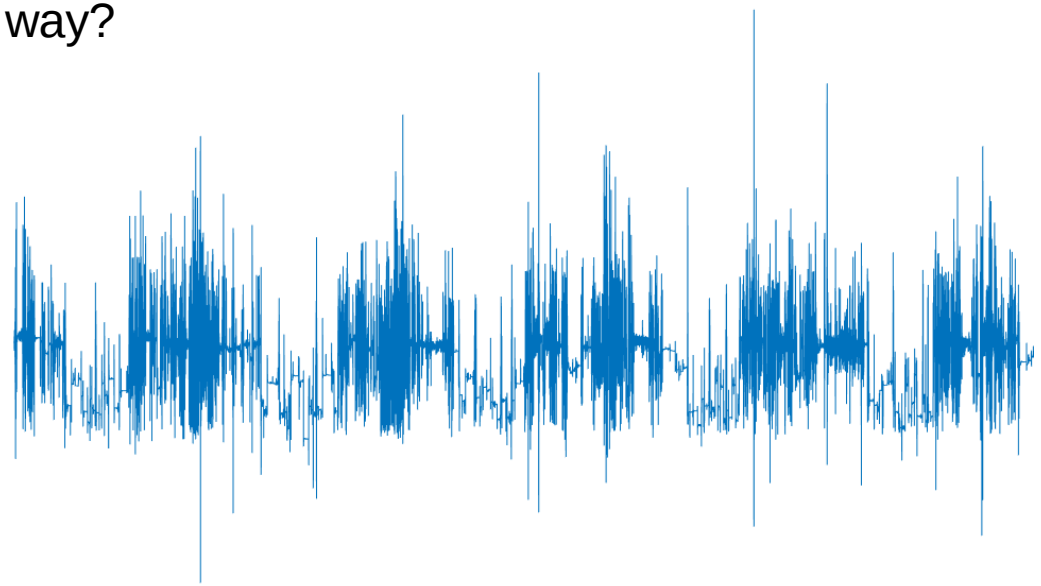
“Black box” IMU data



Did participants wear the sensor for the whole measurement period?

Was the sensor attached/reattached in the wrong way?

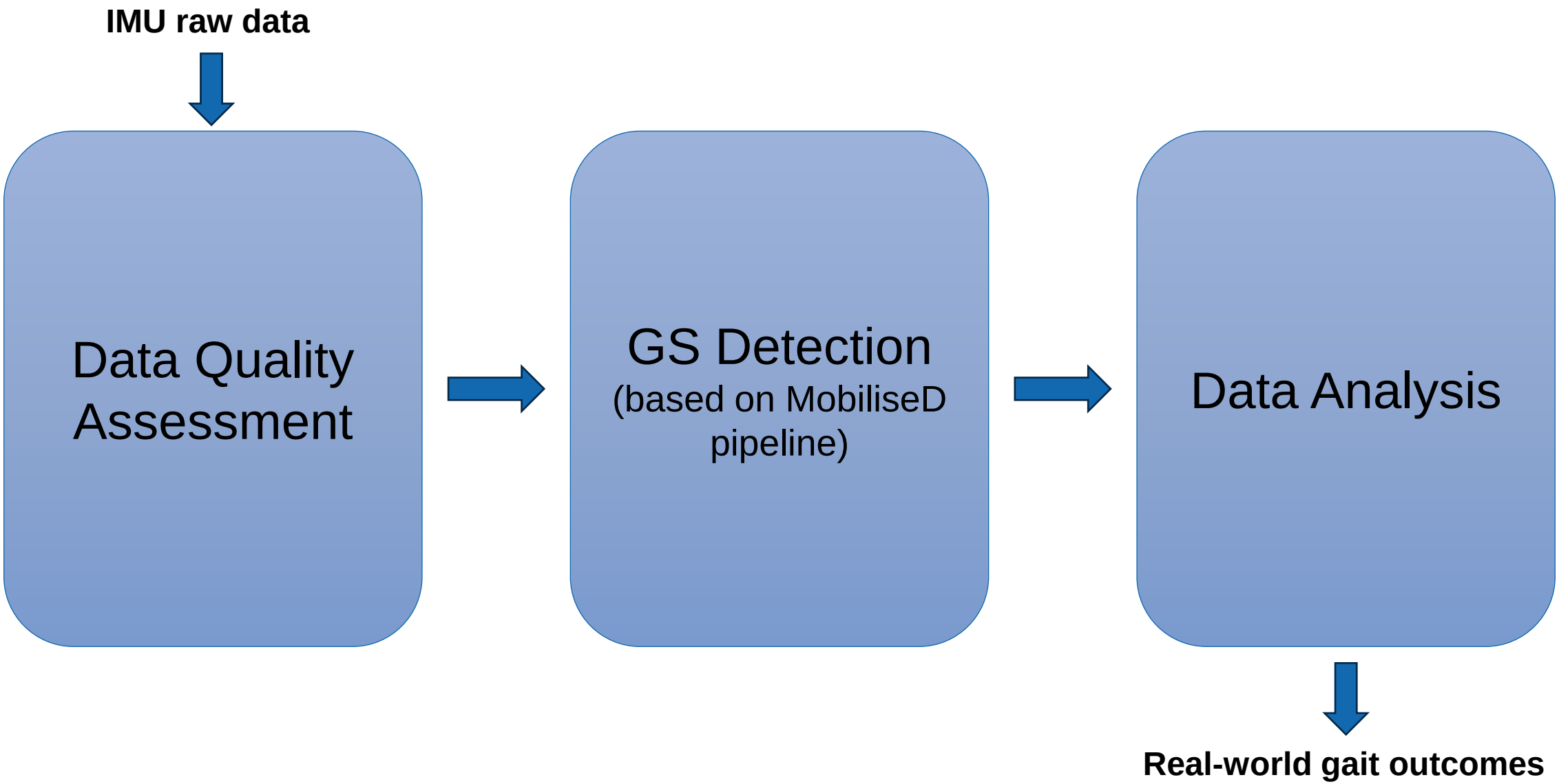
?

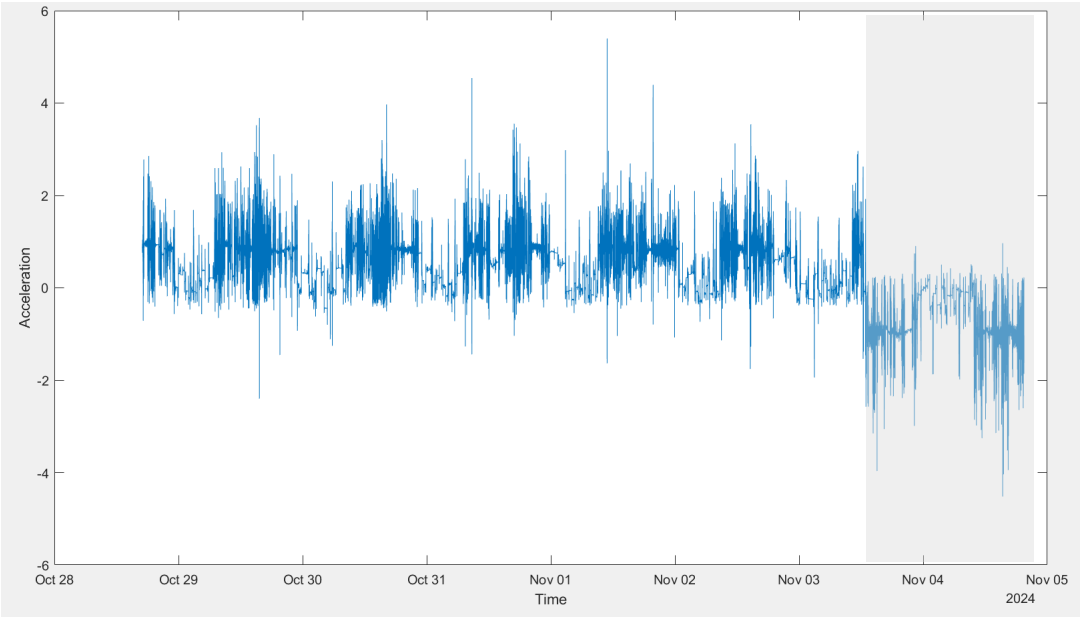


Why is the signal changing at timepoint x?

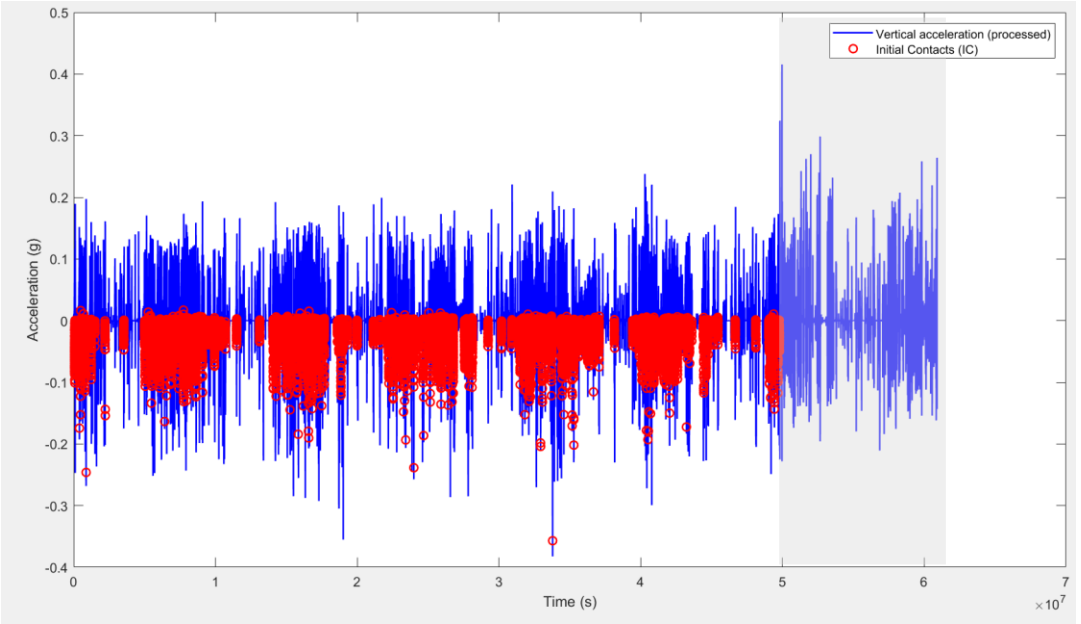
What did the participant do?

From IMU data to real-world gait outcomes

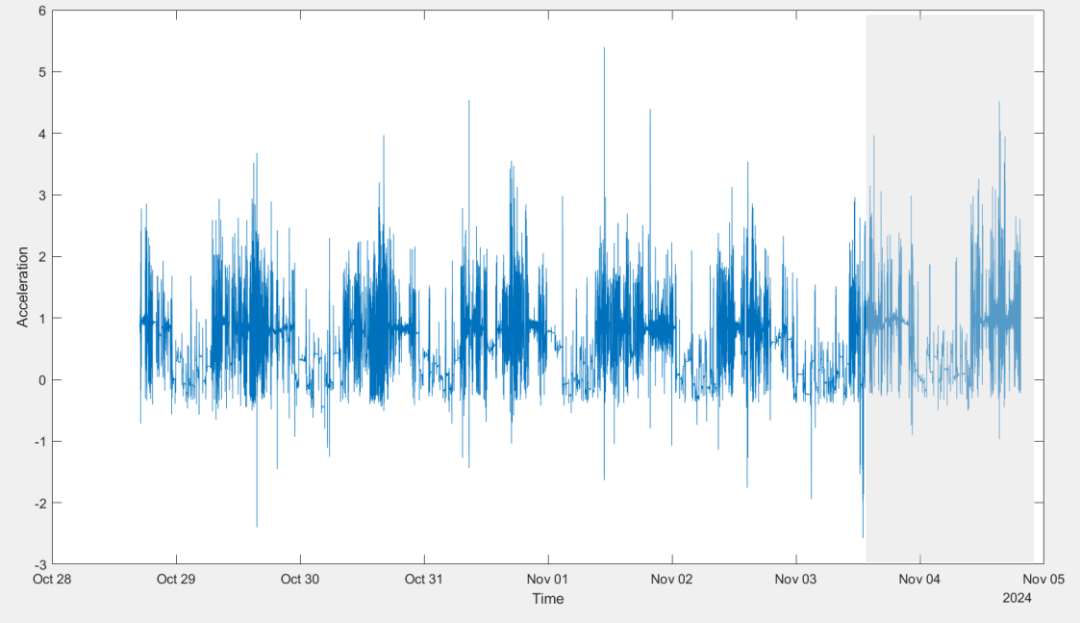




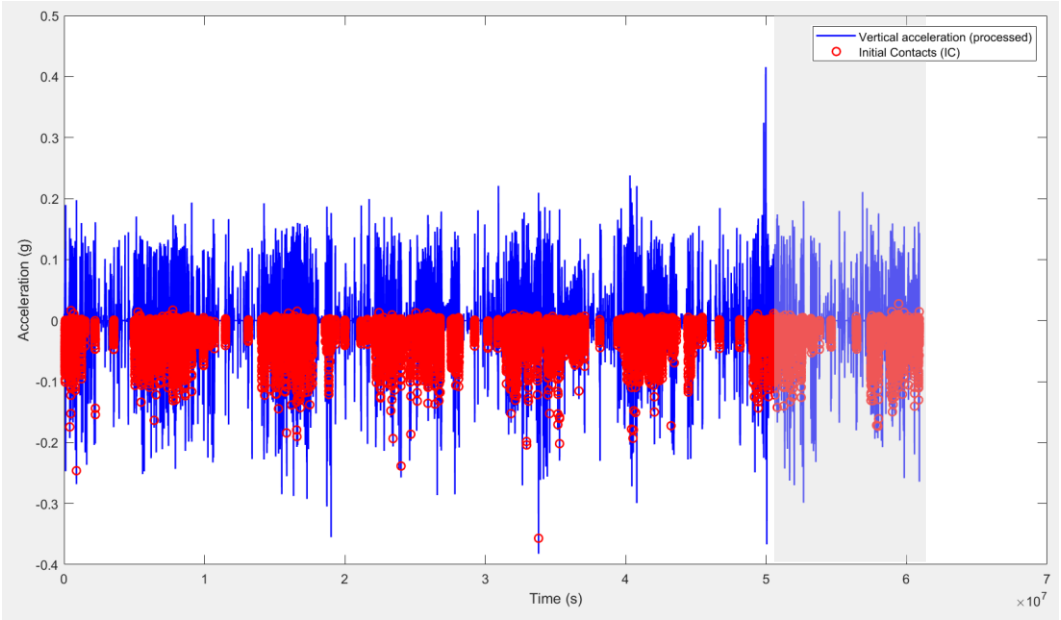
Step detection



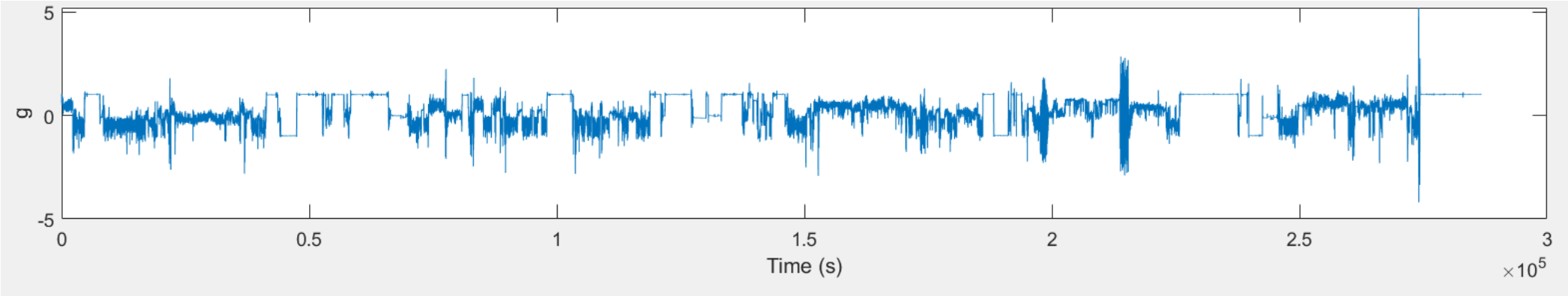
Correction of orientation -g → g

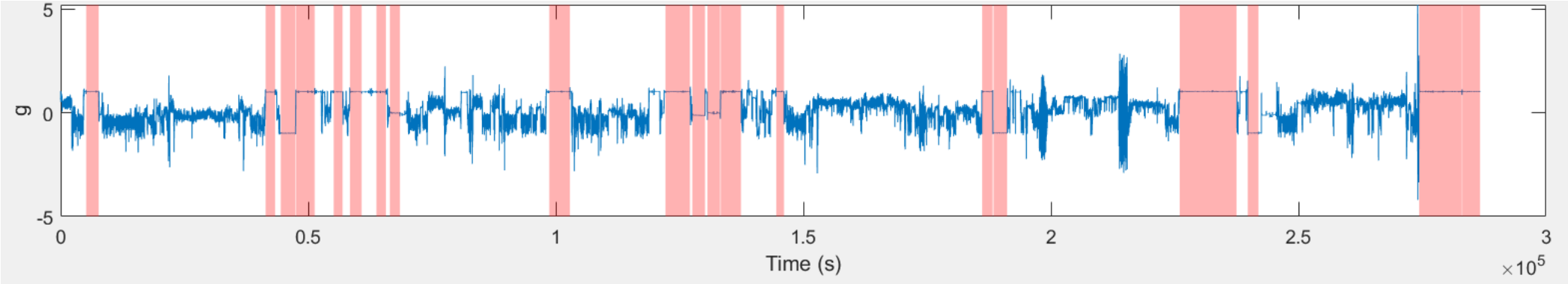


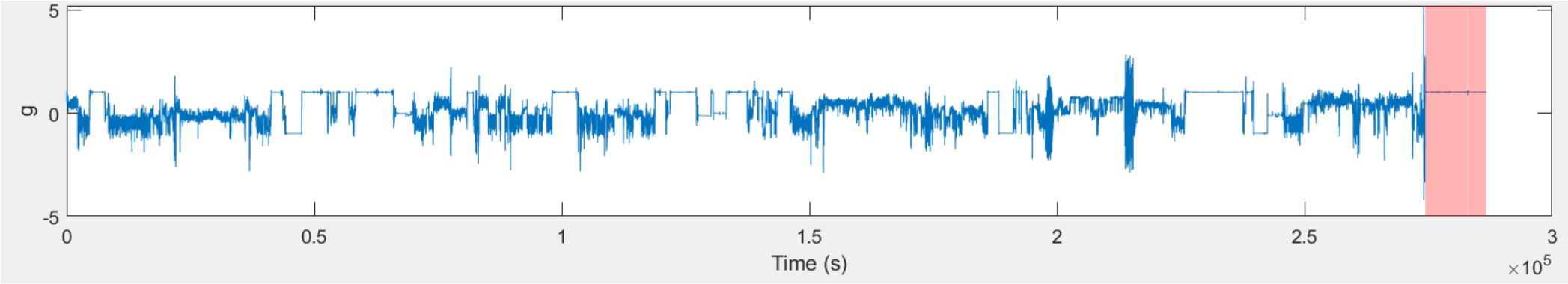
Step detection



Non-wear detection



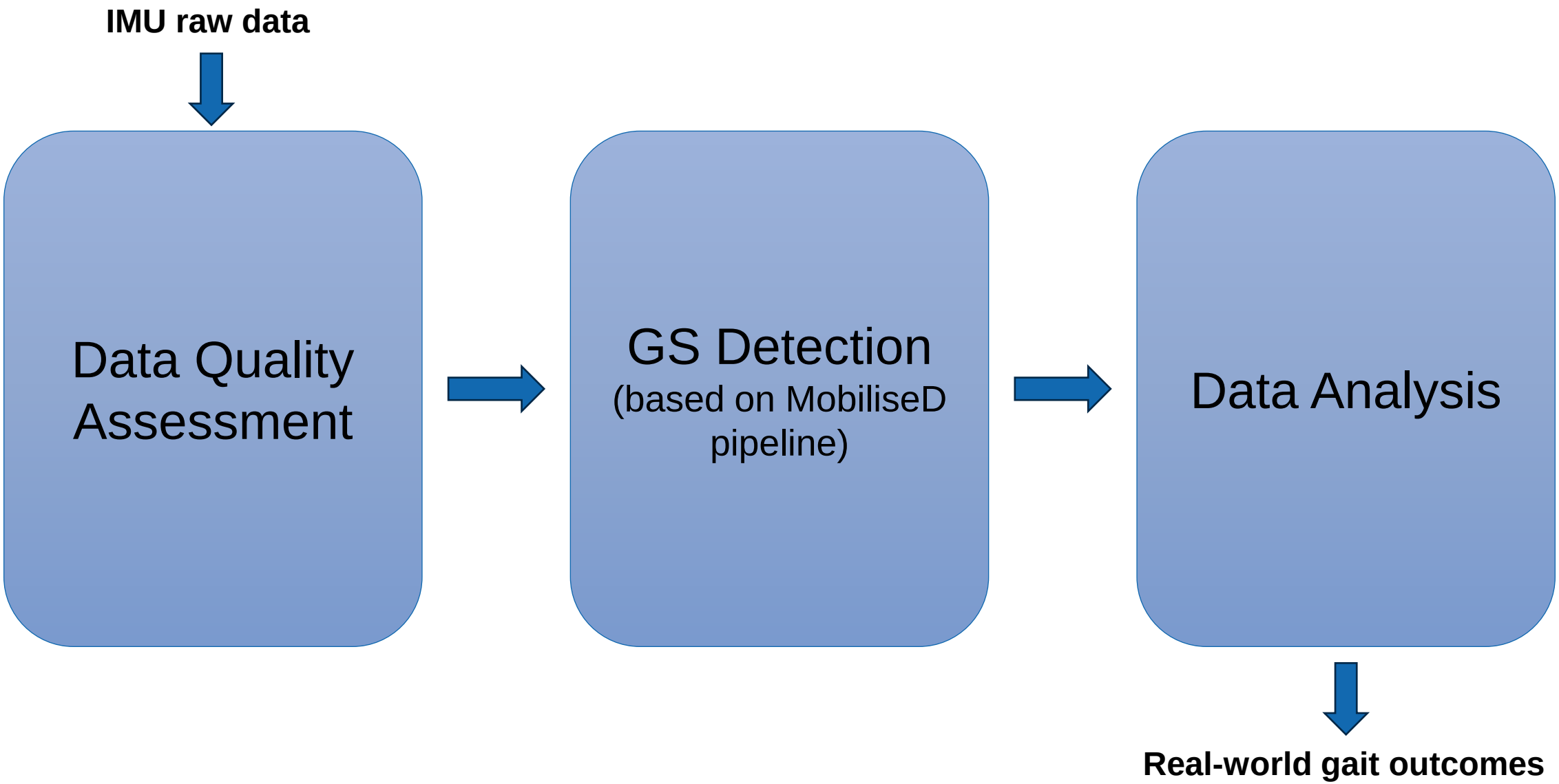




Detection of non-wear based on **acceleration** (std and range of all 3 axes)

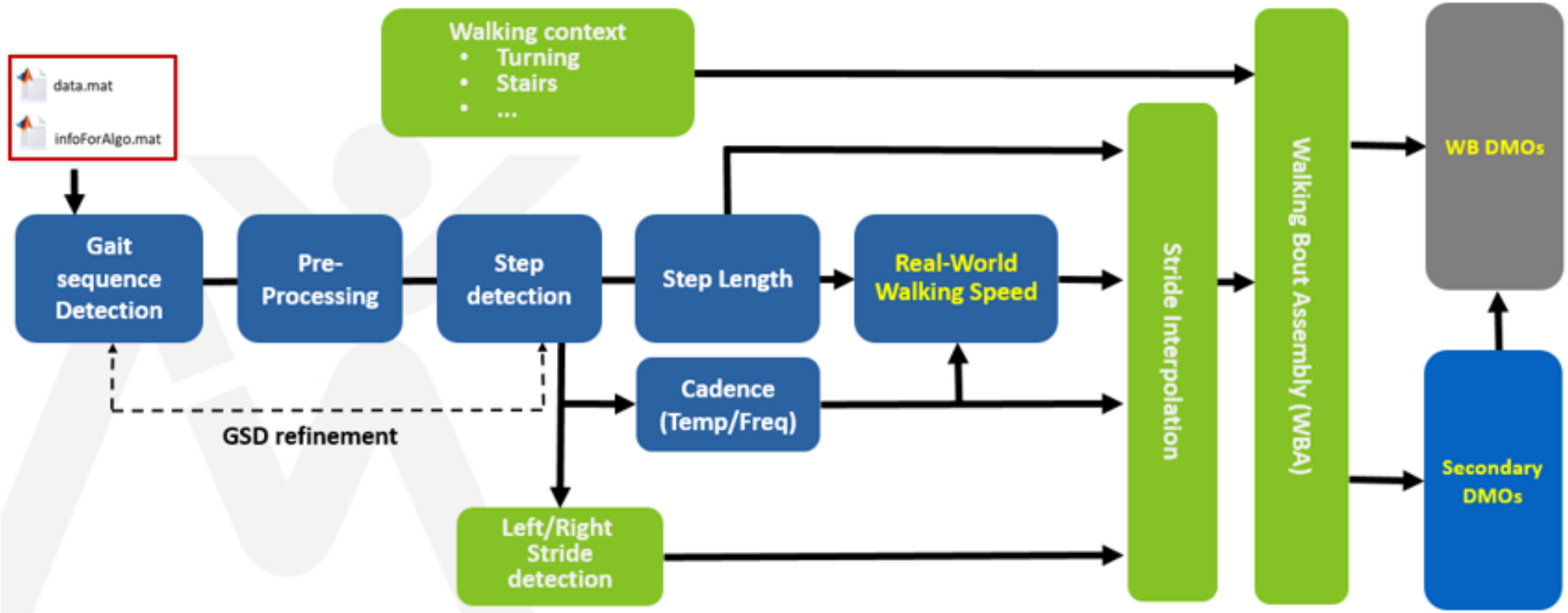
Temperature as 2nd criteria to refine detection (exclude e.g. periods of sleep)

From IMU data to real-world gait outcomes

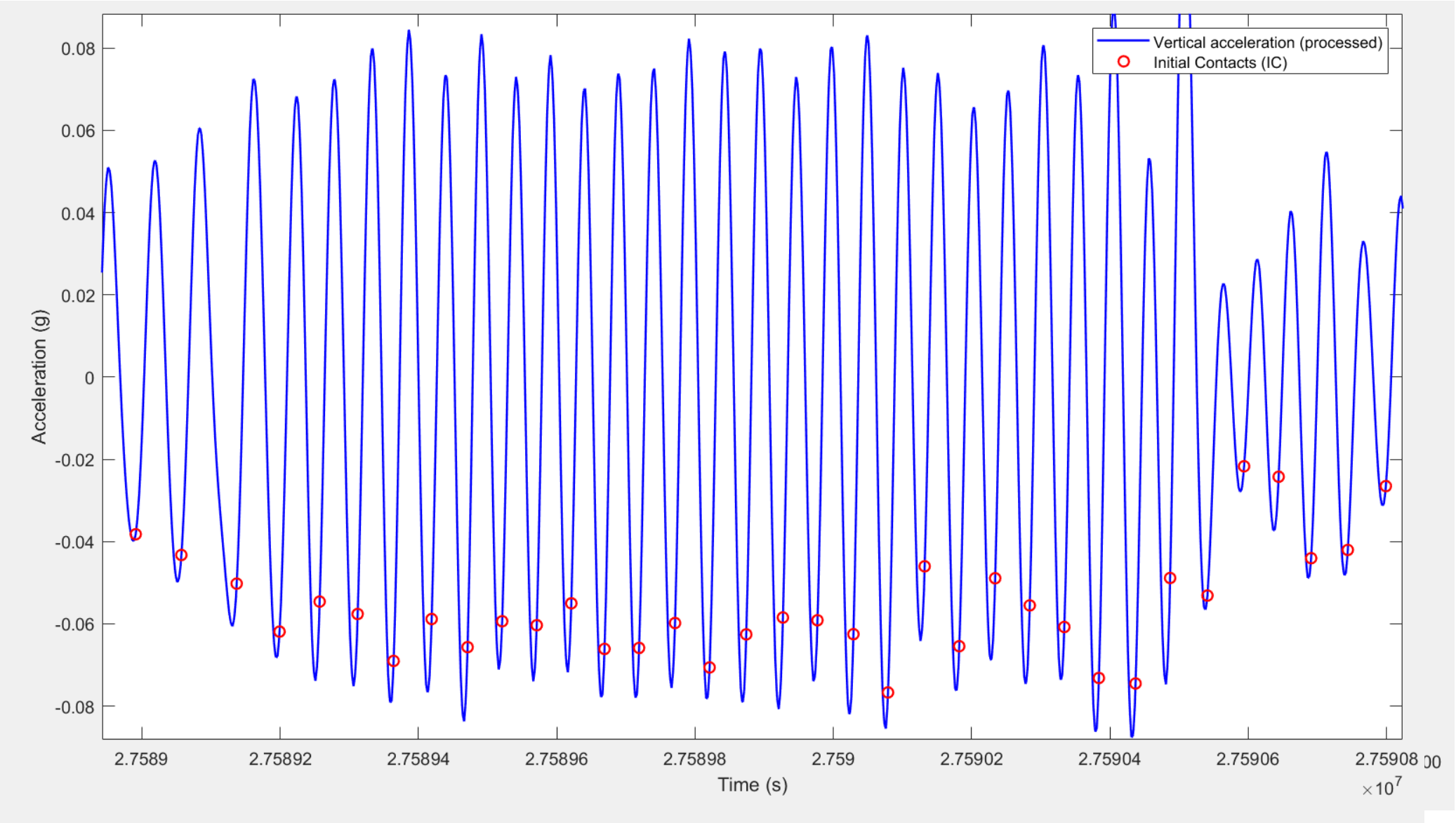


From IMU data to real-world gait outcomes

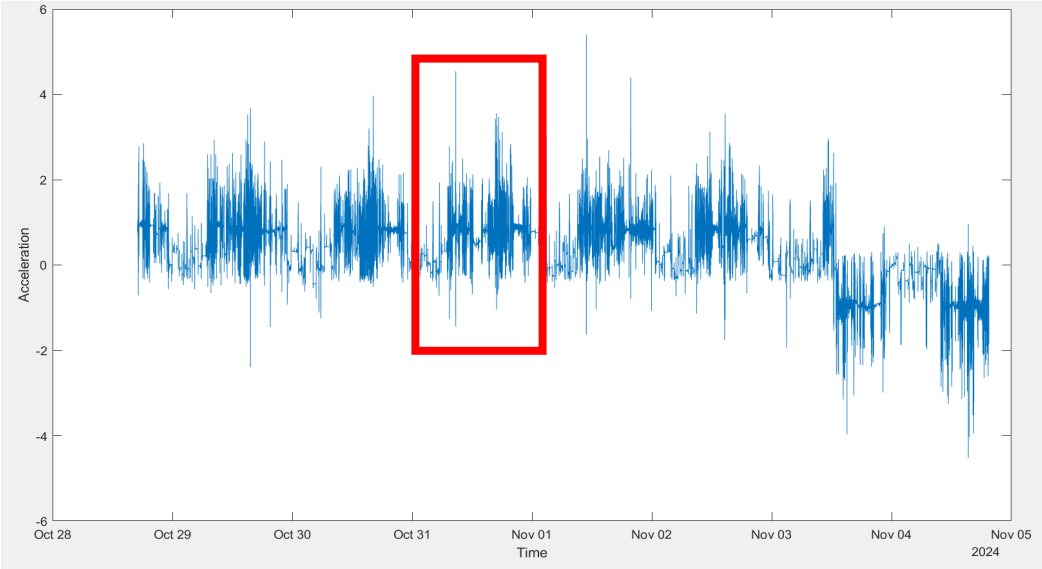
Mobilise-D pipeline

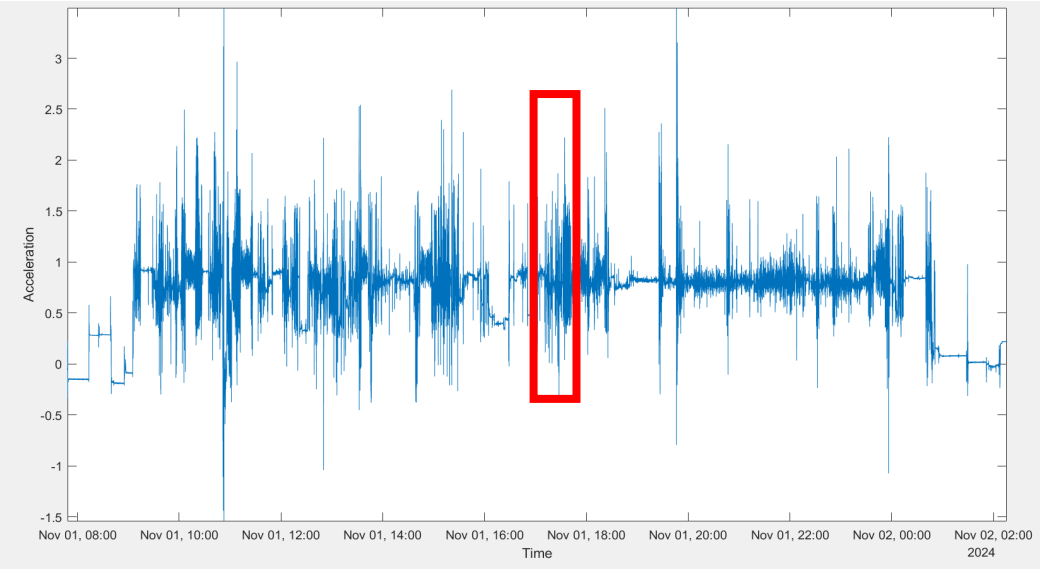


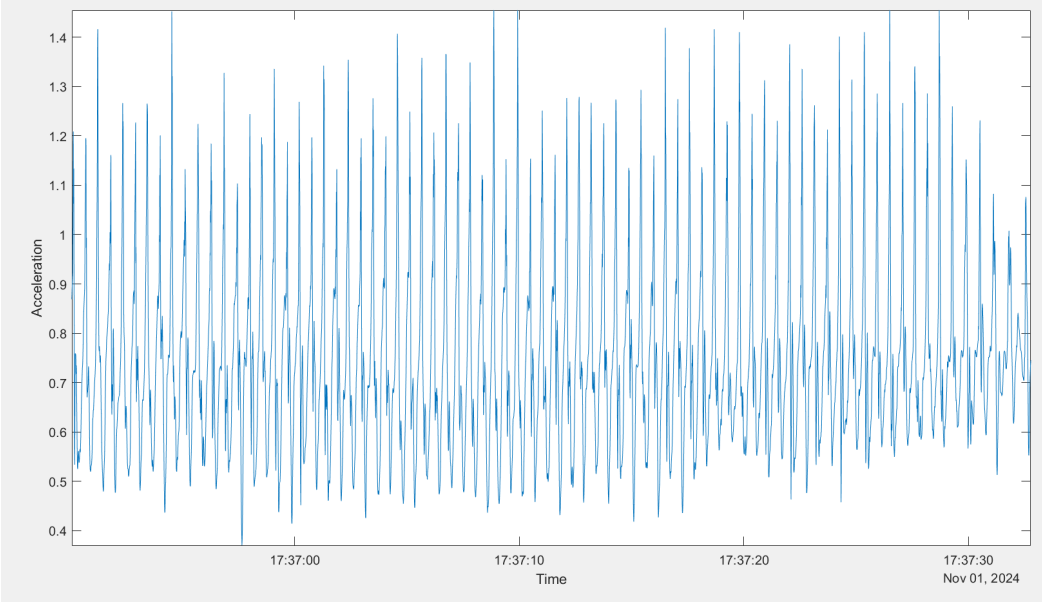
Real-world gait outcomes

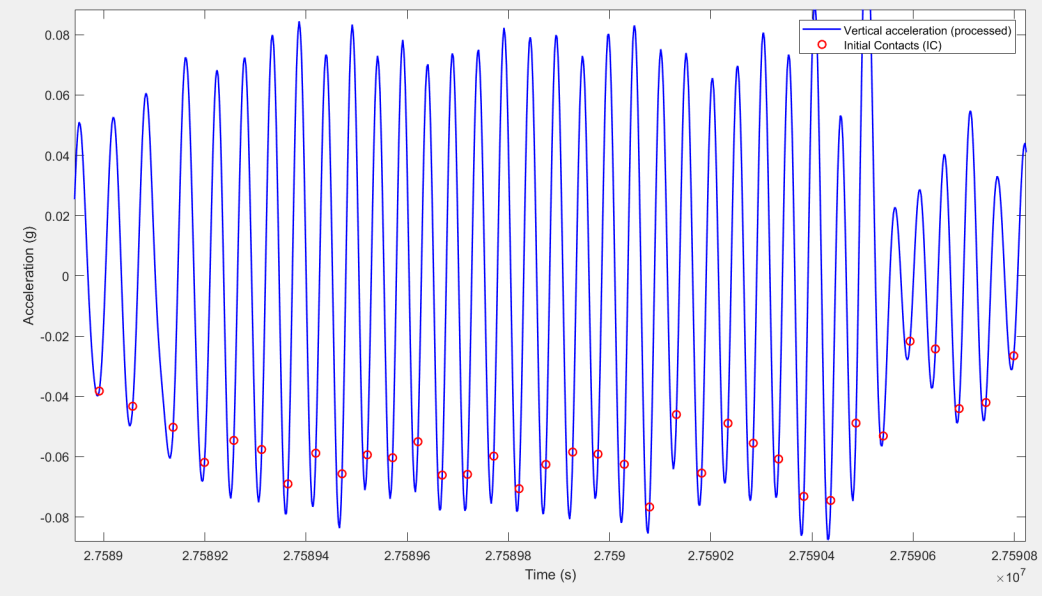


Real-world gait outcomes









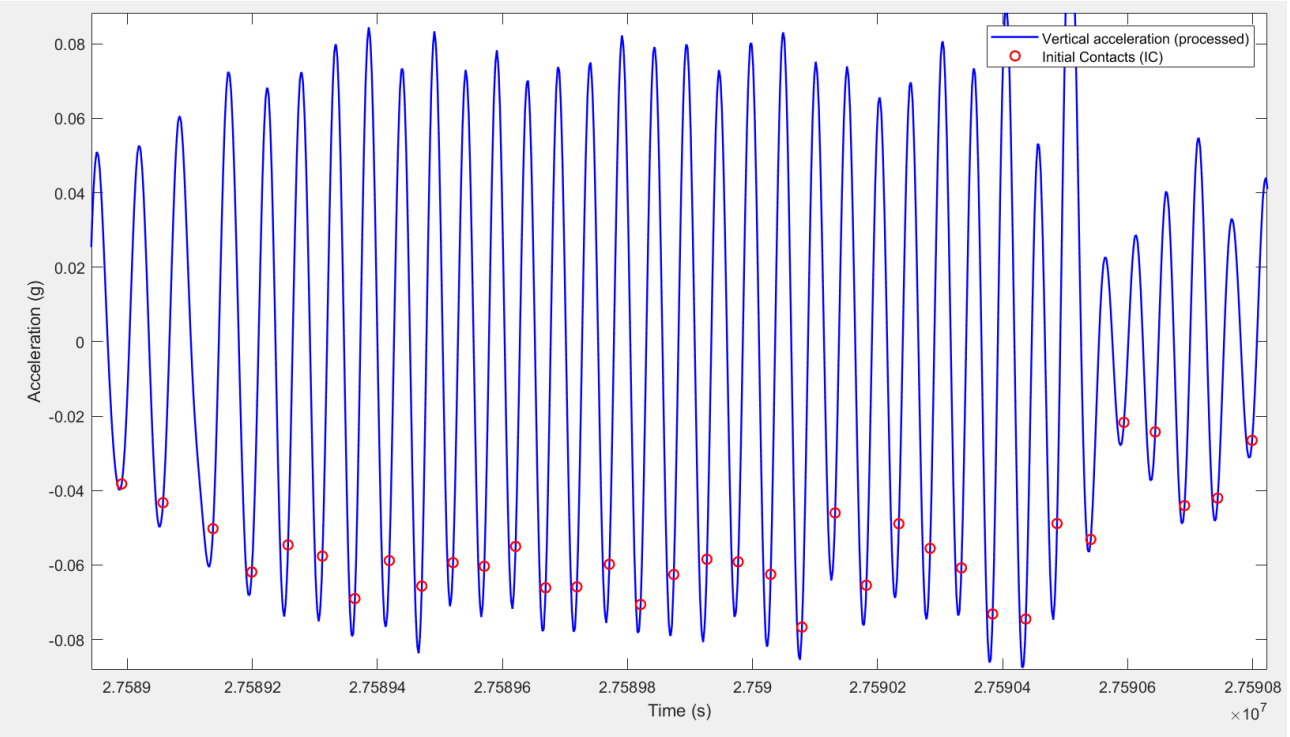
Real-world gait outcomes

1x1104 struct with 22 fields

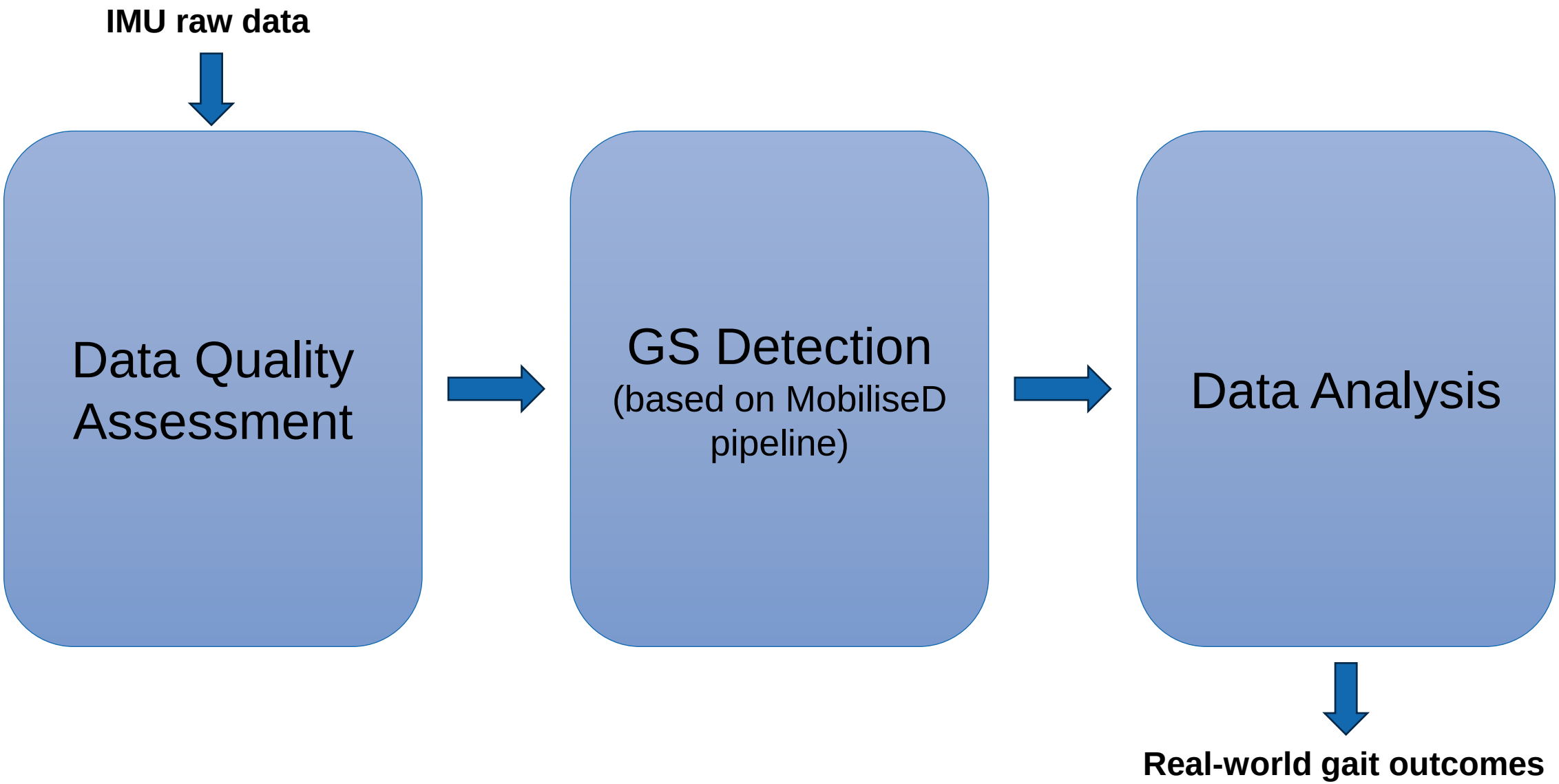
Fields	Start	End	fs	duration	Time	IC	StepTimes	stMean	stSTD	stCoV	cadSec	cadMean	cadSTD	cadCoV
238	8.6197e+04	8.6220e+04	100	22.9500	1x1 datetime	21x1 double	20x1 double	1.0362	0.1450	0.1399	22x1 double	82.5484	18.3906	0.2228
239	8.6227e+04	8.6239e+04	100	12.3000	1x1 datetime	12x1 double	11x1 double	1.1182	0.1670	0.1493	12x1 double	95.3864	15.8231	0.1659
240	8.6274e+04	8.6278e+04	100	3.9500	1x1 datetime	[8.6274e+0...	[0.7250;0.5...	0.9875	0.5010	0.5074	[80.0000;9...	88.2347	9.7426	0.1104
241	8.6308e+04	8.6319e+04	100	11.1750	1x1 datetime	[8.6308e+0...	[1.2000;1.1...	1.2417	0.1139	0.0917	11x1 double	83.6624	21.2532	0.2540
242	8.6447e+04	8.6458e+04	100	11.1000	1x1 datetime	11x1 double	[1.0750;1.0...	1.1100	0.1951	0.1758	11x1 double	77.5608	20.9593	0.2702
243	8.6470e+04	8.6528e+04	100	58.3750	1x1 datetime	50x1 double	49x1 double	1.1597	0.1374	0.1185	58x1 double	91.6615	8.9380	0.0975
244	8.6711e+04	8.6783e+04	100	72.6750	1x1 datetime	70x1 double	69x1 double	1	0.0782	0.0782	72x1 double	69.8443	16.5605	0.2371
245	8.6808e+04	8.6813e+04	100	5.0750	1x1 datetime	[8.6808e+0...	[0.8750;1.0...	1.0150	0.0877	0.0864	[54.5455;6...	68.4658	17.8807	0.2612
246	8.7616e+04	8.7622e+04	100	5.6000	1x1 datetime	[8.7616e+0...	[0.9500;1.0...	0.9333	0.1008	0.1080	[80;66.666...	76.1769	17.8386	0.2342
247	8.7660e+04	8.7667e+04	100	7.0500	1x1 datetime	[8.7660e+0...	[1.1500;0.9...	1.1750	0.2092	0.1780	[92.3077;9...	99.4012	8.9618	0.0902
248	8.7671e+04	8.7685e+04	100	13.7750	1x1 datetime	14x1 double	13x1 double	1.0250	0.2000	0.1951	13x1 double	76.8180	18.2634	0.2377
249	8.8580e+04	8.8603e+04	100	22.8750	1x1 datetime	26x1 double	25x1 double	0.8970	0.1682	0.1875	22x1 double	74.3723	11.1976	0.1506
250	8.9112e+04	8.9131e+04	100	19.6250	1x1 datetime	22x1 double	21x1 double	0.9345	0.1322	0.1414	19x1 double	67.2985	10.8629	0.1614
251	8.9467e+04	8.9473e+04	100	6.6000	1x1 datetime	[8.9467e+0...	[1.1250;1.3...	0.9429	0.2835	0.3007	[98.3278;1...	100.1908	1.0539	0.0105
252	8.9500e+04	8.9540e+04	100	40.5250	1x1 datetime	45x1 double	44x1 double	0.8932	0.1322	0.1480	40x1 double	75.7145	14.6896	0.1940
253	8.9545e+04	8.9550e+04	100	4.6500	1x1 datetime	[8.9545e+0...	[1.1000;0.7...	0.9300	0.1595	0.1715	[77.4194;8...	84.8850	5.0033	0.0589
254	8.9562e+04	8.9567e+04	100	4.2000	1x1 datetime	[8.9562e+0...	[1;1.1750;0....	0.8400	0.2832	0.3371	[96;93.553...	106.8086	18.2770	0.1711
255	8.9599e+04	8.9612e+04	100	13.3750	1x1 datetime	16x1 double	15x1 double	0.8917	0.1298	0.1456	13x1 double	77.2221	11.5420	0.1495
256	8.9683e+04	8.9688e+04	100	4.9750	1x1 datetime	[8.9683e+0...	[1;1.0250;0....	0.9950	0.0542	0.0545	[86.9779;6...	71.7785	11.5289	0.1606
257	8.9710e+04	8.9724e+04	100	14.1000	1x1 datetime	16x1 double	15x1 double	0.9400	0.0934	0.0994	14x1 double	66.6525	6.8586	0.1029
258	8.9882e+04	8.9900e+04	100	18.0250	1x1 datetime	19x1 double	18x1 double	1.0014	0.1062	0.1061	18x1 double	73.0712	19.2749	0.2638
259	9.0191e+04	9.0197e+04	100	6.2250	1x1 datetime	[9.0191e+0...	[1.1250;0.9...	1.0375	0.0959	0.0924	[104.3478;...	100.5952	7.7706	0.0772
260	9.0200e+04	9.0214e+04	100	13.9500	1x1 datetime	15x1 double	14x1 double	0.9054	0.1084	0.1197	13x1 double	77.0834	12.5453	0.1628

Real-world gait outcomes

- Number of walking bouts
- Walking duration
- Steps per walking bout
- Mean walking speed
- Mean step time, step length
- Variability
- Asymmetry



From IMU data to real-world gait outcomes



Intervention effects in daily life

Article

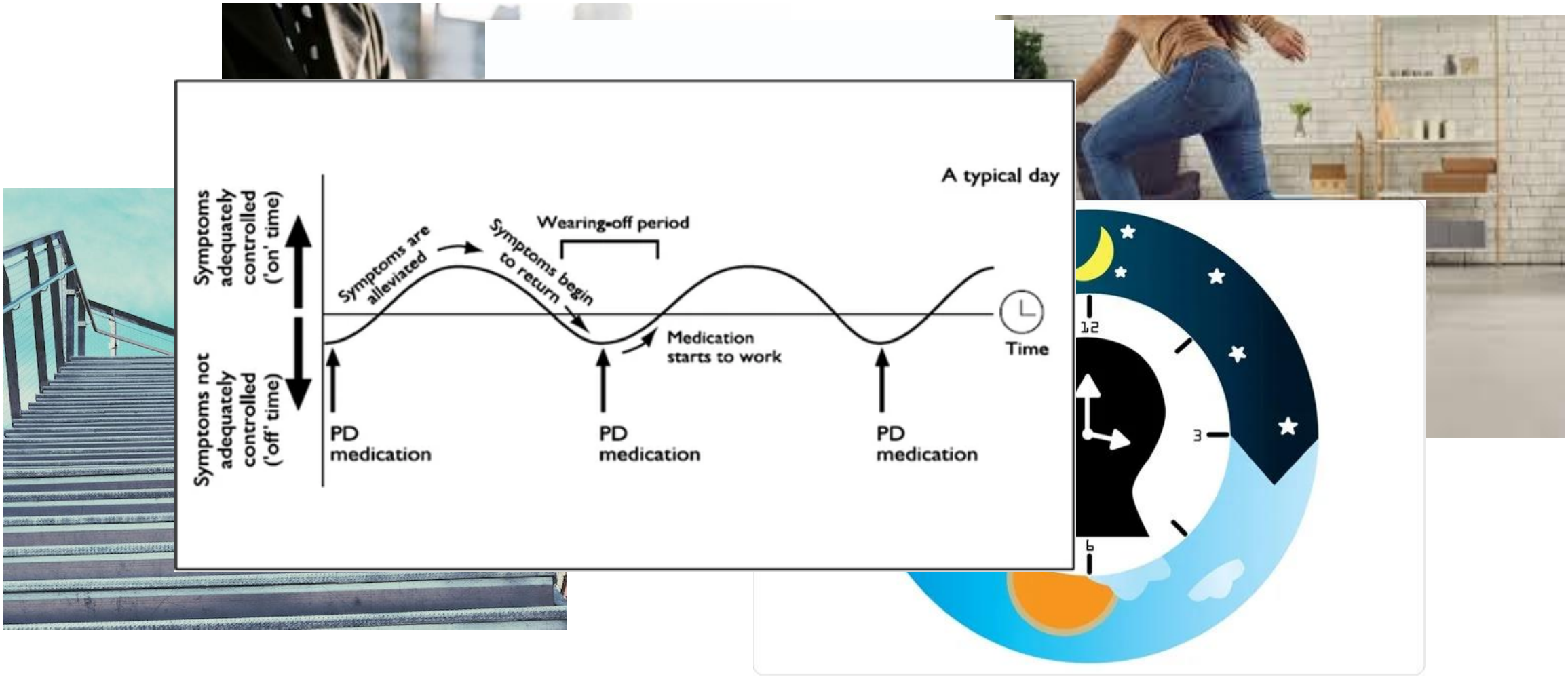
Multidisciplinary Intensive Rehabilitation Program for People with Parkinson's Disease: Gaps between the Clinic and Real-World Mobility

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,*]

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

Daily life influences on gait



Daily life influences on gait – Patient persperctive Lumsdon et al. (2024)

"My stride length varies not just with location […] but **also where I am in the drug cycle**. So it would be useful to not only plot the steps per day but throughout the day."

"I think the information could be very useful if there was a way to link to notes on **how you were feeling on a given day** to see what may have impacted your stats."

"I like the idea of being able to compare **times of day**"

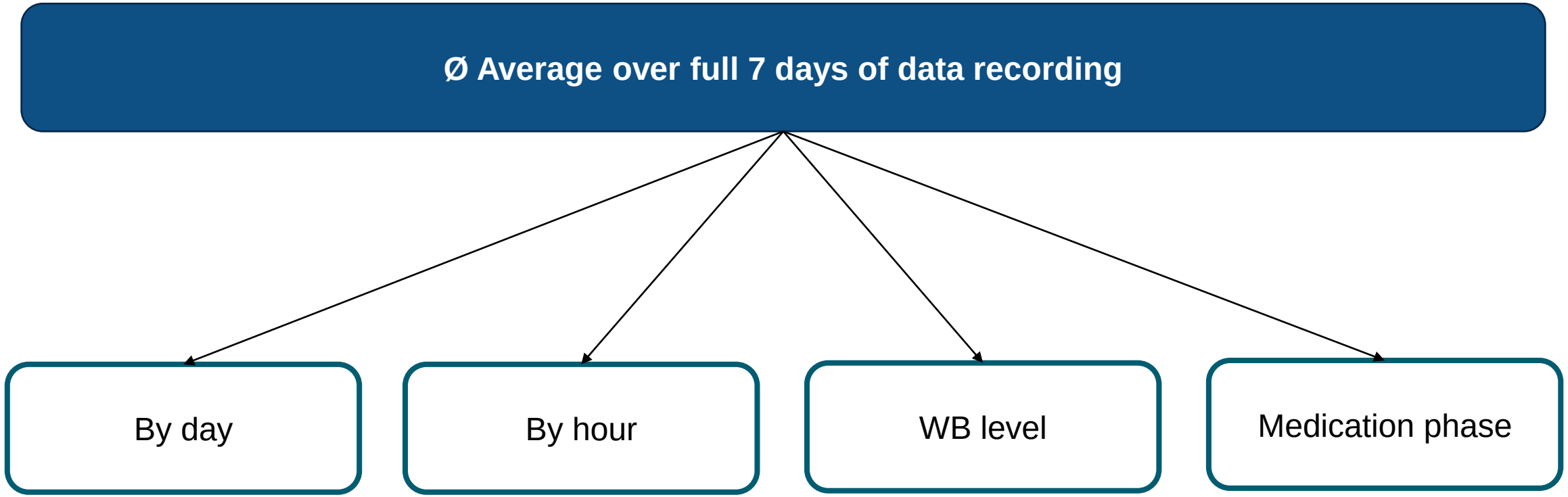
Daily life influences on gait – Patient persperctive Lumsdon et al. (2024)

- Participants described how their walking changed depending on medication phase
- Participants found the differentiation between […] time of day […] to be important as this influences the presentation of their symptoms.

→ But: where are the changes during the day coming from?

→ How can we objectively quantify the changes and describe them?

Levels of data analysis



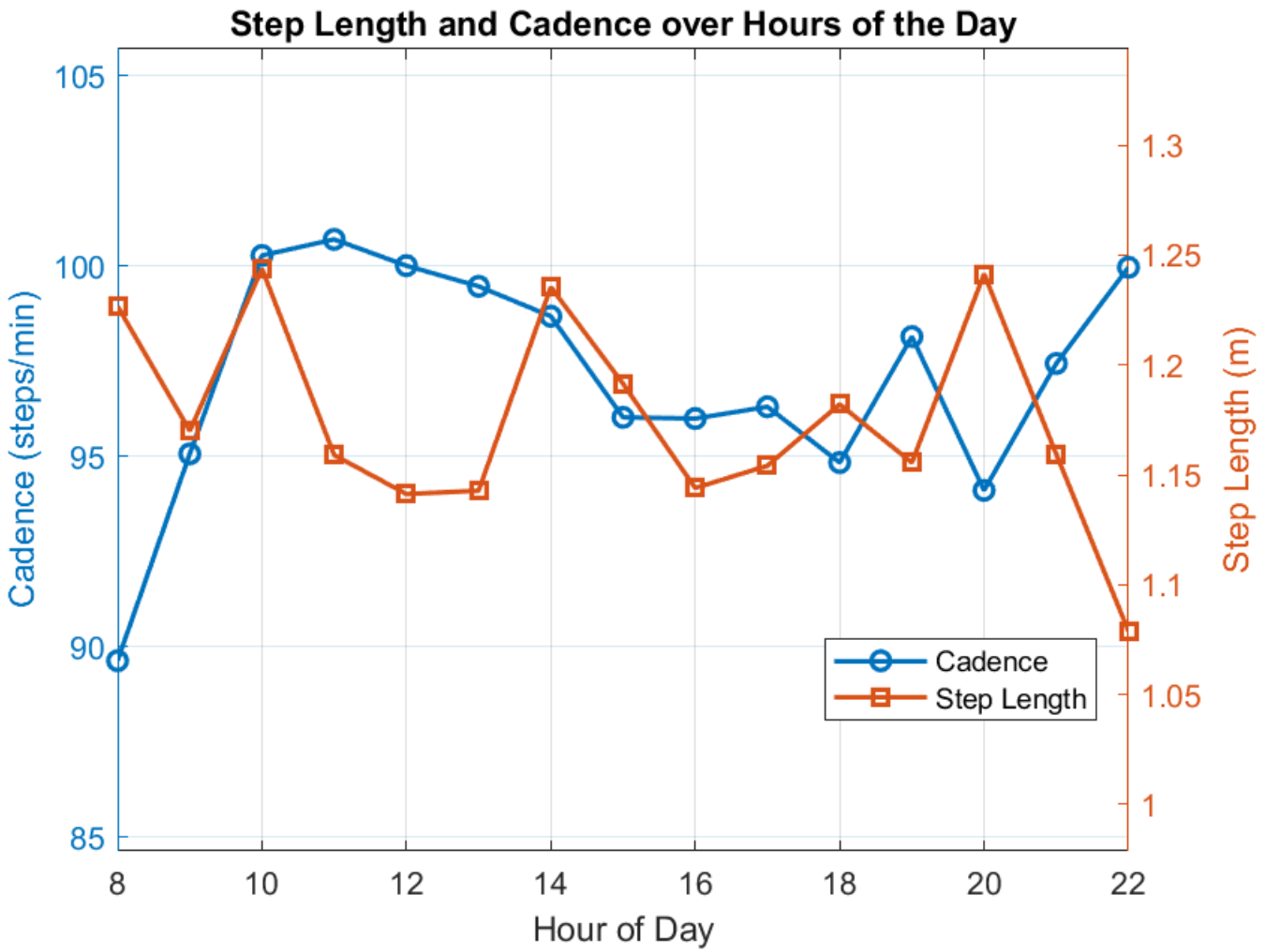
Gait outcomes by **Day**

Walking bouts	**Timestamp**	**Steps**	**…**
WB 1	2024-15-11	39	
WB 2	2024-16-11	10	
…	…	…	
WB n	2024-21-11	254	

Day	**Weekend**	**Steps per day**	**…**
2024-15-11	No	4580	
2024-16-11	Yes	5894	
…	…	…	
2024-21-11	No	11206	

Gait outcomes by **Hour**

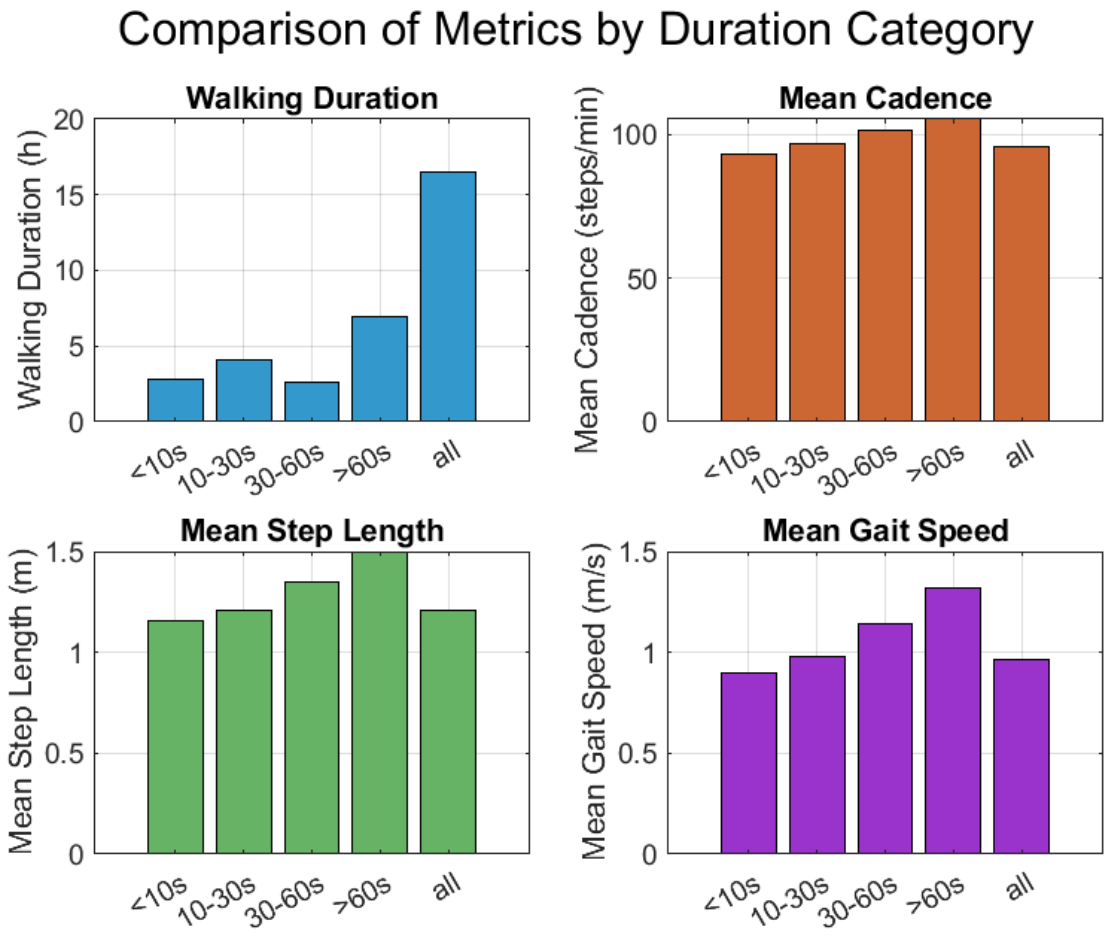
- Combine daytime over several days
- Calculate gait outcomes for each hour between 8am and 10pm



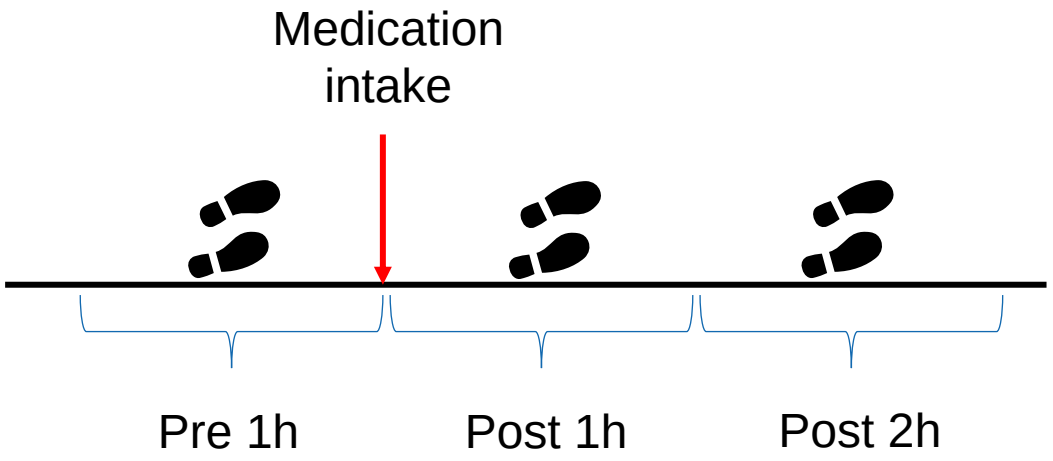
Gait outcomes by **WB length**

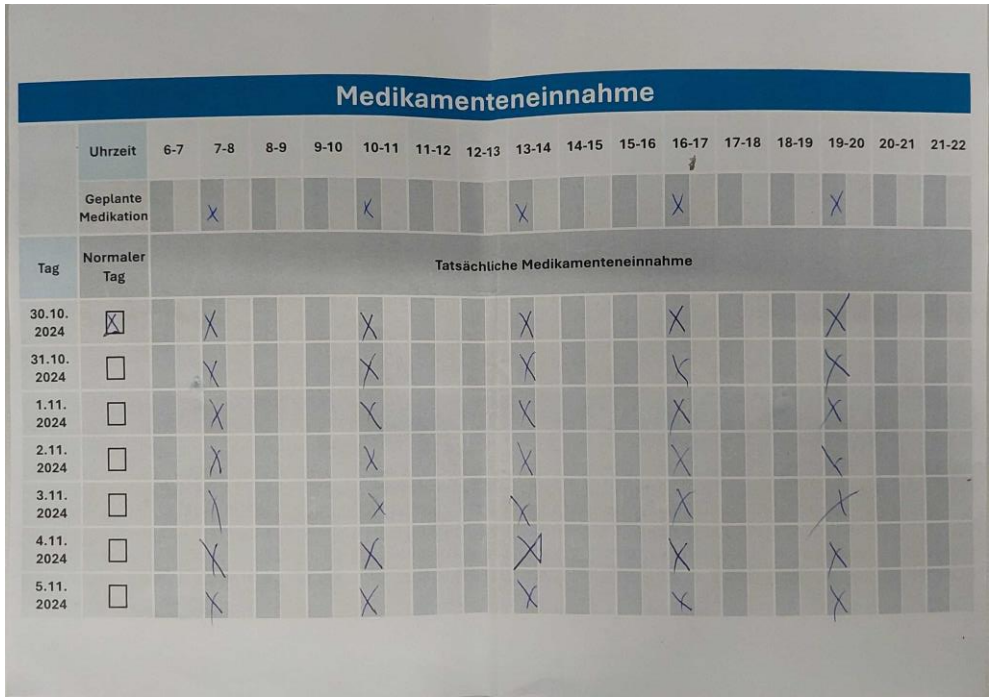
- Categories by WB length
  - < 10s
  - 10 - 30s
  - 30 - 60s
  - > 60s

- Calculate metrics for each wb category separately



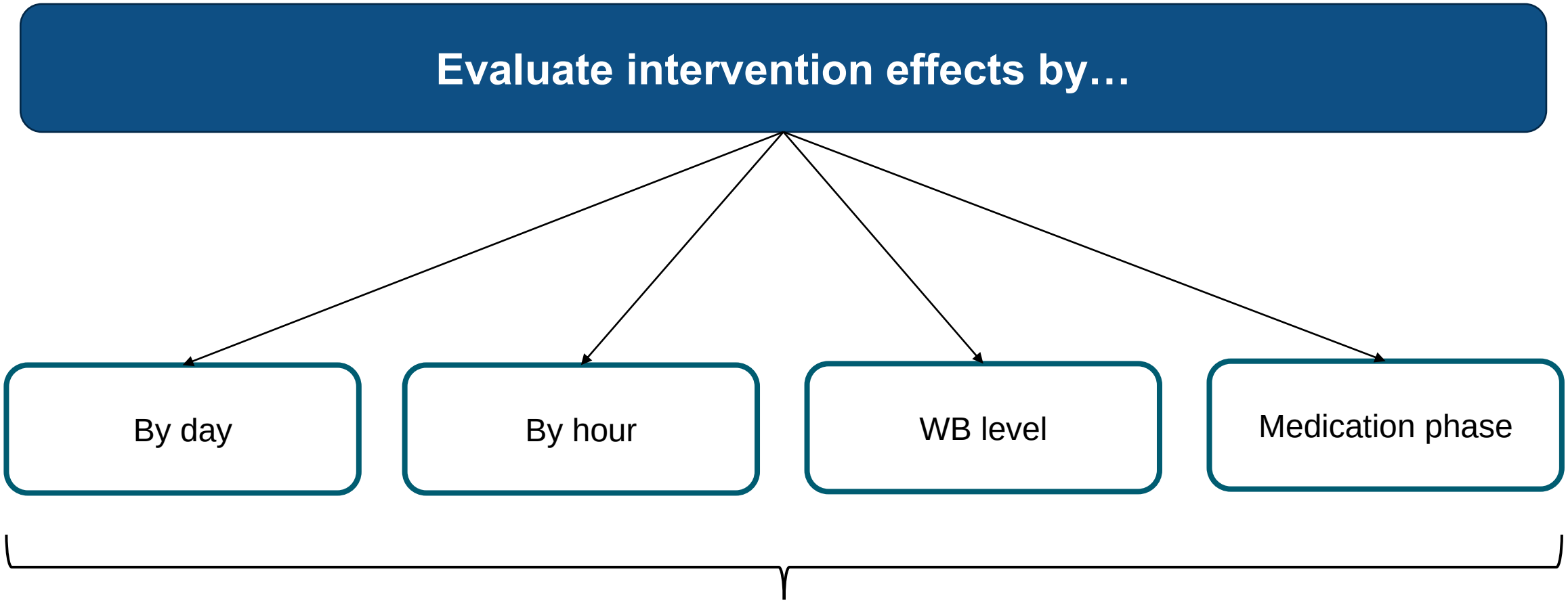
Gait outcomes by **Medication Phase**





- Combine IMU data with contextual information -> medication intake
- Comparison of gait outcomes in different phases of medication cycle

Conclusion



Do intervention effects translate do daily life? · If no, why not? · Suggest improvements for further interventional studies