Balance and Gait Research in Parkinson's Disease

Carolin Curtze, PhD

Assistant Professor, Department of Biomechanics

University of Nebraska at Omaha

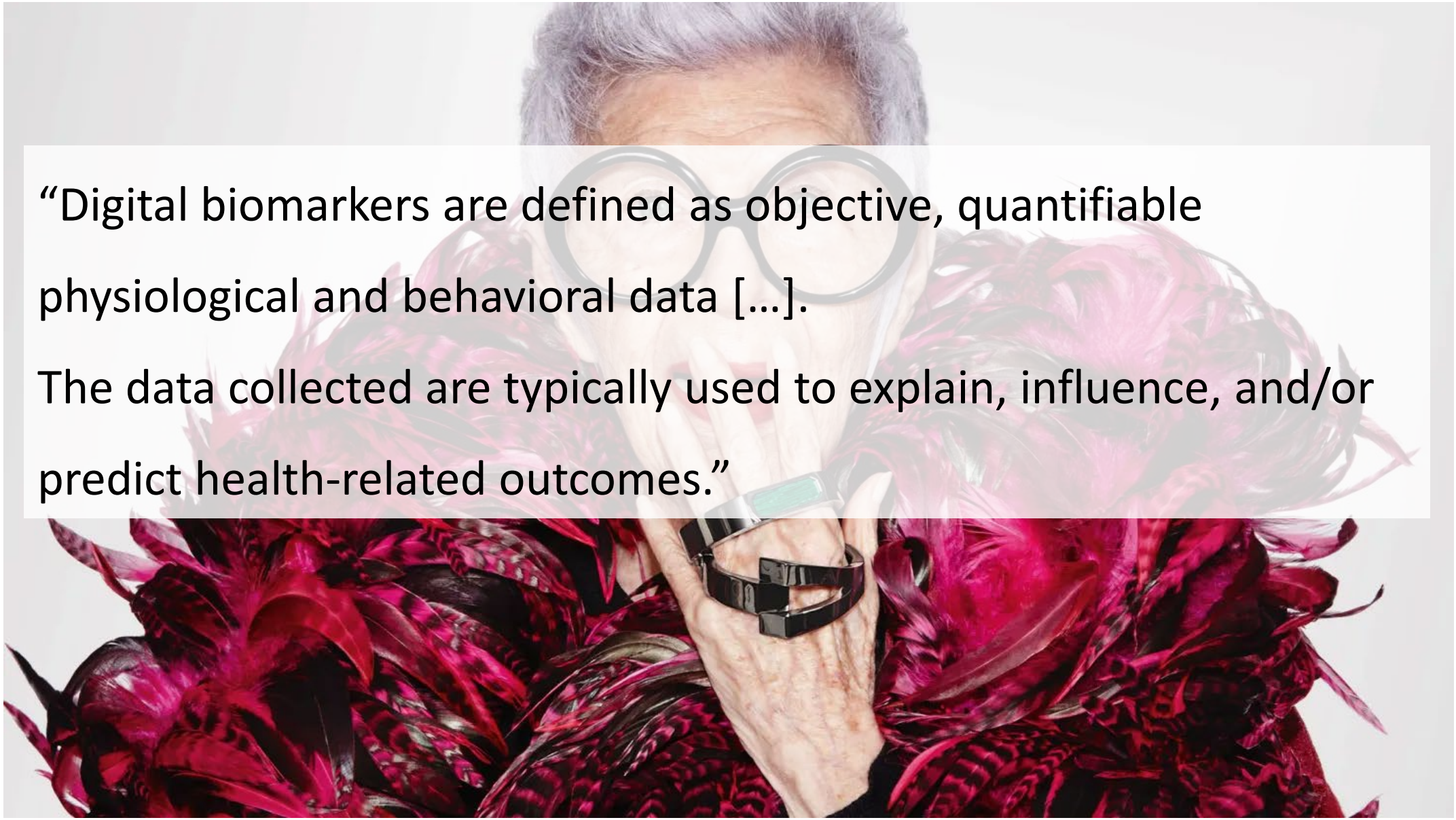
BIOMECHANICS

Grant Support
NIH NIGMS, P20GM109090
Nebraska Research Initiative
Medtronic
Medical Research Foundation of Oregon

Carolin Curtze, PhD
ccurtze@unomaha.edu

Digital Biomarkers

BIOMECHANICS

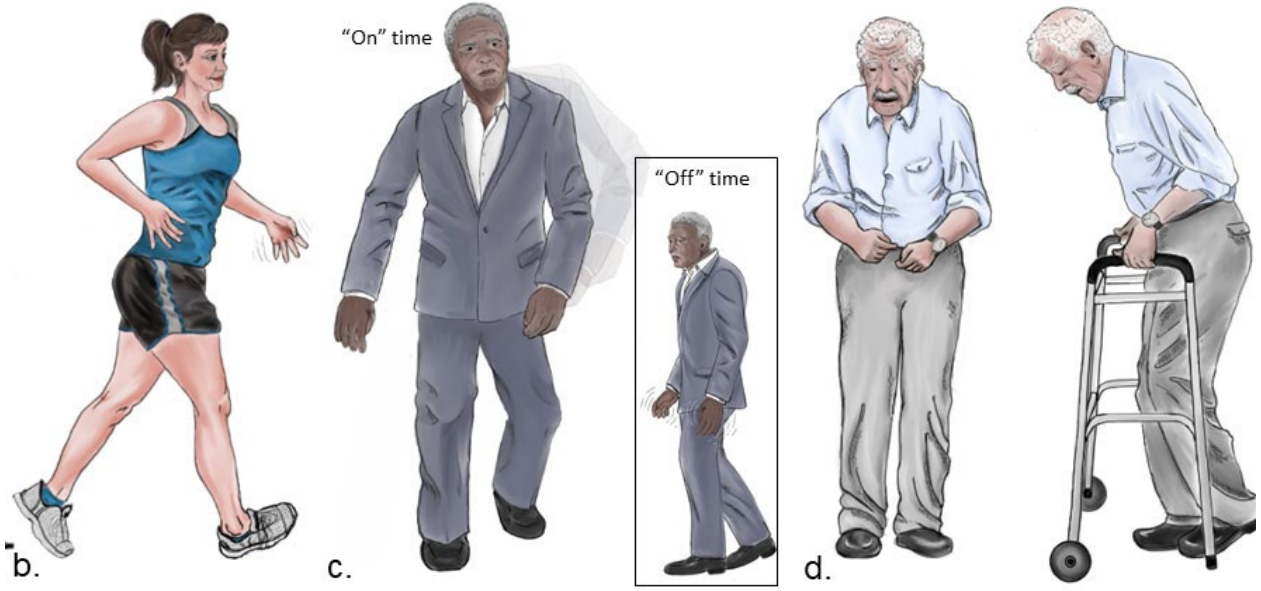


"Digital biomarkers are defined as objective, quantifiable physiological and behavioral data […].

The data collected are typically used to explain, influence, and/or predict health-related outcomes."

Cardinal Signs of Parkinson's Disease

- Tremor
- Bradykinesia
- Rigidity
- Postural Instability



Armstrong & Okun (2020)

Levodopa is the standard treatment of Parkinson's disease.

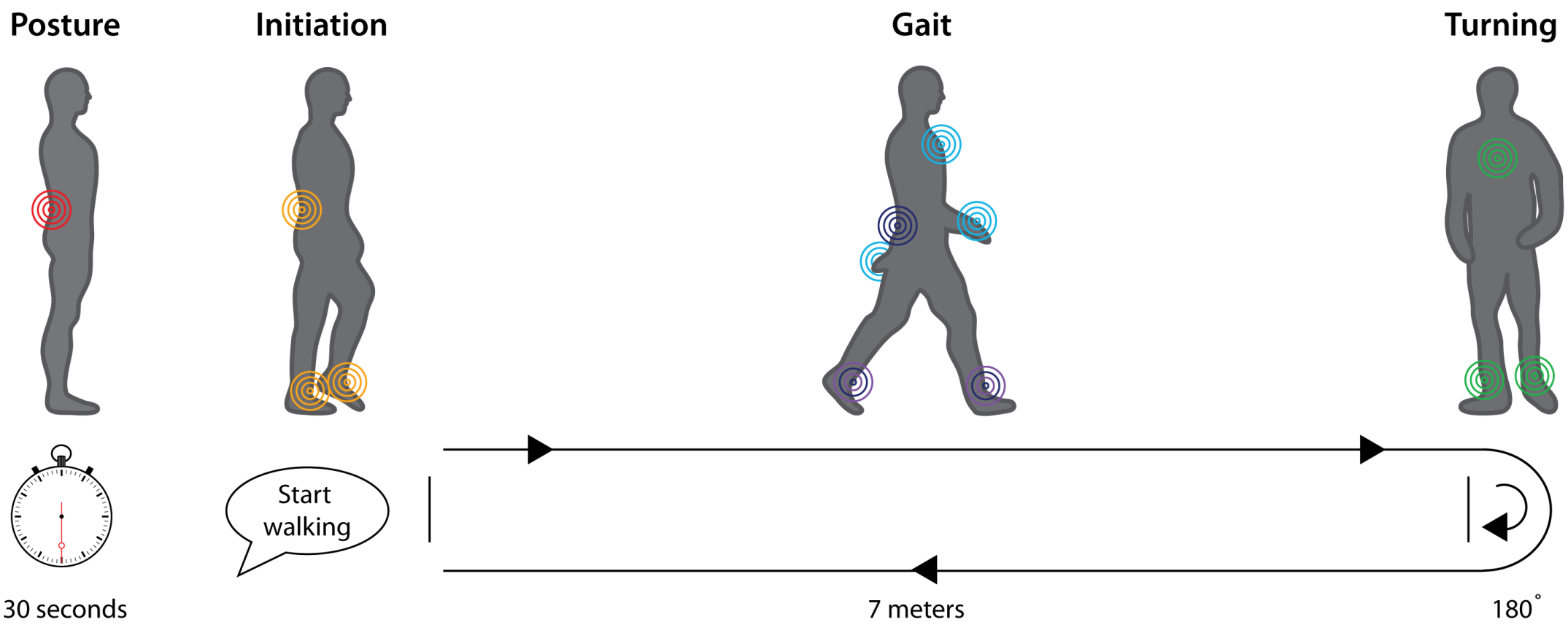
Wearable Sensors

BIOMECHANICS

- Small & Lightweight
- Rechargeable or replaceable batteries
- Battery life of hours to days
- One to many sensors on body segments
- Store & download or real time streaming
- Wireless synchronization

Measures of Mobility

BIOMECHANICS



P - Sway RMS AP (m/s^2)
P - Sway RMS ML (m/s^2)
P - Mean velocity AP (m/s)
P - Mean velocity ML (m/s)
P - Centroidal Frequency AP (Hz)
P - Centroidal Frequency ML (Hz)
P - Frequency Dispersion AP (-)
P - Frequency Dispersion ML (-)
P - Normalized Jerk AP (-)
P - Normalized Jerk ML (-)

I - APA Duration (s)
I - APA Latency (s)
I - APA Peak AP (g)
I - APA Peak ML (g)
I - RoM First Step (deg)
I - Duration of First Step (s)

Gait - Pace
G - Gait Cycle Time(s)
G - Cadence (steps/min)
G - Stride Velocity (%h/s)
G - Stride Length (%h)
G - RoM Leg (deg)

Gait - Arm & Trunk
G - Arm Peak Velocity (deg/s)
G - Arm Swing RoM (deg)
G - Asymmetry Arm Swing RoM (%)
G - RoM Trunk Frontal Plane (deg)
G - RoM Trunk Sagittal Plane (deg)
G - RoM Trunk Horizontal Plane (deg)

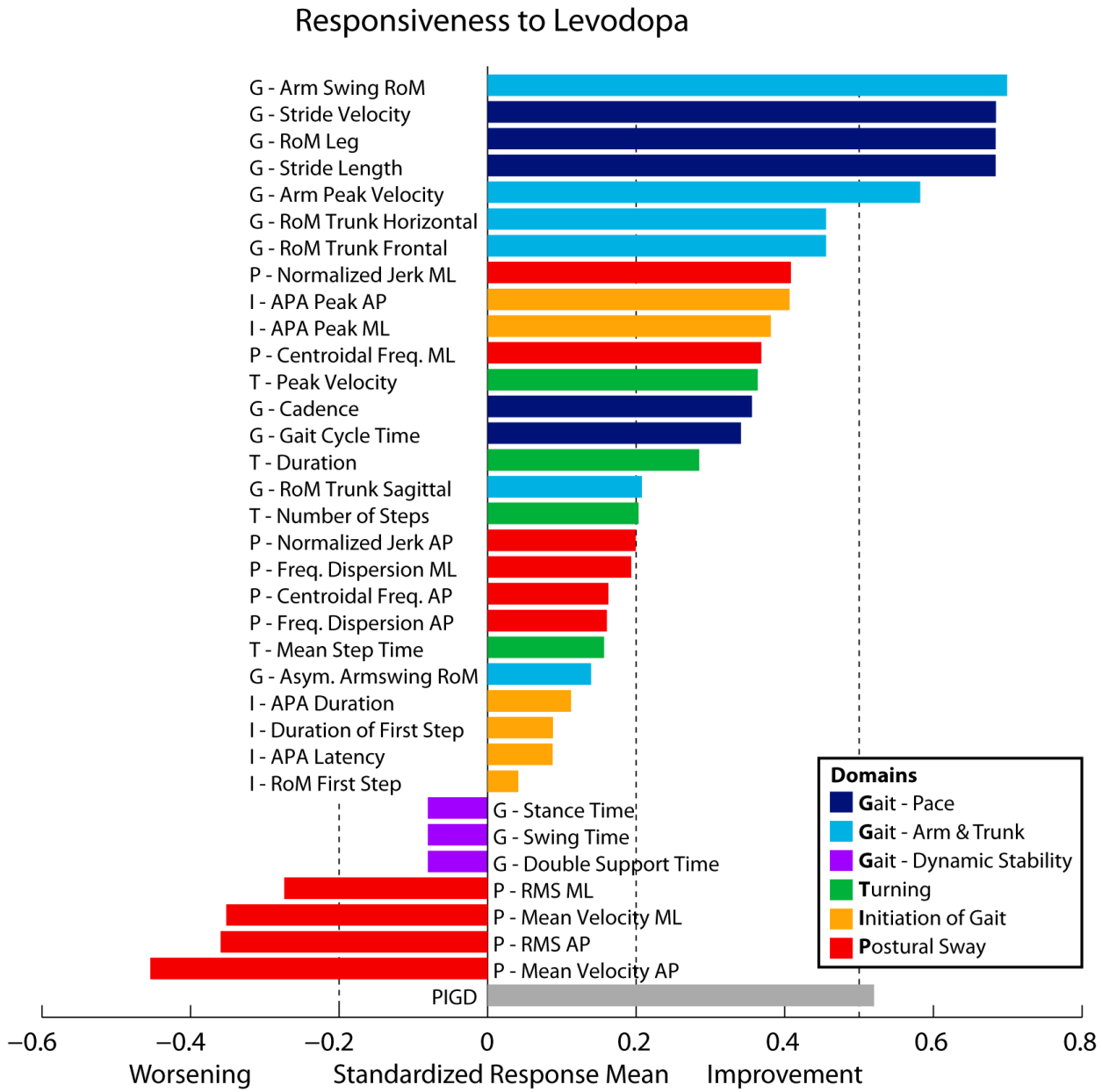
Gait - Dynamic Stability
G - Double Support Time (%)
G - Stance Time (%)
G - Swing Time (%)

T - Peak Velocity (deg/s)
T - Duration (s)
T - Mean Step Time (s)
T - Number of Steps (n)

Curtze et al. (2015)

Levodopa is a Double-edge Sword

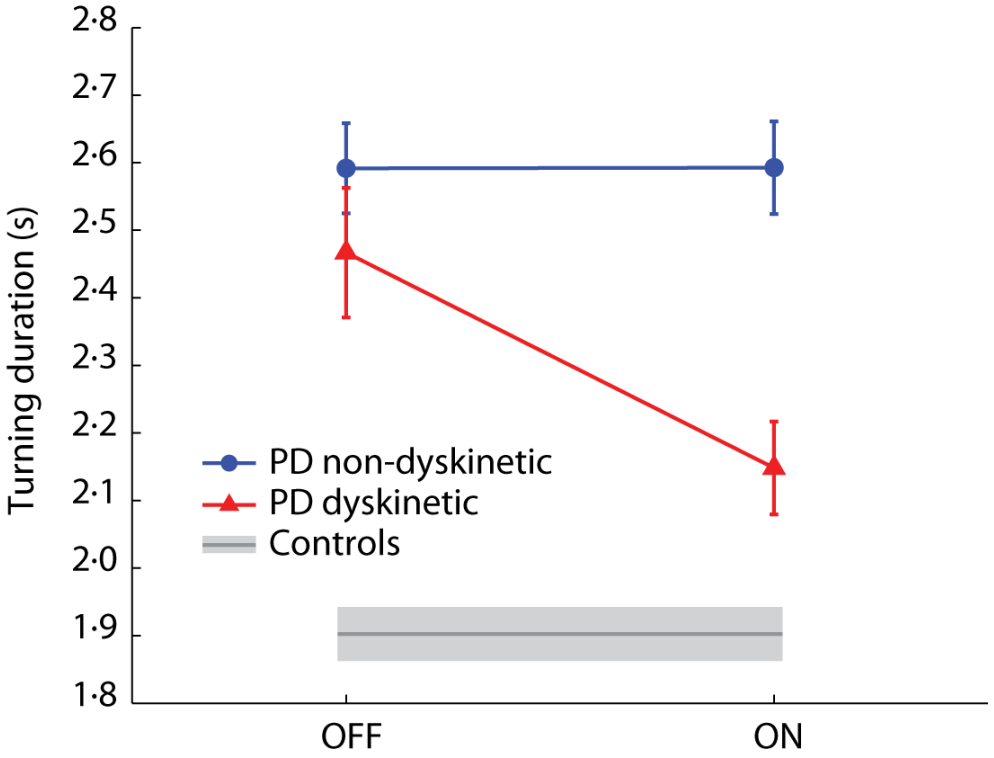
BIOMECHANICS

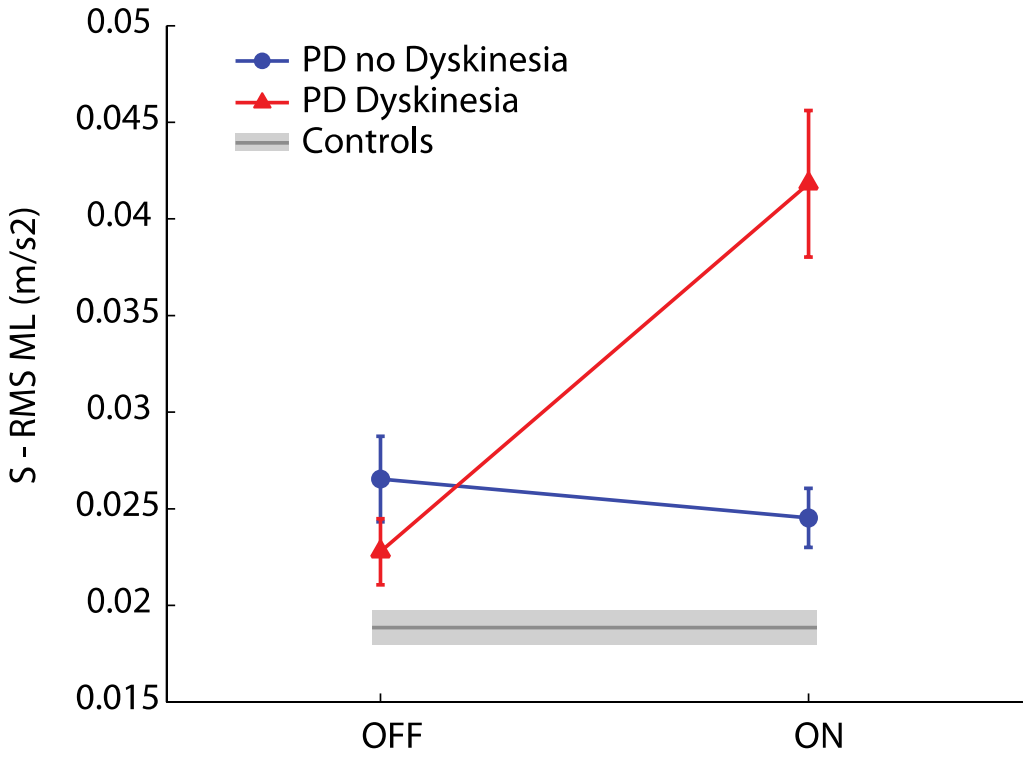


Curtze et al. (2015)

Levodopa is a Double-edge Sword

BIOMECHANICS





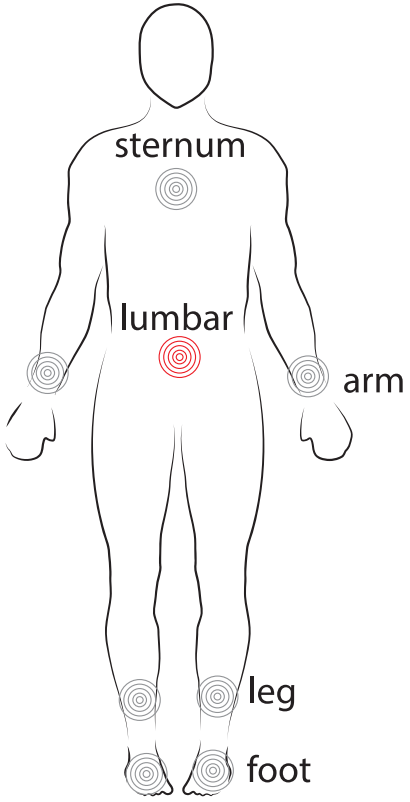
Curtze et al. (2015)

What is balance?

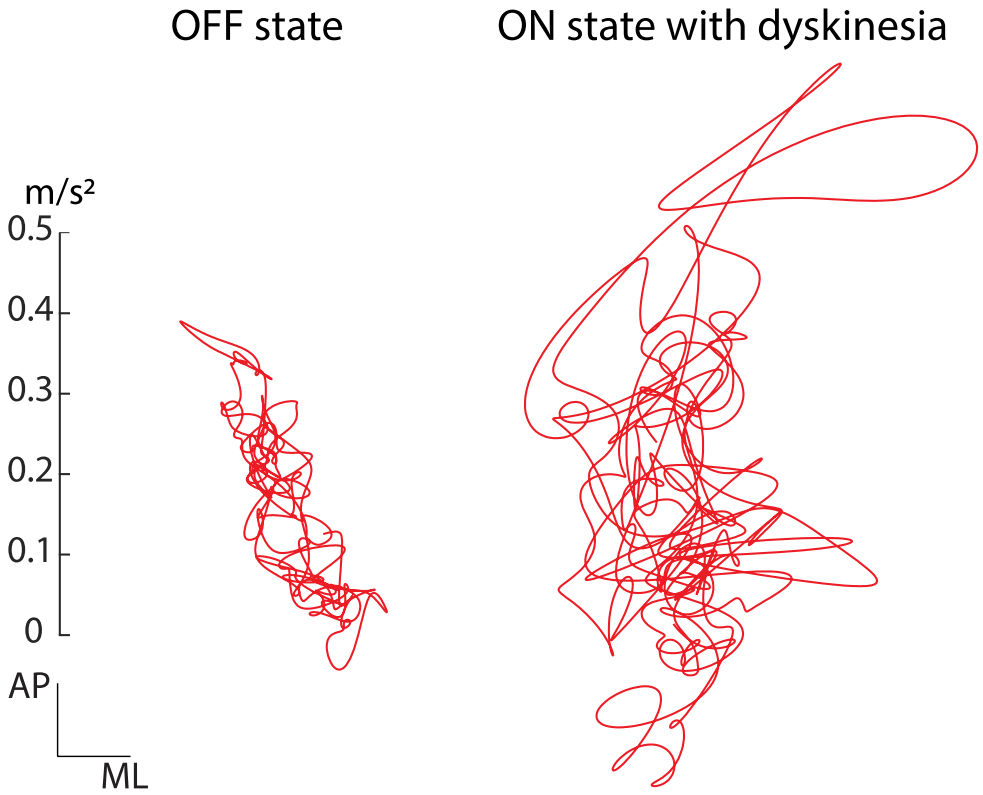
Postural Sway

BIOMECHANICS

Sensor Placement

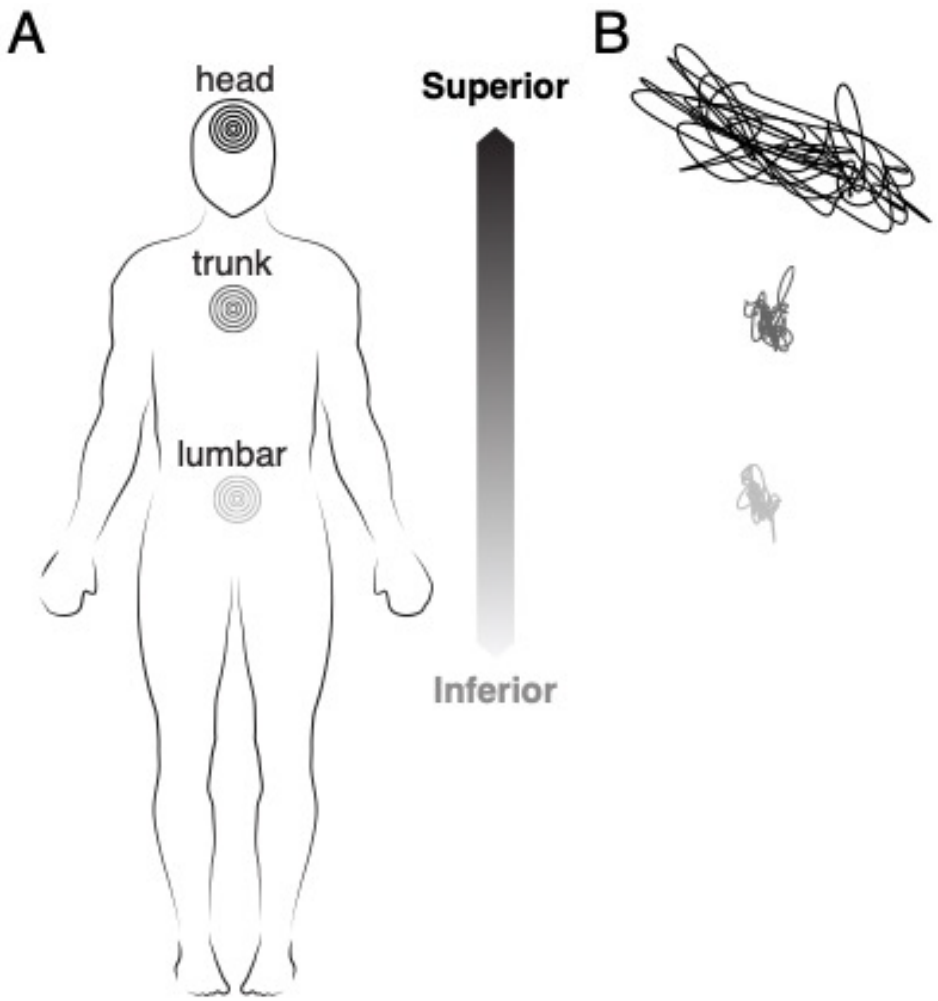


Postural Sway



Postural Sway & Head Stability

BIOMECHANICS



Aderonmu & Curtze (2024)

Optimal Head Stability

BIOMECHANICS

Deep Brain Stimulation

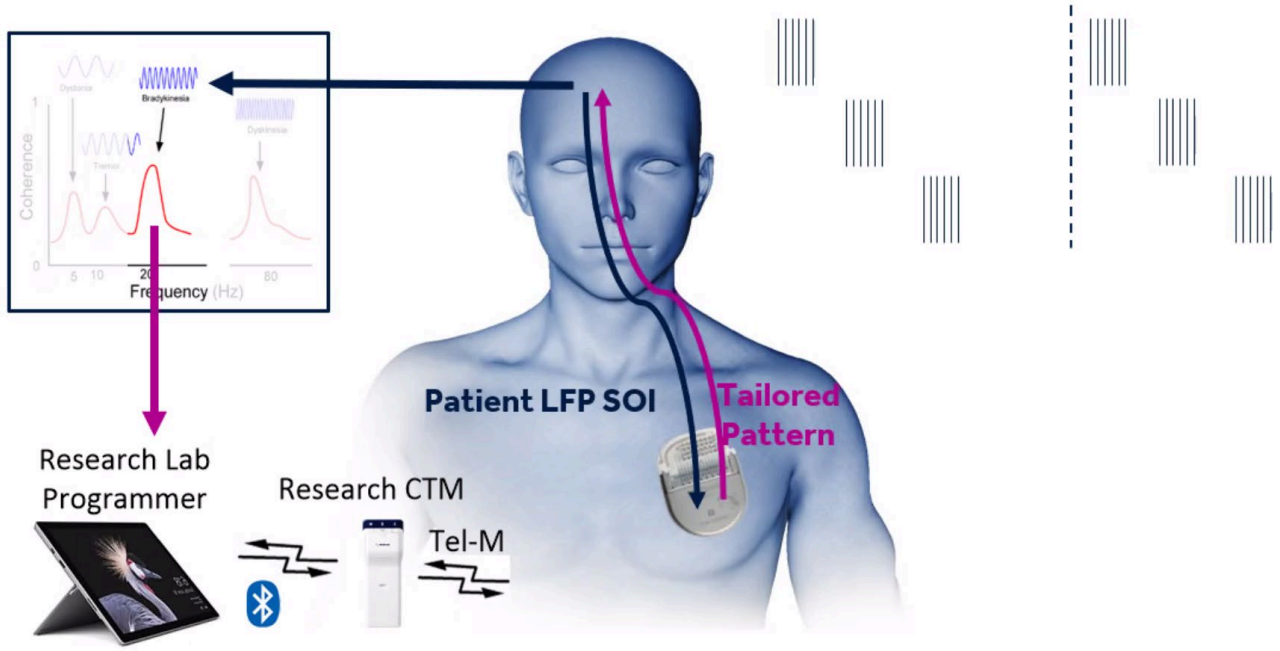
Neuromodulation

UNMC

Medtronic

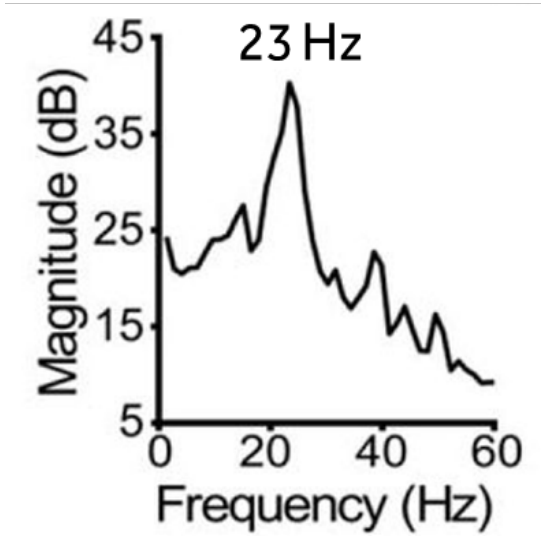
DBS Electrode Switching Patterns in Parkinson's disease

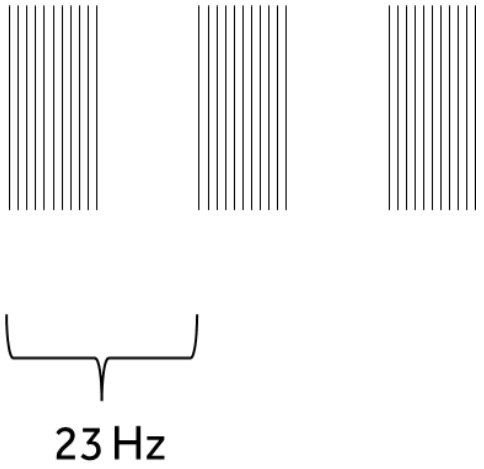
- Study Population
  - 10-15 study subjects total, optimized for clinical stimulation and medication, 3 months post-surgery
- Study Design
  - Open-label, non-randomized, proof-of-concept assessment of clinical and research stimulation



Neuromodulation Study Overview

BIOMECHANICS





Motor

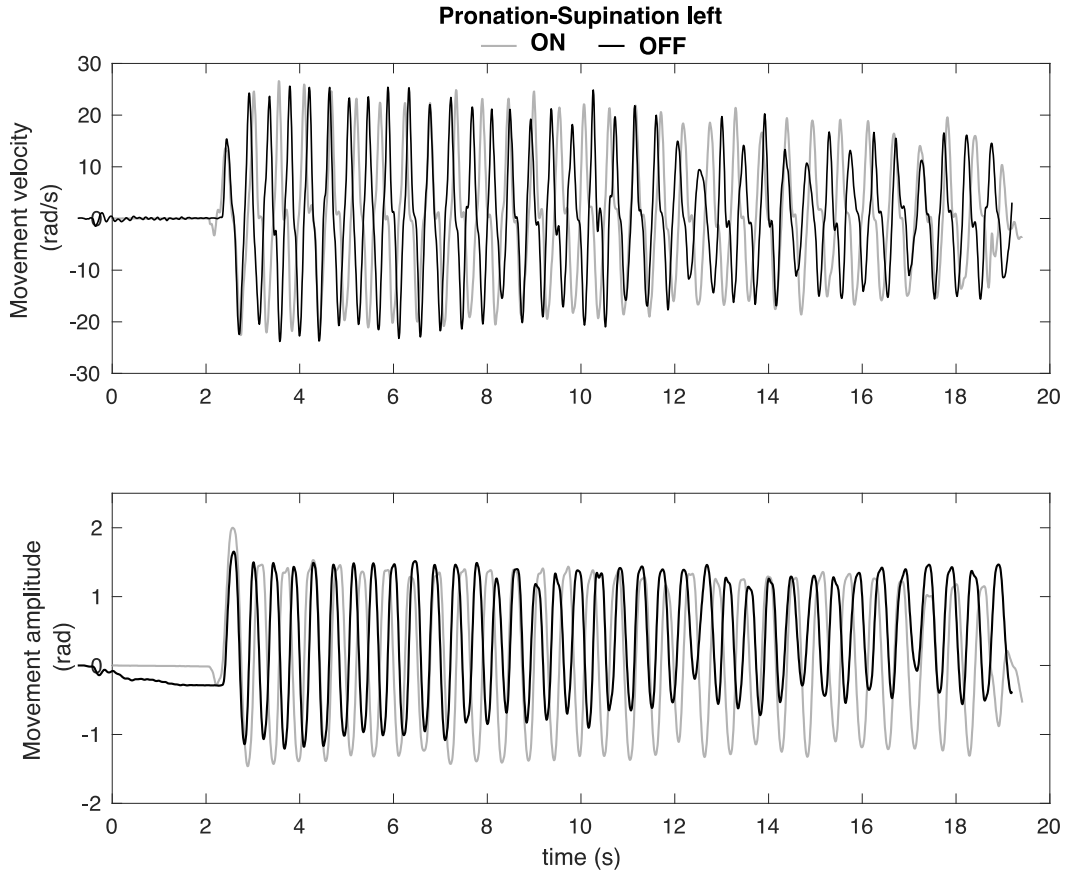
Sense
Patient specific oscillations

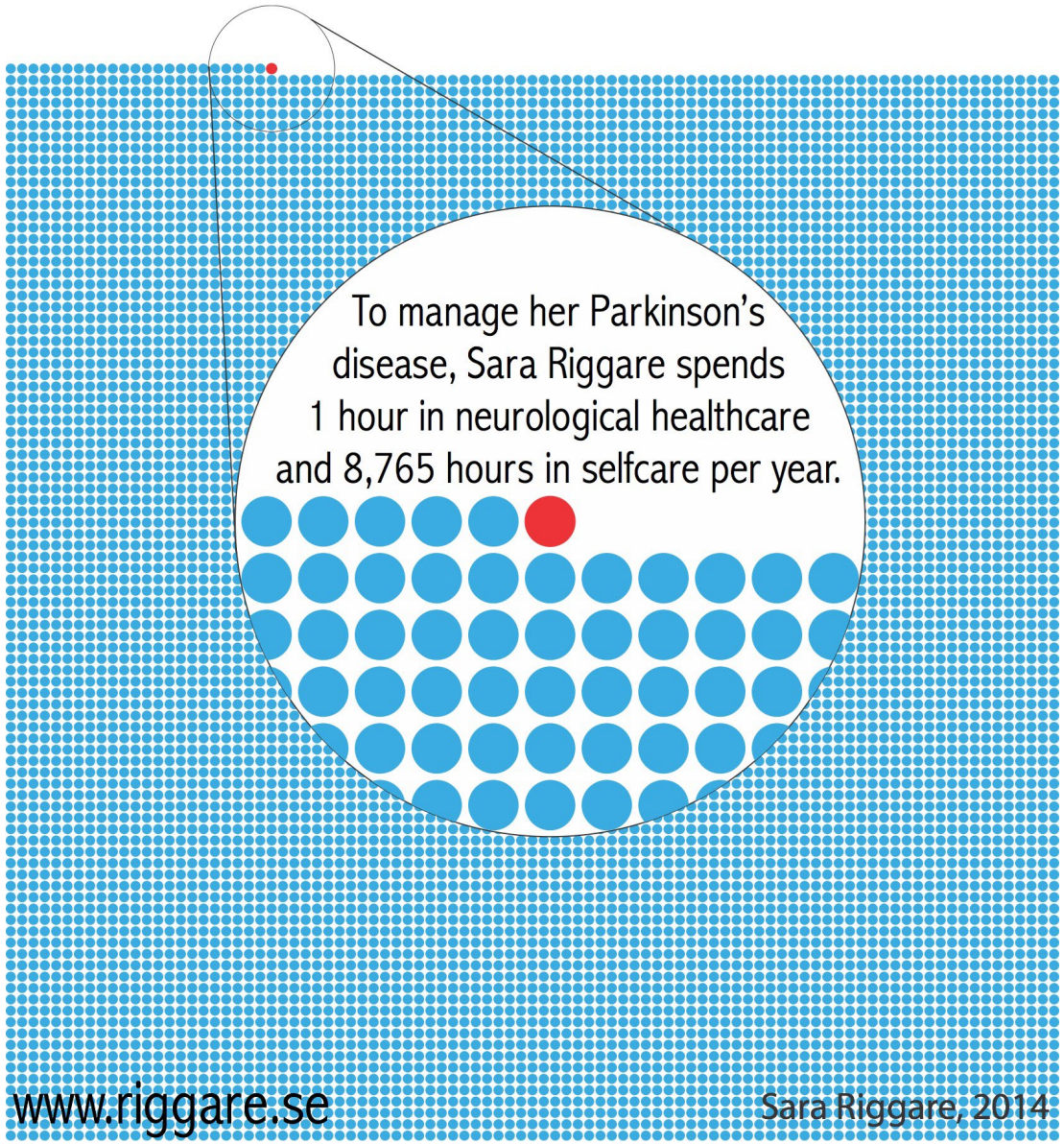
Tune Stim Pattern
Based on sensing

Implement & Evaluate
Sensing and Clinical Scores

Neuromodulation

BIOMECHANICS



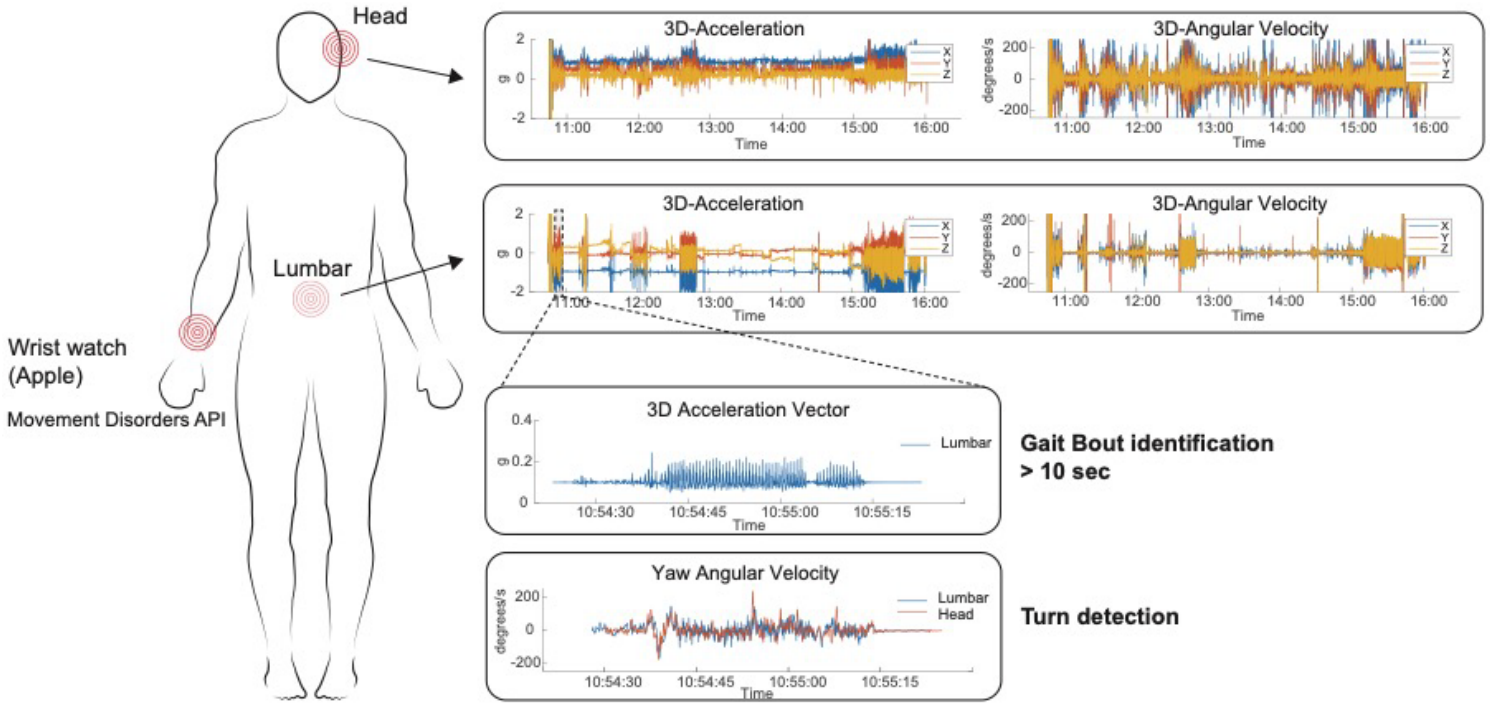


Why continuous monitoring?

Why continuous monitoring?

BIOMECHANICS

The assessment of mobility in the clinic may not adequately reflect variability during daily life.



Can technology be used for detection of turning and walking at home?

Thank you!

Carolin Curtze, PhD
Assistant Professor
Department of Biomechanics University of Nebraska at Omaha

ccurtze@unomaha.edu

NIH

Medtronic