MMG processing pipeline and feature extraction program to quantify onset of muscle fatigue during robotic gait training

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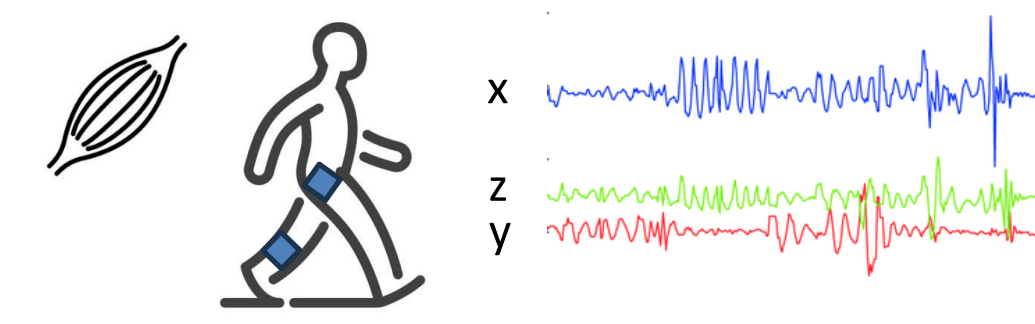
Feasibility, signal processing, and feature extraction of mechanomyography (MMG) recordings during gait in a robotic walker for children with cerebral palsy

Background
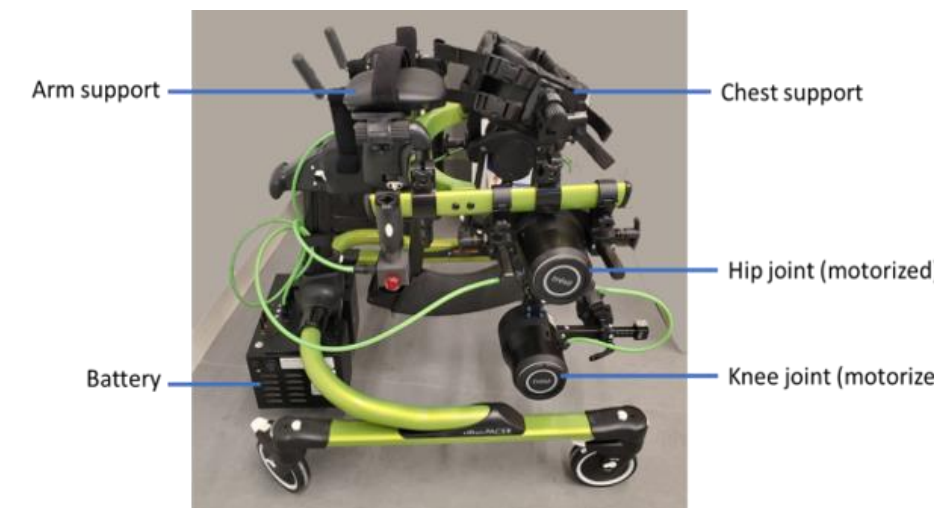
Cerebral palsy - GMFCS level IV

- Require powered or physically assisted methods of mobility [1]

- Dysregulated timing and intensity of muscle contractions [2]

MMG signals

- Measures low frequency oscillations of muscle fibers [3]

Trexo exoskeleton

Arm support   Chest support
Battery   Hip joint (motorized)
    Knee joint (motorized)

Robotic assisted physiotherapy

Helps children with mobility impairments experience the feeling of **over-ground walking**

Intervention (6 weeks, 2x/week)

What are the muscular effects?

Objectives

What is the feasibility of collection and processing of MMG readings in children with CP of GMFCS level IV?
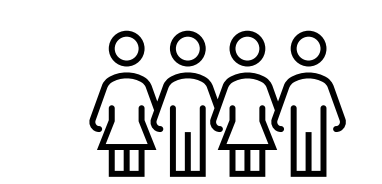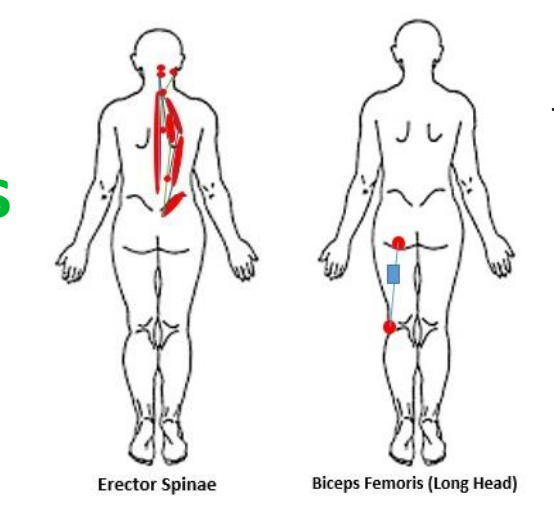
Set-up time   Tolerance   Signal quality

Hypothesis: Muscle activations will appear at lower frequencies when using the robotic walker compared to the manual walker; onset of muscle fatigue will appear sooner during manual walker use

Methods

5 participants
Ages 3-6
GMFCS level IV

Pre- and post- intervention
Robotic and manual walker
Set-up time ~ 5 minutes

MMG sensor placed on top of muscle belly with medical tape

Sensor locations:

Vastus lateralis [thigh], **biceps femoris** [hamstring], **glutes, erector spinae** [lower back]

Erector Spinae   Biceps Femoris (Long Head)

Results

8 muscles   Vastus lateralis

Manual

Trexo

Processing pipeline

Vector summation → Butterworth bandpass filter **2 - 100 Hz** → Wavelet denoising →

Feature extraction (RMS, MPF) + Empirical mode decomposition → Onset of muscle fatigue / Gait patterns / Muscle synergies
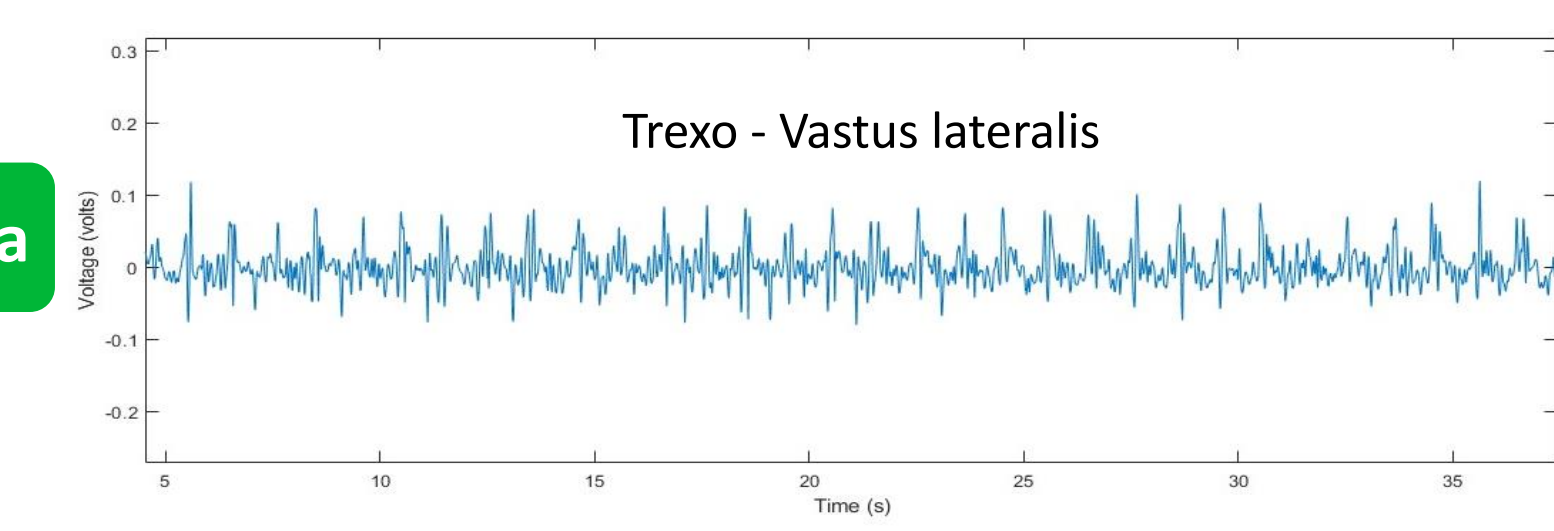
Filtered data

Trexo - Vastus lateralis
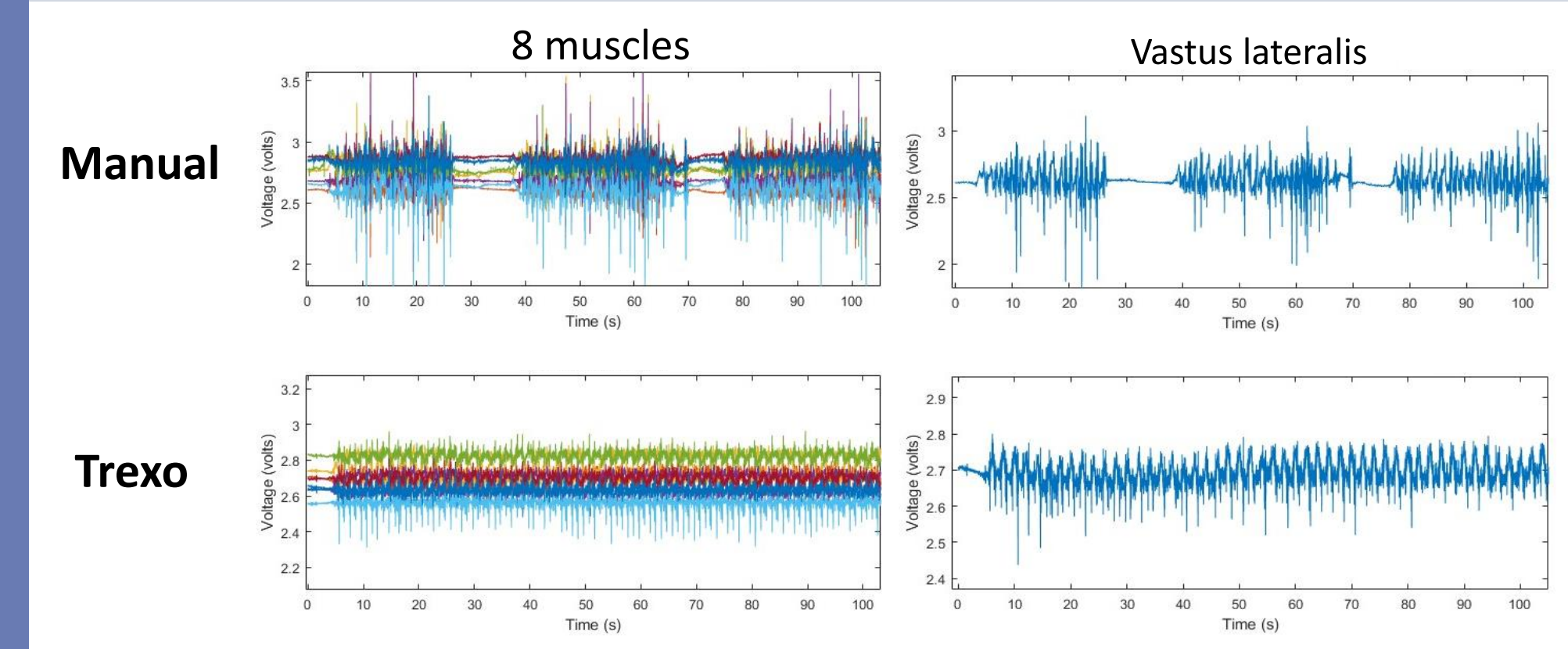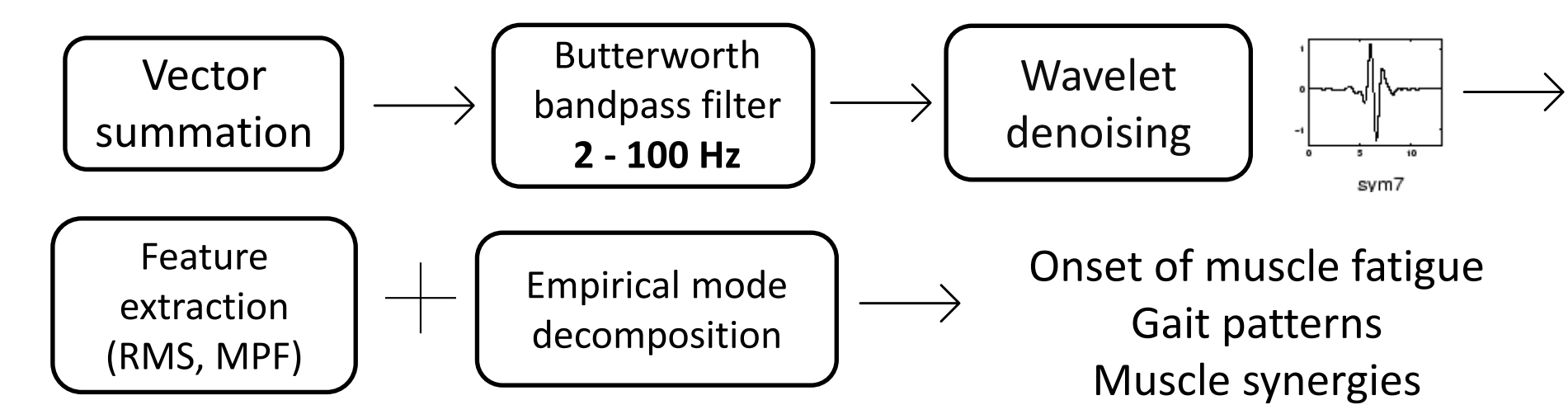
Relevance

- Quantify onset of muscle fatigue to build safe physiotherapy practice regimens, especially for nonverbal children

- Future studies analyzing muscle activity in children with atypical gait

References
[1] Palisano, R. (1997). Development and reliability of a system to classify gross motor function in children with cerebral palsy. *Dev Med Child Neurol*, 214-223. Retrieved from www.canchild.ca
[2] Perry, J., & Burnfield, J. M. (1992). Gait Analysis: Normal and Pathological Function. *Journal of Pediatric Orthopaedics*, 815.
[3] Silva, J., Heim, W., & Chau, T. (2005). A Self-Contained, Mechanomyography-Driven Externally Powered Prosthesis. *Archives of Physical Medicine and Rehabilitation*, 2066-2070.

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