

# Neuroplasticity and Functional Electrical Stimulation (FES) Cycling

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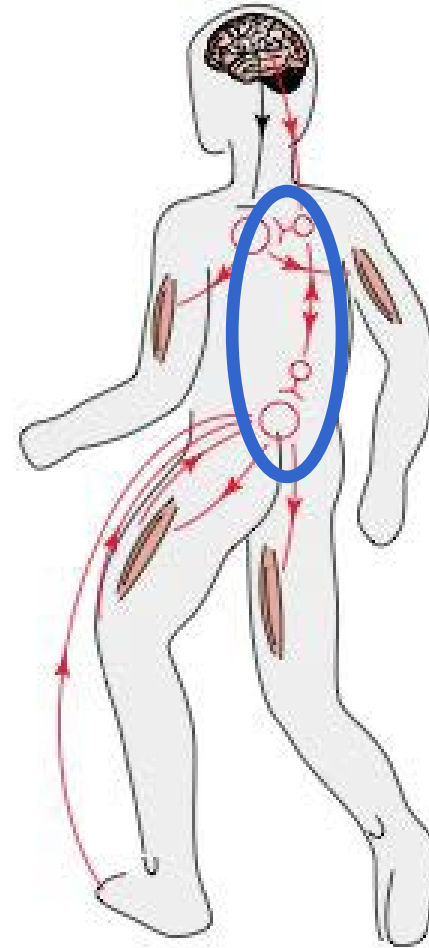
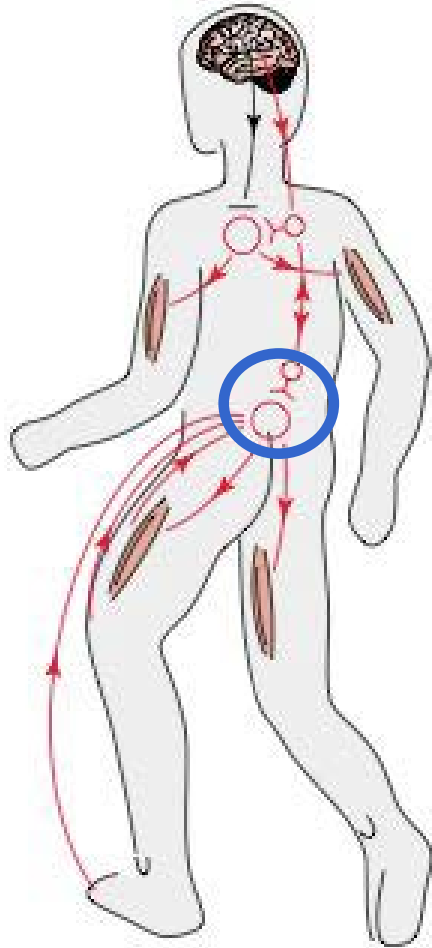


# Objectives

- Demonstrate that FES-assisted cycling **translates to improvements in walking**
- These improvements are the result of **functionally-beneficial neuroplasticity**
- **Simultaneous arm AND leg cycling produces larger improvements** in walking than current rehabilitation interventions



# Activation of Spinal Networks throughout the Cord



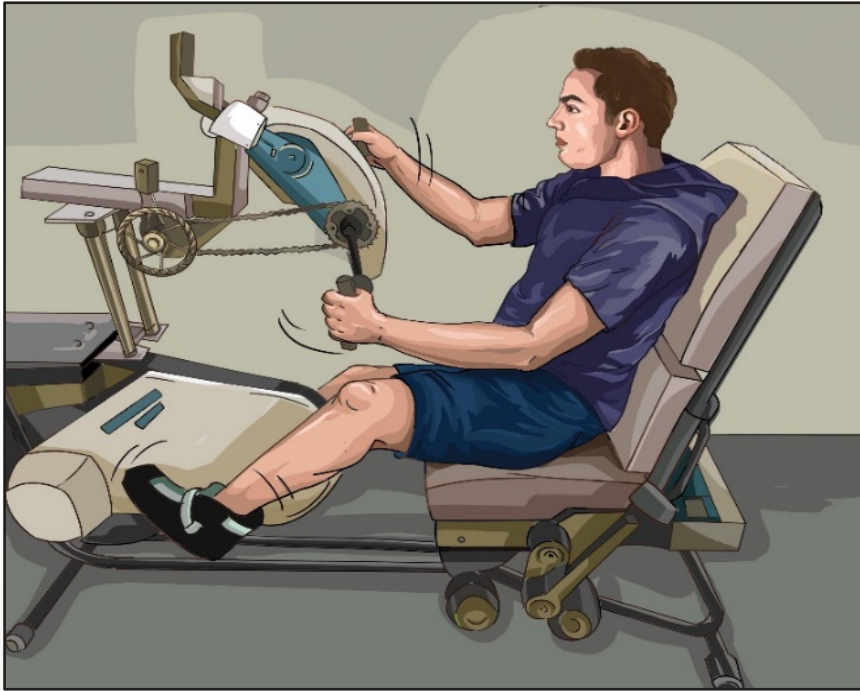
Cartoon from:  
Dietz 2002



# FES Cycling Systems



# Is FES-Cycling an Efficient Intervention for Improving Walking?



- Coordinated activation of the arms and leg
- Electrical stimulation for assisting movement generation

Zhou et al, 2018

# Participants

## A&L cycling (n=7)

- AIS: C or D
- 6 male, 1 female
- Age:  $52 \pm 7$  year old
- Level of injury: C3 to T12
- Years since injury:  $9 \pm 12$

## Leg cycling (n=8)

- AIS: C or D
- 4 male, 4 female
- Age:  $47 \pm 11$  year old
- Level of injury: C4 to T10
- Years since injury:  $12 \pm 14$



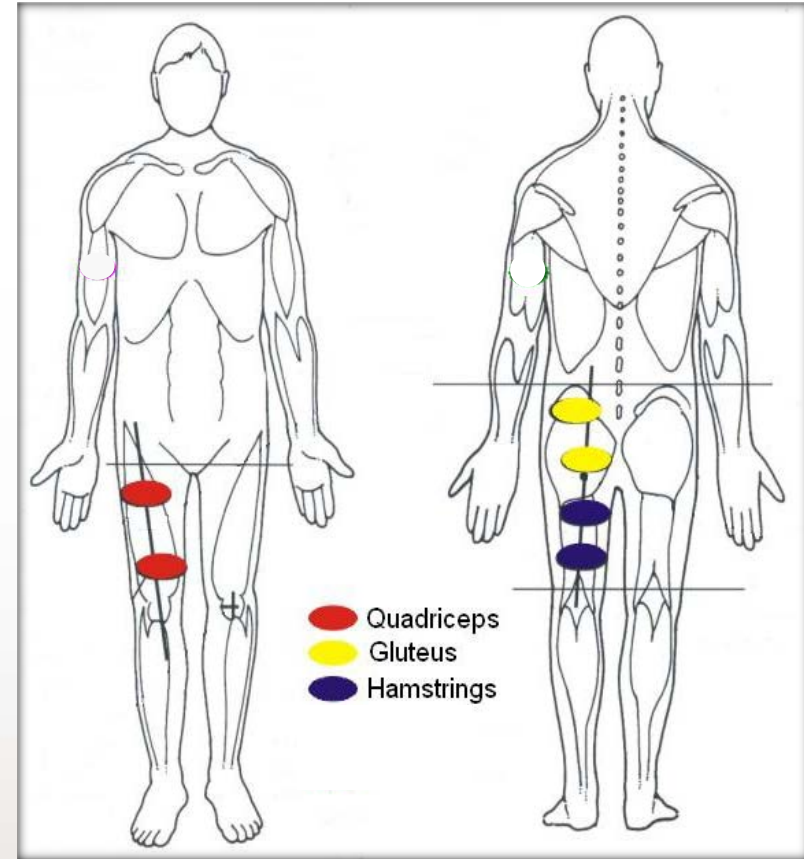
# Training Protocol and Assessments:

## Training:

- 1 hr/day, 5 days/week, 12 weeks
- Electrical stimulation applied to the leg extensors

## Assessments (no stim):

- Clinical
- Biomechanical
- Neurophysiological



# Assessments

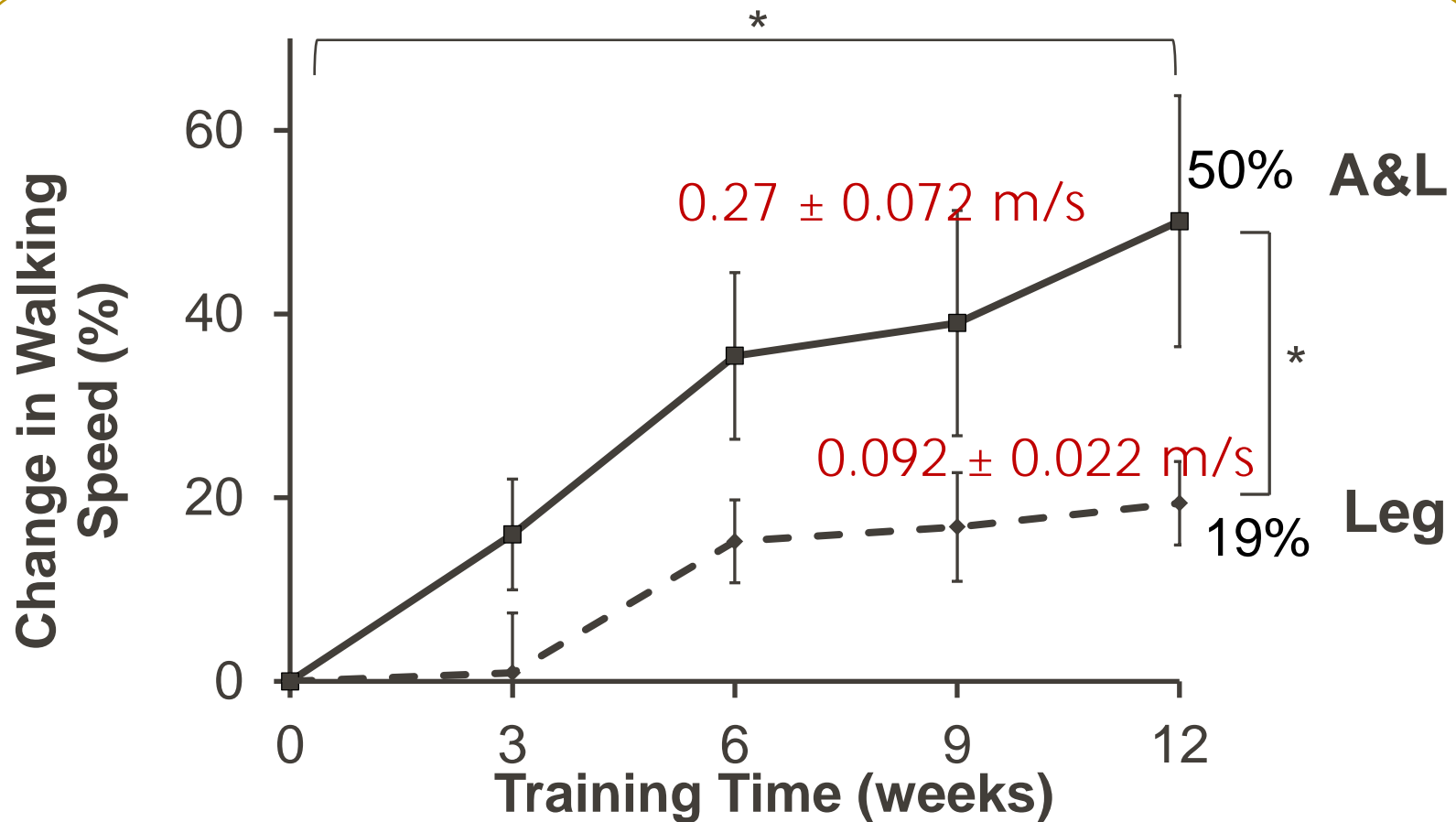
- Clinical
  - 10m WT, 6min WT
  - Berg Balance Scale
  - AIS Motor and Sensory Scores
- Neurophysiology
  - Descending drive
  - Intraspinal modulation (propriospinal)
  - EMG activity
- Biomechanics
  - Kinematics of walking (stride length, step symmetry, etc.)
  - Joint angles
  - Inter-joint coordination



# Significant Improvements in Walking speed: 10 m walking test

Leg Pre-training:  $0.50 \pm 0.08 \text{ m/s}$

A&L Pre-training:  $0.45 \pm 0.08 \text{ m/s}$



Zhou et al, 2018



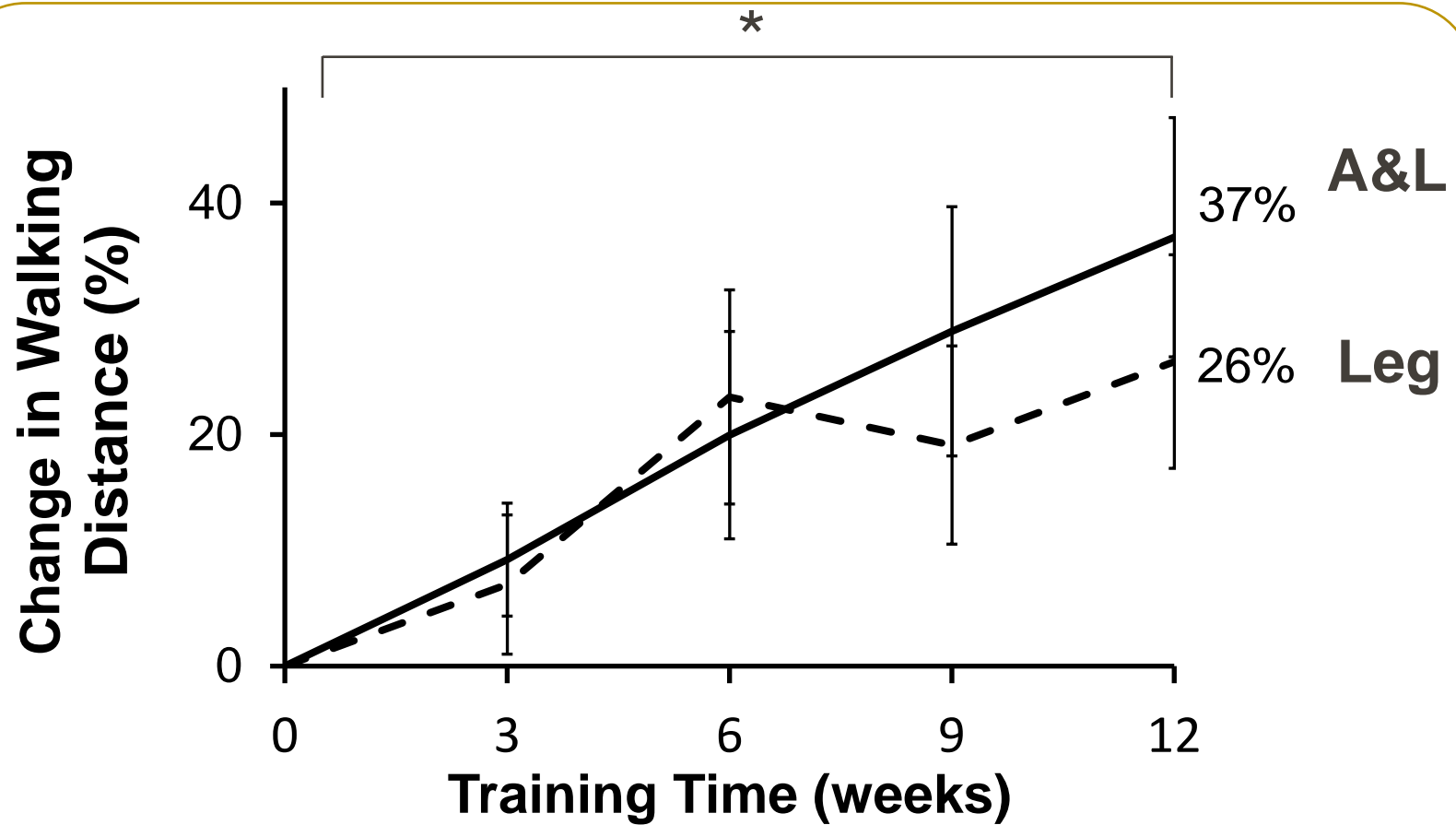
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# Significant Improvements in Walking speed: 6 min walking test

Leg Pre-training:  $157.1 \pm 20.3\text{m}$

A&L Pre-training:  $164.5 \pm 22.6\text{m}$



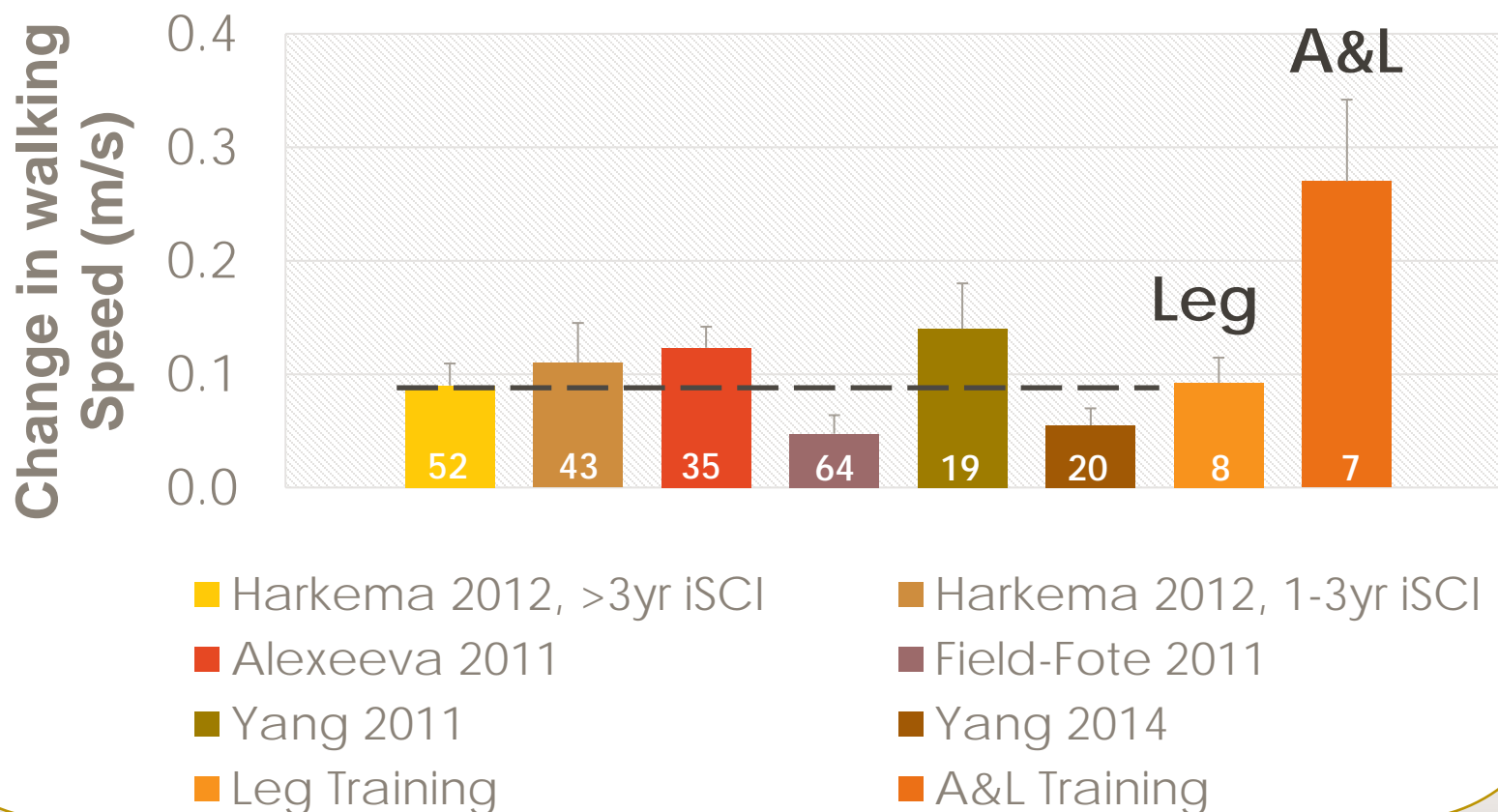
Zhou et al, 2018



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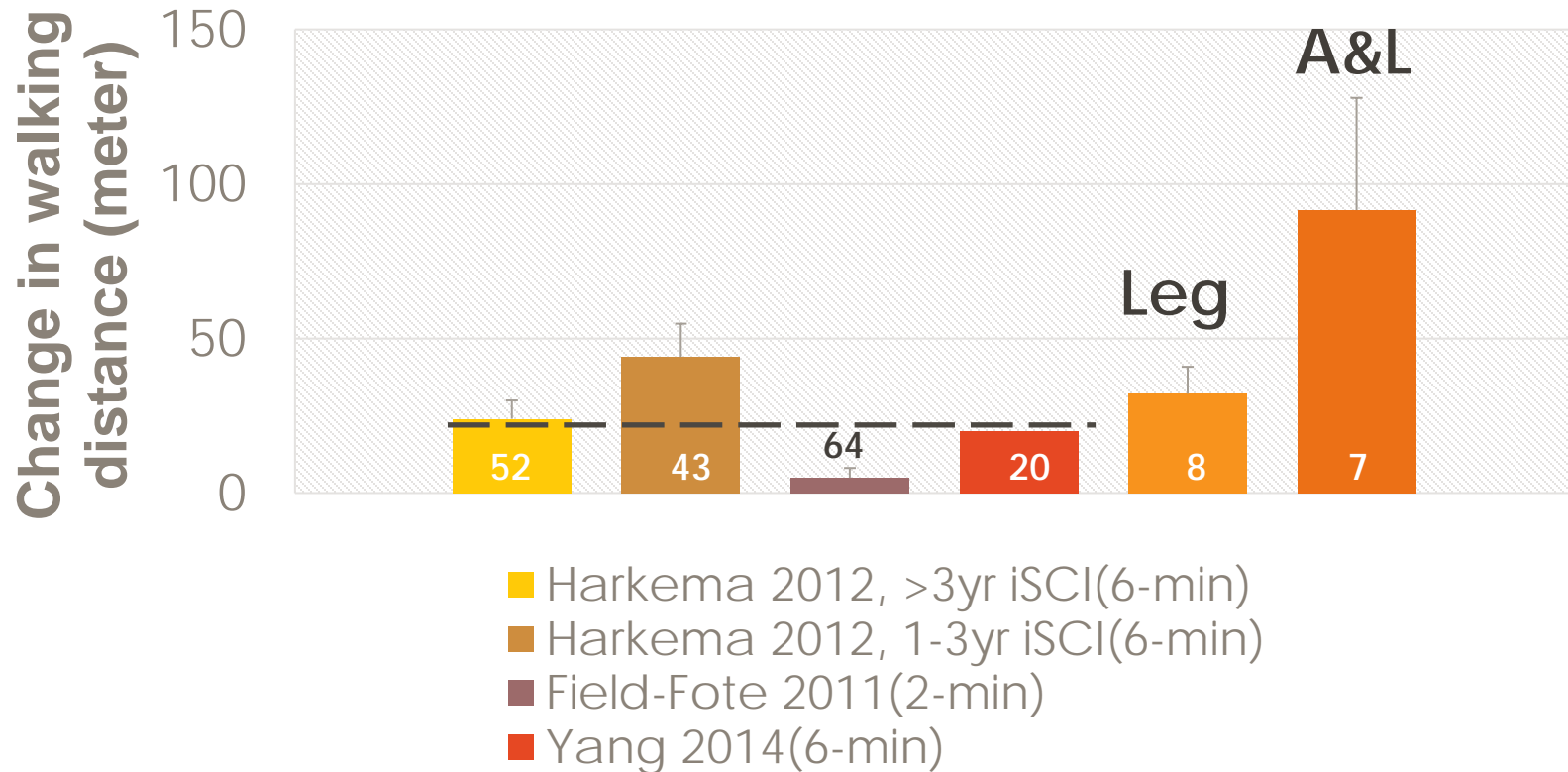
# Results relative to Current Approaches: *Walking Speed*



Zhou et al, 2018



# Our Results relative to Current Approaches: *Walking Distance*



Zhou et al, 2018



# Improvement in walking after **Leg cycling**

Pre-training:



**Post-training:**



# Improvement in walking after **A&L cycling**

Pre-training:



Post-training:



- No weight-support
- Harness used for safety only

# Neurophysiological Outcomes

- Improved **balance**
- Improved **cortico-spinal drive**
- Improved **modulation within the spinal cord**
- Improved **EMG activity in the legs**
- Reduced **spasticity**
- Improved **sensation**



# Summary of Findings and Ongoing Work

- **Cycling translates** to improvements in walking
- **Active engagement of the arms (cervico-lumbar networks)** leads to larger improvements in walking
- Underlying mechanisms include **improvements in corticospinal drive and cervico-lumbar modulation**
- **Addition of transcutaneous spinal cord stimulation** to the cervical / lumbar cord during cycling
- Effect of A&L cycling with transcutaneous stimulation **in people with more severe SCIs (e.g., AIS B)**

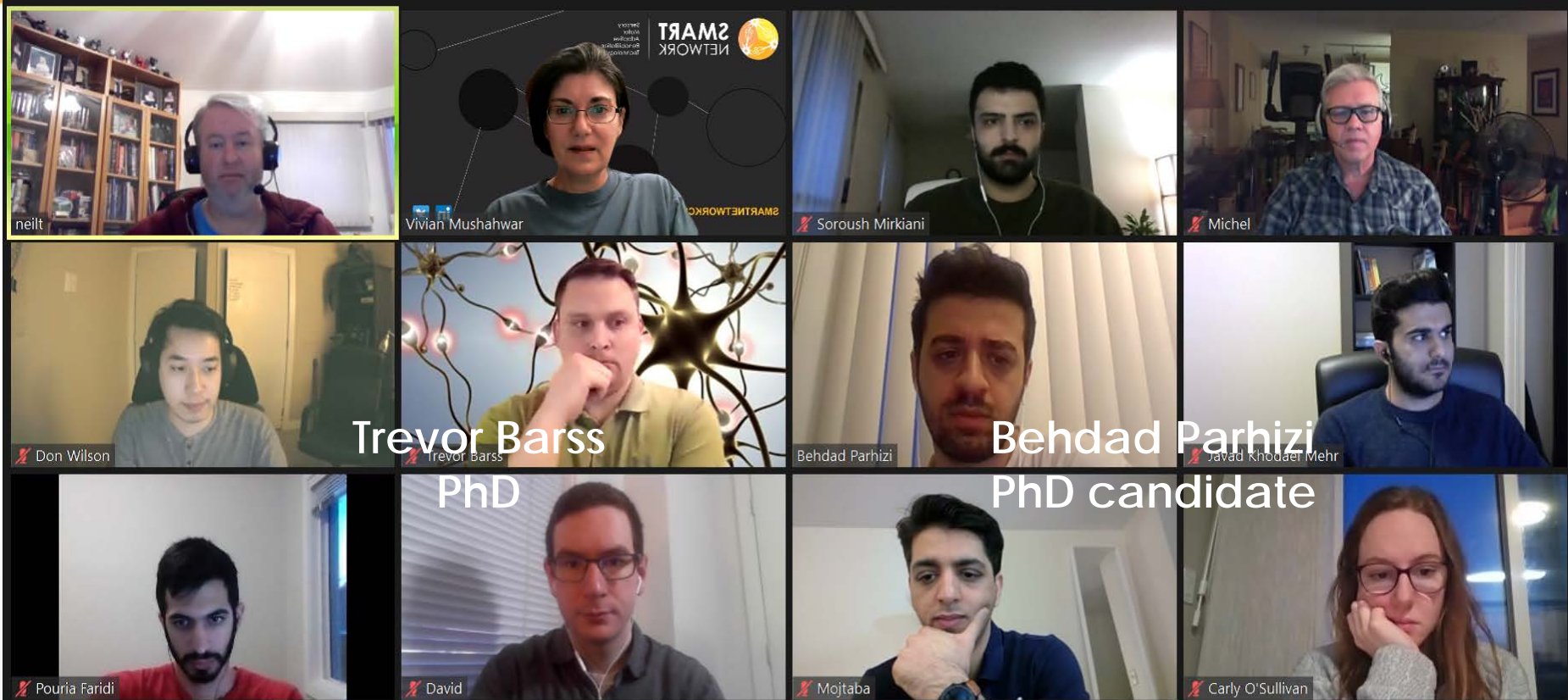


# Importantly...

- Participants highly **receptive of FES cycling and wanted to continue**
- **FES cycling is less physically demanding** on the physiotherapy staff than current walking interventions
- **More clients with SCI can receive therapy** than possible with current interventions
- **FES cycling can be used very early after SCI** to retain muscle mass and reduce neural disorganization



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**NEVER SAY... "NEVER"**

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(Northern Alberta) Society



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