



# SPINAL STIMULATION WITH LOCOMOTOR TRAINING FOR PHYSICAL FUNCTION AFTER SPINAL CORD INJURY

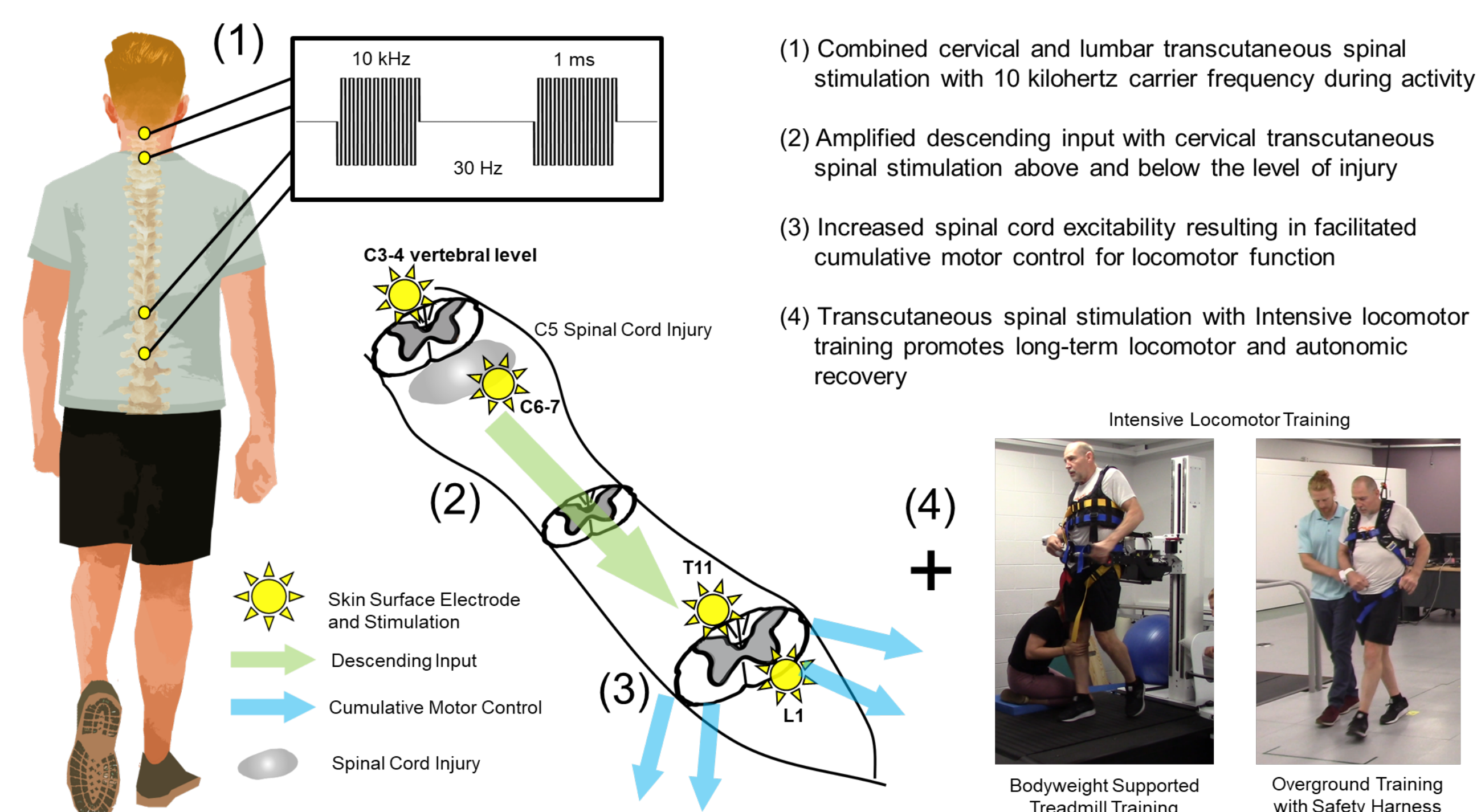
SOSHI SAMEJIMA

## Spinal Stimulation for Spinal Cord Injury

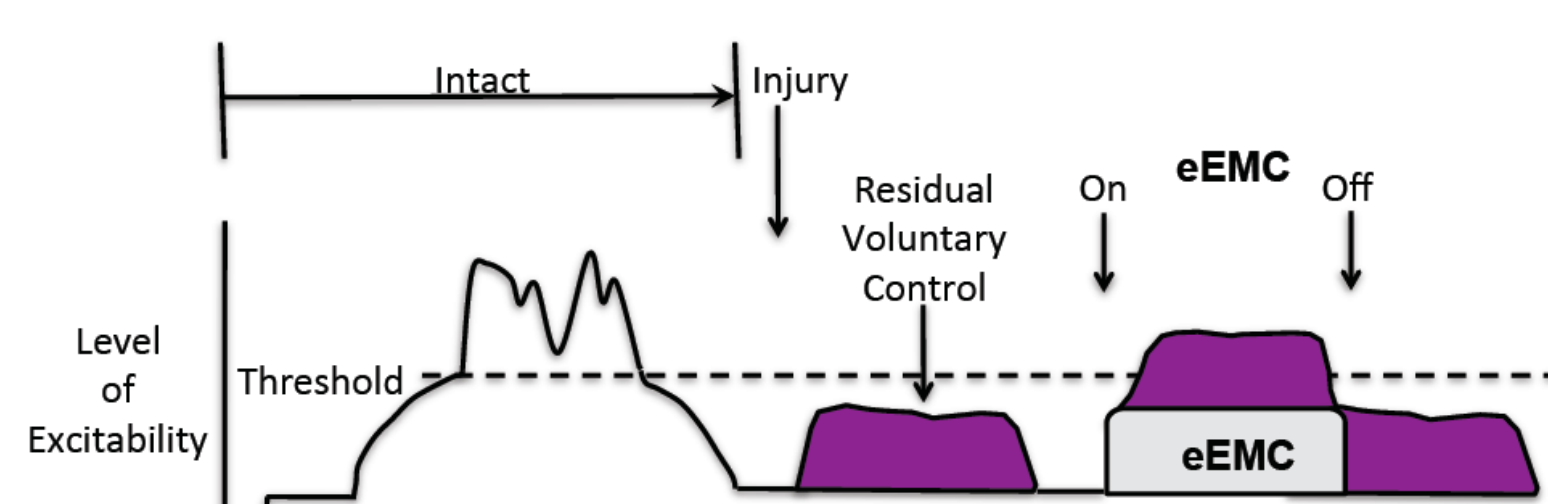
- Epidural stimulation with intensive exercise improved stepping in chronic SCI.<sup>1,2,3</sup> Non-invasive, transcutaneous spinal stimulation without explicit exercises modestly induced locomotor pattern.<sup>4</sup>
- Transcutaneous cervical spinal stimulation with intensive exercises restored hand and arm function in chronic SCI.<sup>5,6</sup>
- Hypothesis: Intensive locomotion training combined with transcutaneous spinal stimulation promotes neuroplasticity leading to long-term improvement in locomotor function.**

## 10 kilohertz Spinal Stimulation with Locomotor Training

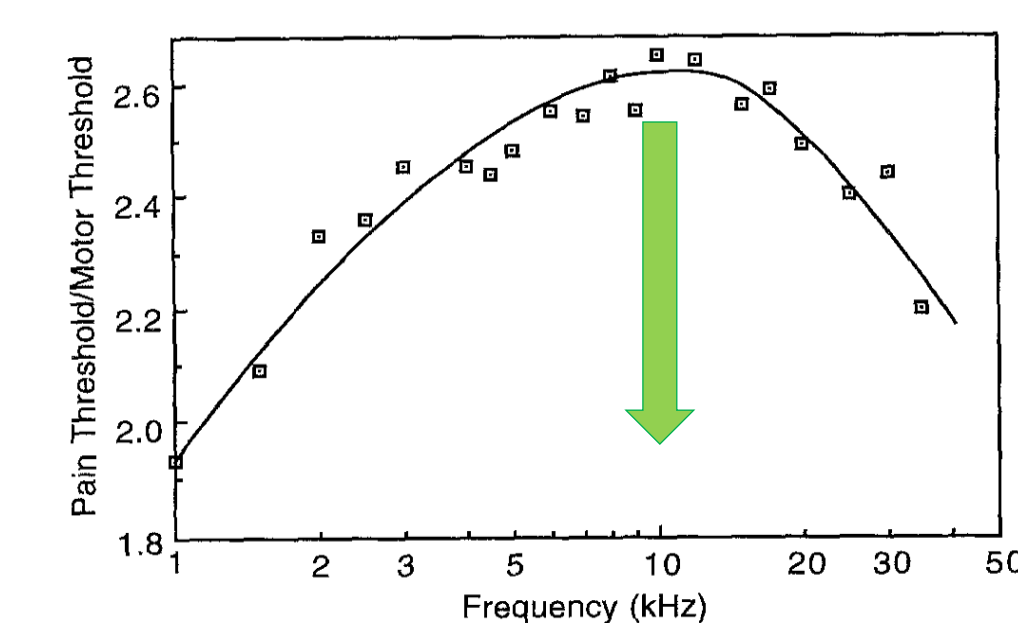
### Non-Invasive Spinal Stimulation + Locomotor Training



### Excitability of Spinal Circuitry Modulated by Spinal Stimulation<sup>4</sup>



### Motor & Sensory Threshold in High Frequency<sup>7</sup>



## Cases & Protocol

### Participant 1

- 64-year-old male
- C4, AIS D (Incomplete Injury)
- 3.5 years post-injury
- Max assist for all mobility



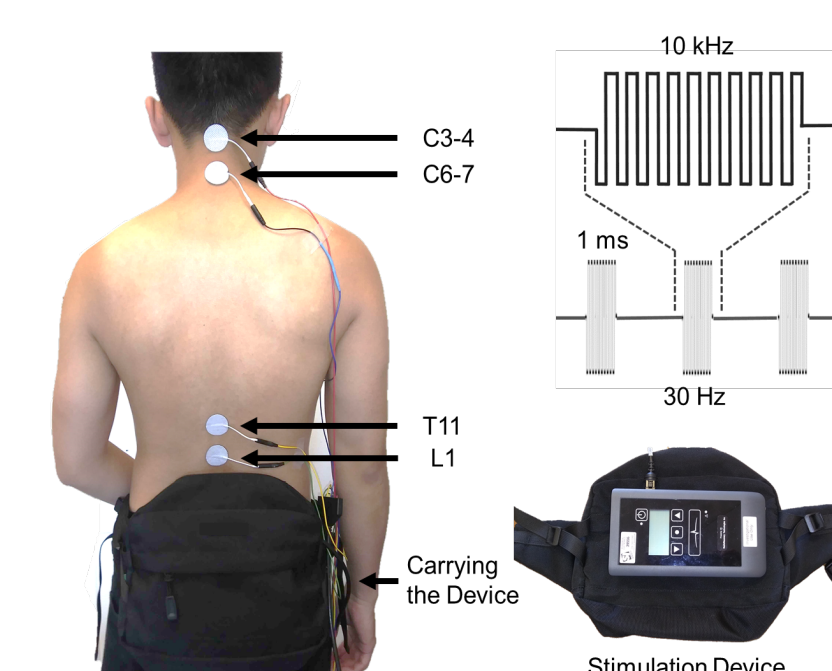
### Participant 2

- 64-year-old male
- C6, AIS D
- 4 years post-injury
- Close supervision with forearm crutch



### Protocol

- 2-hour session, 3-4x per week
- Total 2 months for Locomotor training only
- Total 2 months for Spinal Stimulation with Locomotor training



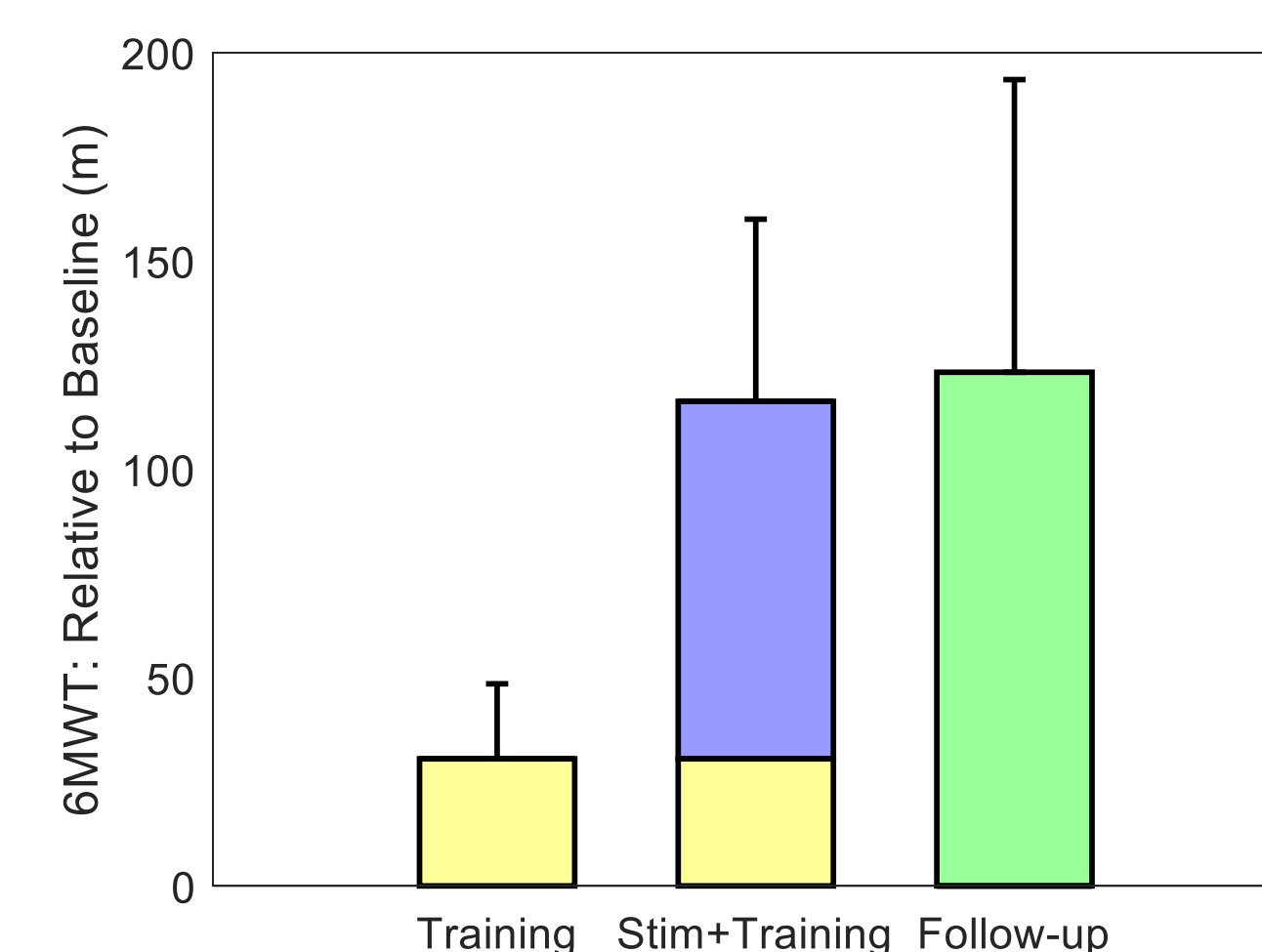
## Walking Function

- Six-minute walking test (6MWT) improved 3 times greater with spinal stimulation than locomotor training only.
- Participant 1 progressed from using platform walker to a narrow quad cane walking with assist.
- Participant 2 doubled his endurance and walking speed.
- The improved function lasted at least 3 months

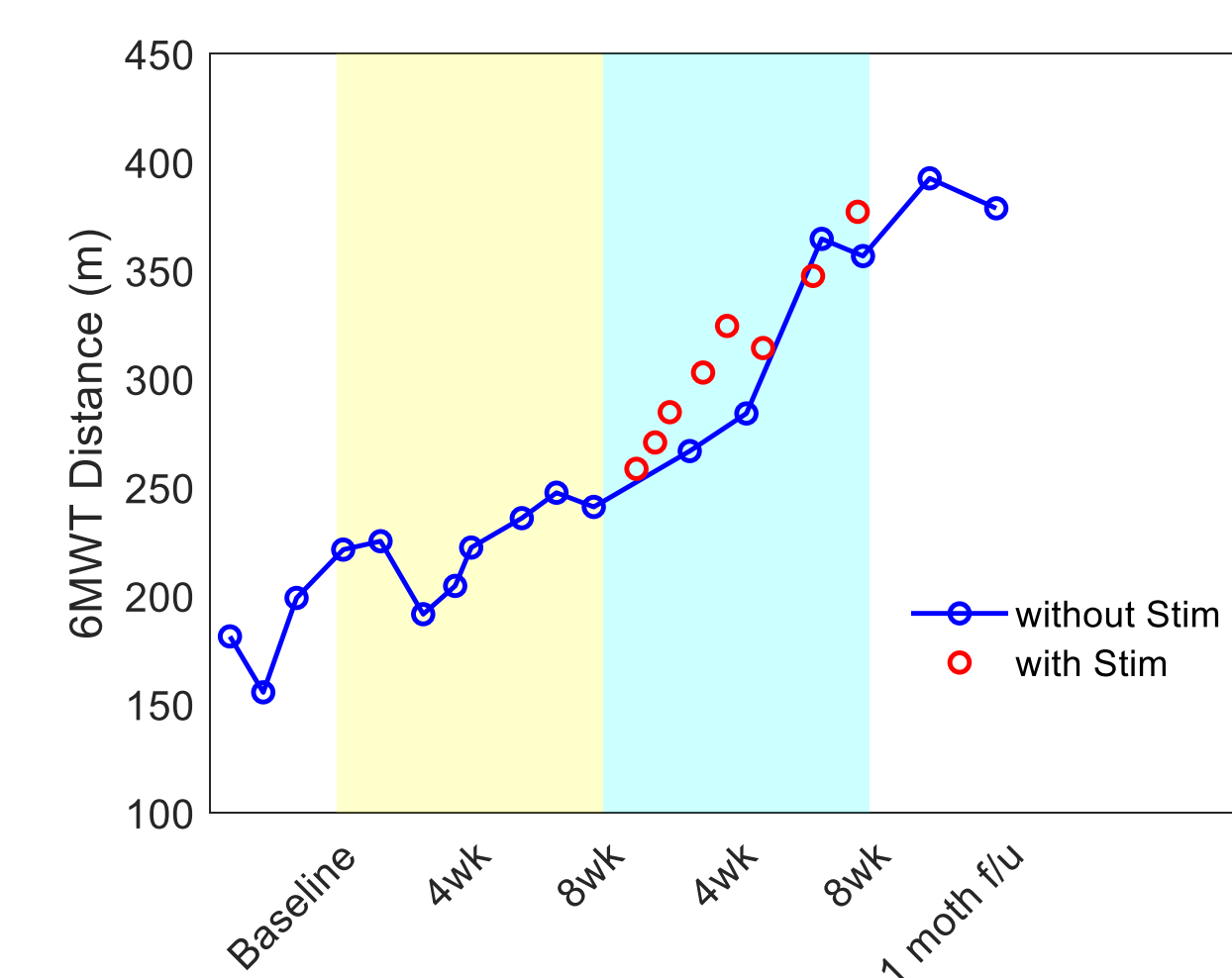
### Progress of Walking Function in Participant 1



### Six-Minute Walking Test in Participant 1 & 2

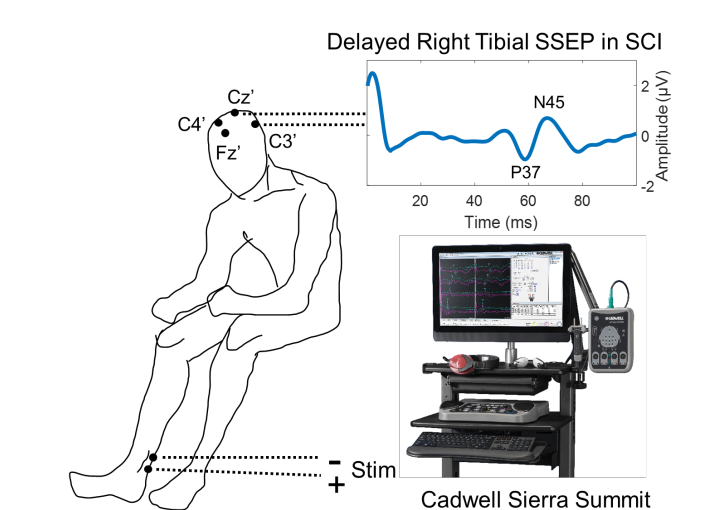


### Progress of Endurance in Participant 2

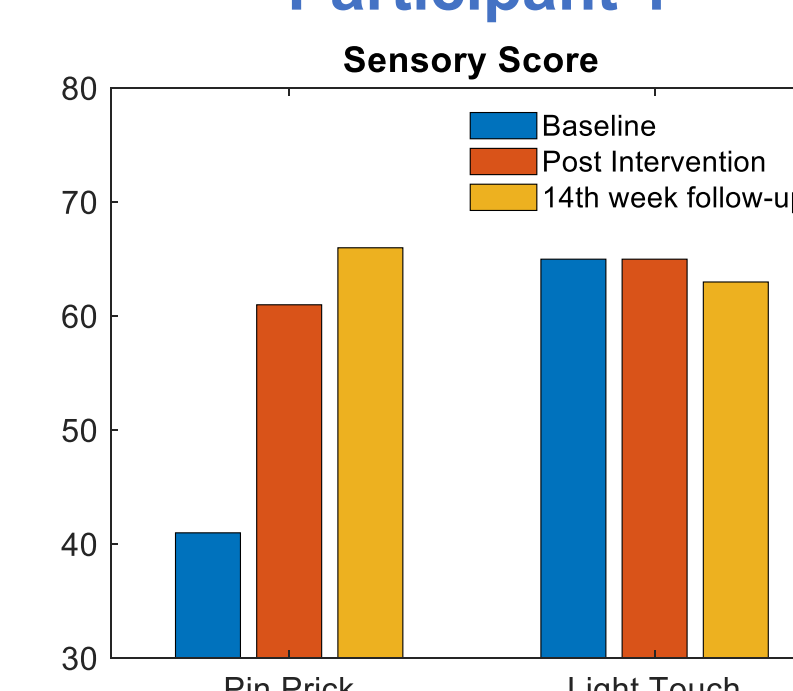


## Sensory & Autonomic Function

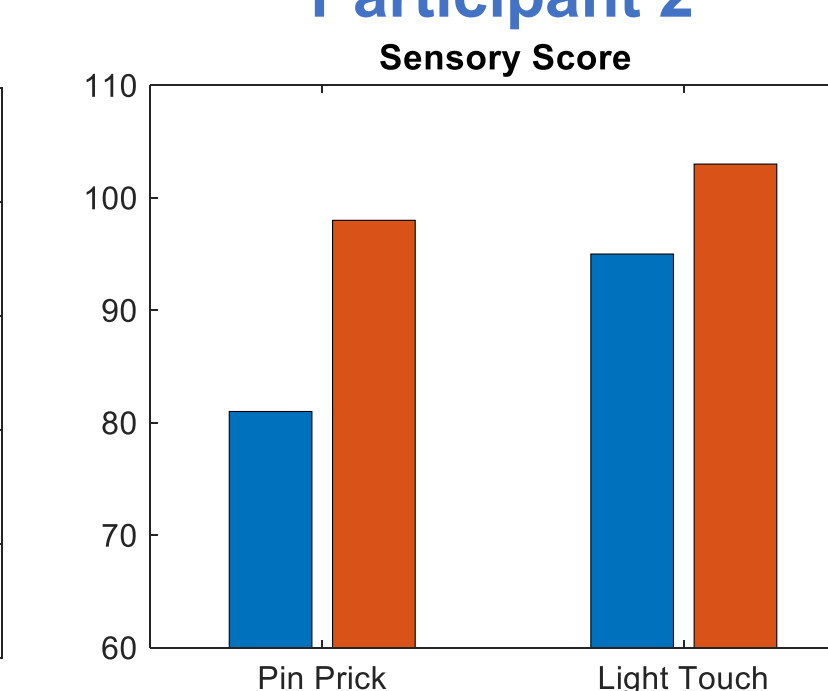
- Pin-Prick Sensation Improved with the spinal stimulation
- Sensory evoked potentials (SSEP) showed more clear responses after the spinal stimulation intervention



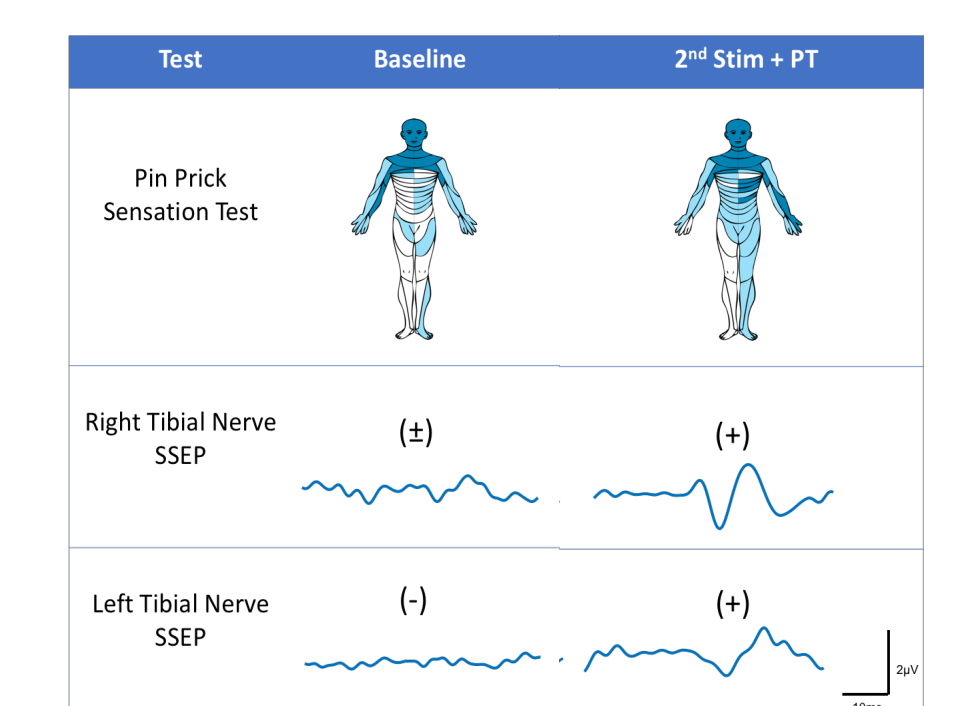
### Improved Pin Prick Sensation Participant 1



### Participant 2



### Modulated Somatosensory Evoked Potentials



- Participant 1 could get rid of intermittent catheterization and required not catheterization at the follow-up phase
- Participant 2 showed improved bowel function from bowel movement frequency once per 3 days to daily and Improved low temperature tolerance



### Improved Bladder and Bowel Function

#### Participant 1

	Baseline	Post 1st Stim + LT	Post 2nd Stim + LT	14-week Follow-Up
SCI-QOL Bladder Mngmt	25	18	10	9
NBSS	27	12	26	13
NBDS	15	13	8	11

NBSS: Neurogenic Bladder Symptom Score  
NBDS: Neurogenic Bowel Dysfunction Score

#### Participant 2

	Baseline	Post LT only	Post Stim + LT
SCI-QOL Bladder Mngmt	9	9	8
NBSS	8	7	7
NBDS	12	14	3

## Conclusion and References

- High-frequency non-invasive spinal stimulation with locomotor training improves walking function greater than training alone.
- Stimulation facilitates positive changes in reported autonomic function.
- All benefits seen with stimulation are sustained at follow-up without stimulation or training.

- Angeli et al. NNEJM. 2018;379(13):1244-1250.
- Gill et al. Nature Medicine. 2018; (online).
- Wagner et al., Nature 2018 563:65-71
- Gerasimenko et al. Journal of Neurotrauma. 2015;32(24):1968-1980.
- Inanici et al. IEEE TNSRE. 2018;26(6):1272-1278.
- Gad et al. Journal of Neurotrauma. 2018;35(18): 2145-2158.
- Ward et al. Arch Phys Med Rehabil. 1998;79(3), 273-278.