REACTIVE, REWIRE, RESTORE: challenging the nervous system to optimize function after SCI

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Stimulation can mimic practice

Vibration elicits involuntary step-like movement in ND individuals

- Vibration elicits locomotor-like movements
- Single muscle or contralateral leg
- Cyclic behavior suggesting CPG origin


Vibration elicits involuntary stepping in individuals with SCI

Field-Fote, Exerc Sport Sci Rev, 2004
Whole-body Vibration (WBV) improves walking and decreases spasticity in SCI

- Subjects: 17 individuals with chronic SCI
- 50 Hz, low amplitude (2-4 mm)
- 3 days/week x 4 wks
- Outcomes:
  - increased walking speed
  - decreased quad spasticity

Spasticity: Ness & Field-Fote. Restor Neurol Neurosci, 2009
Improved walking following 12-session course of WBV

WBV is associated with improved gait speed and quality

Biomechanical quantification of stretch reflex excitability

WBV influences on spasticity
- cumulative multi-session effects
- early within-session effects
- late within-session effects

Ness & Field-Fote. Gait & Posture, 2009
Ness & Field-Fote. Restor Neurol Neurosci, 2009
Should we train to↓ reflexes or to↑ voluntary control?

- 3 baseline sessions
- 300 repetitions/session ➔ 12 training sessions
  (3/wk × 4 wks)

**Outcomes**
reflexes, strength, walking, EMG

<table>
<thead>
<tr>
<th></th>
<th>TA</th>
<th>SOL</th>
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</thead>
<tbody>
<tr>
<td>TA %MVC amplitude</td>
<td>✓</td>
<td>✓ **</td>
</tr>
<tr>
<td>Stretch reflex threshold</td>
<td>✓</td>
<td></td>
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<tr>
<td>Active dorsiflexor ROM</td>
<td>✓</td>
<td></td>
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<tr>
<td>Dorsiflexor strength</td>
<td>✓</td>
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<tr>
<td>Step height in walking</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>2MinWT distance</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>TA/SOL co-activation</td>
<td>✓</td>
<td>✓</td>
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</table>

**significant between-group diff

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Sample SOL ↓ Outcome

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Is there a “best” approach to locomotor practice?

- Treadmill training with manual assistance (TM)
- Treadmill training with CPN stimulation assist (TS)
- Overground training with CPN stimulation assist (Walkaide II stimulator; OG)
- Treadmill training with robotic assistance (Lokomat robotic orthosis; LR)

N = 74 enrolled, 64 completed (across 4 groups)

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Manella & Field-Fote. *J Neurophys*, 2013

Groupwise changes in Walking Speed & Distance

Ia Reciprocal Inhibition (3ms ISI)

EMG Timing and Amplitude

Limb Coordination is the Hallmark of Motor Control
Intralimb Coordination  
Subject with SCI - pre & post training

The cortex reorganizes after SCI...  
...does this contribute to functional deficits?

Sensory input influences corticomotor excitability

Can sensory stimulation augment motor training?

Green et al. Neurology, 1998


Motor learning principles:
modify tasks for success / challenge

Change in hand function is associated
with change in cortical excitability

Is all that training worth
the effort?
Somatosensory stimulation as an accessible approach to augmenting hand practice

- Repetitive transcranial magnetic stimulation
  - Activates neurons
  - Studies in persons with stroke
    - High frequency
- Transcranial direct current stimulation (tDCS)
  - Modulates neuronal excitability
  - Studies in persons with stroke
    - Anodal vs cathodal

rTMS is associated with improved functional scores in persons with SCI

- Spike timing-dependent plasticity for enhanced corticospinal transmission

Approaches for direct cortical stimulation

- Repetitive transcranial magnetic stimulation
  - Activates neurons
  - Studies in persons with stroke
    - High frequency
- Transcranial direct current stimulation (tDCS)
  - Modulates neuronal excitability
  - Studies in persons with stroke
    - Anodal vs cathodal


tDCS represents a clinically accessible approach to direct cortical stimulation

- Anodal = EXCITATION
- Cathodal = INHIBITION

![Brain diagram](image)

(Fregni & Pascual-Leone, 2007)

Bimanual finger-sequencing scores

![Graph](image)

(Gomes-Osman & Field-Fote, J Motor Behav, 2013)

The Caudal End

- Stimulation (electric & vibration) activates much the same circuitry as training
- In people with SCI, training promotes adaptive neuroplasticity of cortical and spinal circuits
- Clinically accessible stimulation can be a valuable adjuvant to training
- Continued training at a sufficient dose is necessary to maintain gains

![Graph](image)

(Gomes-Osman & Field-Fote, J Neurol Phys Ther, 2015)

tDCS is associated with most effect

TENS also influenced function

![Bar chart](image)

Gomes-Osman & Field-Fote, J Neurol Phys Ther, 2015