

Intraspinal microstimulation for motor rehabilitation modulates neural transmission in spinal pain pathways

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Spinal cord injury (SCI) results in dramatic changes in neural excitability below the lesion, leading to debilitating motor impairments, dysregulation of reflexes, and neuropathic pain. Voluntary motor output is reduced below the lesion, whereas the spinal effects of sensory feedback become pathologically increased, contributing to hyperreflexia and neuropathic pain. Therapies seeking to restore sensorimotor function after SCI face a dual challenge: increasing spinal motor output in response to descending motor commands while decreasing the spinal responses to sensory feedback that contribute to hyperreflexia and pain.

We characterized whether electrical intraspinal microstimulation (ISMS) of the ventral horn, which increases spinal motor output, concurrently modulates transmission in spinal pain pathways of the dorsal horn. After T13-L2 laminectomy in adult Sprague-Dawley rats, electrode arrays were implanted at the L5 dorsal root entry zone. Electrodes locations for ventral ISMS targeted Laminae 8-9 and electrode locations for quantifying transmission in nociceptive pathways targeted Laminae 1-3 of the dorsal horn.

Prior to and after ISMS, we mechanically stimulated the peripheral receptive field by applying controlled forces of varying magnitude. We classified pain and non-pain-related spinal neurons in the superficial dorsal horn based on their responses to these mechanical stimuli. We found that even short periods of ventral ISMS could modulate transmission in spinal pain pathways, with some effects persisting after ISMS was discontinued. These results could not be explained by direct current spread, and thus reflect transynaptic activation of superficial dorsal horn neurons potentially leading to induction of neural plasticity.

Our results demonstrate that neuroprosthetic therapies intending to use ventral ISMS only to increase spinal motor output in actuality modulate transmission throughout a wide and functionally diverse set of spinal neurons. Future work is required to systematically characterize these off-target effects, optimizing beneficial changes while mitigating unintended activity that could lead to hyperreflexia or pain.

