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Non-invasive activation of cervical spinal networks after severe paralysis

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Abstract

© Copyright 2018, Mary Ann Liebert, Inc. 2018. Paralysis of the upper extremities following cervical spinal cord injury (SCI) significantly impairs one's ability to live independently. While regaining hand function or grasping ability is considered one of the most desired functions in tetraplegics, limited therapeutic development in this direction has been demonstrated to date in humans with a high severe cervical injury. The underlying hypothesis is that after severe cervical SCI, nonfunctional sensory-motor networks within the cervical spinal cord can be transcutaneously neuromodulated to physiological states that enable and amplify voluntary control of the hand. Improved voluntary hand function occurred within a single session in every subject tested. After eight sessions of non-invasive transcutaneous stimulation, combined with training over 4 weeks, maximum voluntary hand grip forces increased by ~325% (in the presence of stimulation) and ~225% (when grip strength was tested without simultaneous stimulation) in chronic cervical SCI subjects (American Spinal Injury Association Impairment Scale [AIS] B, n = 3; AIS C, n = 5) 1-21 years post-injury). Maximum grip strength improved in both the left and right hands and the magnitude of increase was independent of hand dominance. We refer to the neuromodulatory method used as transcutaneous enabling motor control to emphasize that the stimulation parameters used are designed to avoid directly inducing muscular contractions, but to enable task performance according to the subject's voluntary intent. In some subjects, there were improvements in autonomic function, lower extremity motor function, and sensation below the level of the lesion. Although a neuromodulation-training effect was observed in every subject tested, further controlled and blinded studies are needed to determine the responsiveness of a larger and broader population of subjects varying in the type, severity, and years post-injury. It appears rather convincing, however, that a "central pattern generation" phenomenon as generally perceived in the lumbosacral networks in controlling stepping neuromodulator is not a critical element of spinal neuromodulation to regain function among spinal networks.

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Keywords

cervical spinal cord injury, non-invasive spinal cord stimulation, tetraplegia, upper extremity rehabilitation

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