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Electrical spinal stimulation, and imagining of lower limb movements to modulate brain-spinal connectomes that control locomotor-like behavior

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Abstract

© 2018 Gerasimenko, Sayenko, Gad, Kozesnik, Moshonkina, Grishin, Pukhov, Moiseev, Gorodnichev, Selionov, Kozlovskaya and Edgerton. Neuronal control of stepping movement in healthy human is based on integration between brain, spinal neuronal networks, and sensory signals. It is generally recognized that there are continuously occurring adjustments in the physiological states of supraspinal centers during all routines movements. For example, visual as well as all other sources of information regarding the subject's environment. These multimodal inputs to the brain normally play an important role in providing a feedforward source of control. We propose that the brain routinely uses these continuously updated assessments of the environment to provide additional feedforward messages to the spinal networks, which provides a synergistic feedforwardness for the brain and spinal cord. We tested this hypothesis in 8 non-injured individuals placed in gravity neutral position with the lower limbs extended beyond the edge of the table, but supported vertically, to facilitate rhythmic stepping. The experiment was performed while visualizing on the monitor a stick figure mimicking bilateral stepping or being motionless. Non-invasive electrical stimulation was used to neuromodulate a wide range of excitabilities of the lumbosacral spinal segments that would trigger rhythmic stepping movements. We observed that at the same intensity level of transcutaneous electrical spinal cord stimulation (tSCS), the presence or absence of visualizing a stepping-like movement of a stick figure immediately initiated or terminated the tSCS-induced rhythmic stepping motion, respectively. We also demonstrated that during both voluntary and imagined stepping, the motor potentials in leg muscles were facilitated when evoked cortically, using transcranial magnetic stimulation (TMS), and inhibited when evoked spinally, using tSCS. These data suggest that the ongoing assessment of the environment within the supraspinal centers that play a role in planning a movement can routinely modulate the physiological state of spinal networks that further facilitates a synergistic neuromodulation of the brain and spinal cord in preparing for movements.

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Keywords

Brain-spinal connectome, Imaging, Locomotor circuitry, TMS, Transcutaenous spinal cord stimulation

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