

Non-invasive DC Spinal Cord Neuromodulation

Alberto Priori

Centro Clinico per la Neurostimolazione, le Neurotecnologie ed i Disordini del Movimento,

Fondazione IRCCS Ca' Granda Ospedale Maggiore Policlinico, Milan, Italy

Università degli Studi di Milano, Dipartimento di Scienze Neurologiche, Italy

Aiming to develop a new, non invasive approach to spinal cord neuromodulation, we assessed the possibility modulating the spinal cord function by transcutaneous direct current stimulation. In a group of 12 healthy volunteers we evaluated the after-effects of anodal and cathodal tsDCS delivered on the skin overlying the thoracic spinal cord on somatosensory potentials (SEPs) evoked in normal subjects by stimulation of the posterior tibial nerves (PTN) and median nerve (Cogiamanian et al. 2008). Anodal tsDCS induces a long-lasting (at least 20 min) depression of cervico-medullary component (P30) of the PTN-SEPs. Conversely, despite a tendency to increase, cathodal tsDCS did not induce significant change to P30 amplitude. This long-lasting depression suggests that thoracic tsDCS modulates conduction along the spinal somatosensory pathways without eliciting adverse effects. The sensory axons running in the posterior columns of spinal cord are comparable to the axons in a peripheral nerve. At this level whereas cathodal currents depolarize, anodal currents hyperpolarize the axon, ultimately leading to the “anodal block” (Bhadra and Kilgore, 2004).

Winkler and colleagues investigated the effects of thoracic tsDCS on H-reflex size and post-activation depression. In 10 healthy volunteers these authors showed a long lasting decrease in H-reflex post-activation depression after anodal stimulation (2.5 mA, 0.063 mA/cm²) while cathodal stimulation resulted in a sustained increase. H-reflex parameters were unaffected by stimulation. These results expanded our findings suggesting that tsDCS, besides modulating conduction along the spinal pathways, is capable of inducing sustained changes segmental spinal pathways (Winkler et al. 2010).

Given the clinical effectiveness of invasive spinal neuromodulation to treat several pain syndrome, we designed a further study to evaluate whether tsDCS affects the central nociceptive signal transmission in humans. To do so, in healthy subjects, we evaluated the after-effects of anodal direct current applied on the skin overlying the thoracic spinal cord by measuring changes in the size of lower limb flexion reflex which is a reliable and widely investigated neurophysiological tool to assess the efficacy of analgesic therapies.

In our healthy subjects anodal thoracic tsDCS reduced the total lower-limb flexion reflex area by 40.25% immediately after stimulation and by 46.9% 30 minutes after stimulation offset. When we analyzed the two lower-limb flexion reflex components (RII tactile and RIII nociceptive) separately we found that anodal tsDCS induced a significant reduction in RIII area with a slight but not significant effect on RII area. None of our subjects reported adverse effects after active stimulation (Cogiamanian et al., submitted).

Taken together these data suggest that tsDCS can modulate the conduction along the spinal ascending tracts and the function of segmental spinal pathways probably acting on interneurons and synaptic connections. Moreover our findings on tsDCS-induced lower limb flexion reflex depression in healthy subjects confirm that this technique holds promise as a novel clinical tool in managing chronic pain and, possibly, in rehabilitation after spinal cord injury.

References

Bhadra and Kilgore. Direct current electrical conduction block of peripheral nerve” *IEEE Trans Neural System Rehabilitation Eng* 12 (2004), pp. 313–324

Cogiamanian F, Vergari M, Pulecchi F, Marceglia S, Priori A “Effect of spinal transcutaneous direct current stimulation on somatosensory evoked potentials in humans. *Clinical Neurophysiology* 2008;119(11):2636-40.

Cogiamanian F, Vergari M, Schiaffi E, Marceglia S, Ardolino G, Barbieri S, Priori “Transcutaneous Spinal Cord Direct Current Stimulation (tsDCS) Inhibits the Lower Limb Nociceptive Flexion Reflex in Humans”, 2011 in press.

T. Winkler, P. Hering, A. Straube. Spinal DC stimulation in humans modulates post-activation depression of the H-reflex depending on current polarity. *Clinical Neurophysiology* 121 (2010) 957–961