Spinal Direct Current Stimulation (tsDCS) in Hereditary Spastic Paraplegias (HSP): A Double-Blind, Sham-Controlled, Crossover Electrophysiological and Clinical Study

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Introduction

Hereditary spastic paraplegias (HSP) comprise a heterogeneous group of neurodegenerative diseases characterized by progressive spasticity and lower limb weakness and are variably associated with non-motor symptoms, ranging from sensory disturbances to cognitive impairment, epilepsy and cerebellar dysfunction.
The treatment has been exclusively symptomatic. Spasticity may benefit from daily physical therapy, or from baclofen or intramuscular injections of botulinum toxins A/B.
In the recent past, transcutaneous spinal direct current stimulation (tsDCS) has been introduced as a non-invasive technique for modulating spinal cord function in animals and humans; it has been used both for interfering with the maladaptive phenomena taking place in spinal cord-injured patients (Hubli et al., 2013) and improving the effects of robotic gait-training in chronic stroke patients (Picelli et al., 2015).

Methods

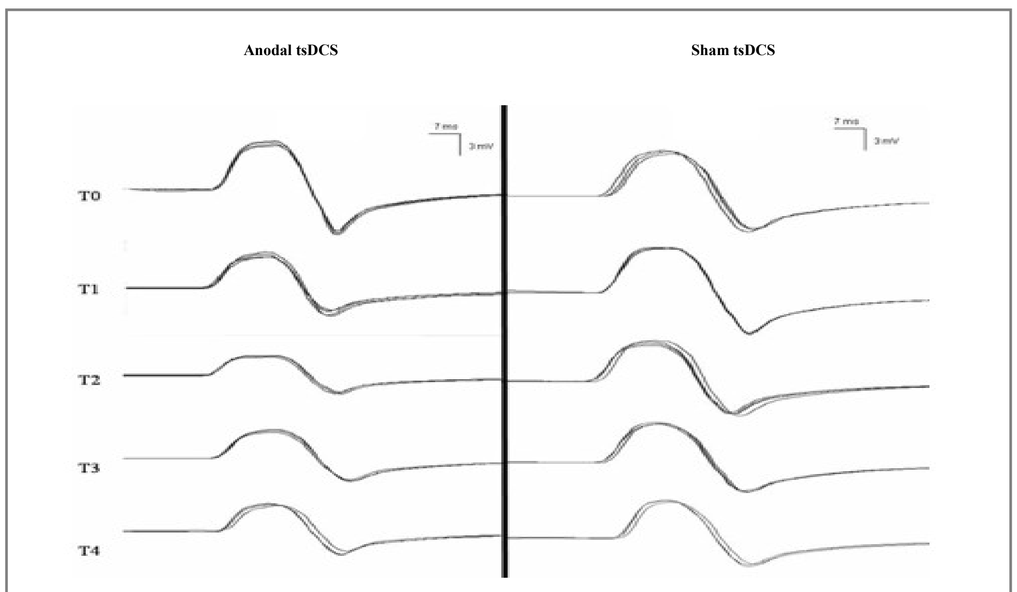
Motor evoked potentials, the H-reflex, the patellar tendon reflex, F-waves, the Ashworth scale for clinical spasticity, the 5'-walking test and the spastic paraplegia rating scale were assessed. tsDCS (anodal or sham, 2.0 mA, 20 min, 5 consecutive days) was delivered over the lower thoracic spinal cord (T10-T12). Patients were evaluated before tsDCS (T0), immediately at the end of the stimulation (T1), after one week (T2), one month (T3) and two months (T4).

Results

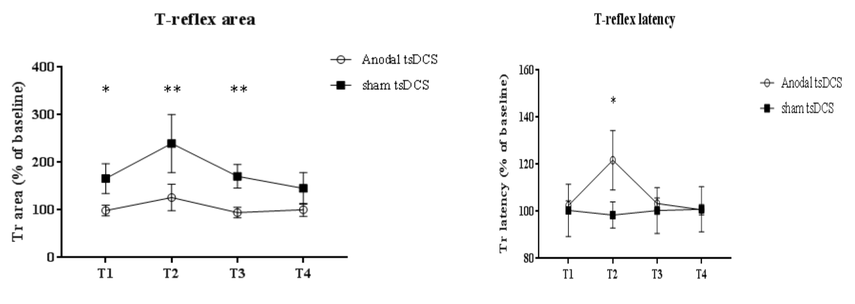
Whereas T-reflex area increased after the sham intervention, it was unchanged after anodal tsDCS ($p = 0.0088$). T-reflex latency also was modulated by the two different polarities (T2: $p = 0.0139$). A significant improvement in the Ashworth scores was observed in the anodal group at T1 ($p = 0.0137$) and T4 ($p = 0.0244$), but not in the 5'-walking test and SPRS.

Conclusioni

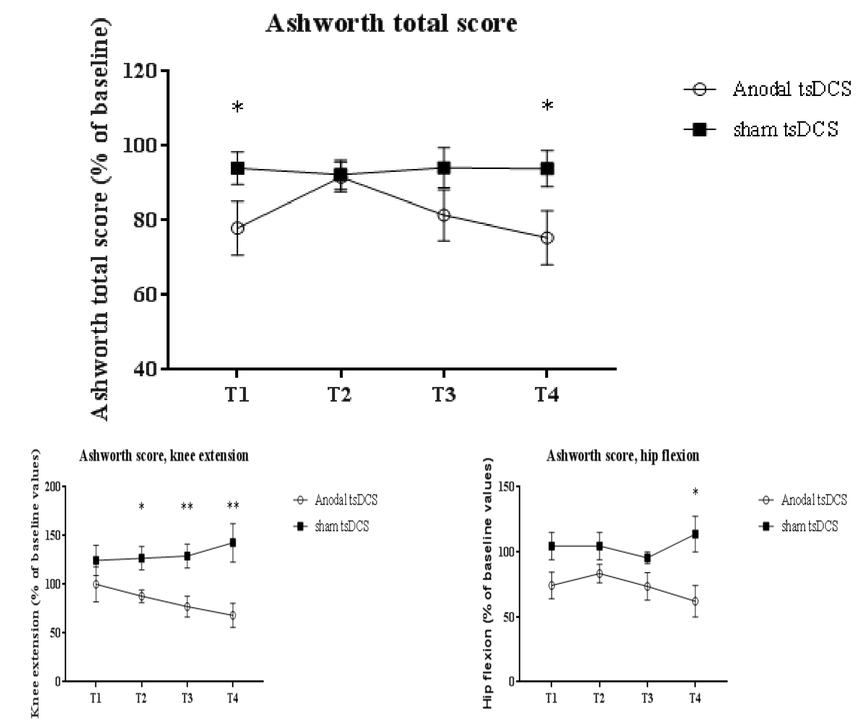
This study is the first to investigate the effects of spinal tDCS in patients with HSP. The results are in line with previous data on spinal cord injuries (Hubli et al., 2013) and chronic stroke (Picelli et al., 2015), thereby confirming the efficacy of tsDCS for the treatment of spasticity. Our results may, therefore, contribute to the design of more specific applications in clinical practice; in particular, the use of a combined transcranial and spinal stimulation strategy would be of interest in the wide field of movement disorders, possibly improving motor recovery, as seen in animals (Song et al., 2015). Moreover, as the improvement lasts up to two month (T4) with a subsequent worsening of both electrophysiological and clinical scores, future studies should provide more frequent stimulation cycles. Another critical point to be assessed in future studies is the target of tDCS; a combined spinal and cortical stimulation protocol to improve the clinical outcome should be evaluated. Lastly, as in other human diseases, the optimal tsDCS repetition rate and duration to promote clinical improvements remains unknown.



Representative traces of the T-reflex recorded from the same subject after anodal and sham stimulation



T-reflex area and latency after the completion of anodal (white circles) and sham (black squares) polarization



Ashworth scale for lower limbs and sub-items. Anodal tsDCS significantly reduced total Ashworth score compared with sham stimulation (black squares), at T1 and T4 ; this improvement with respect to hip flexion and knee extension

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