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TECHNOLOGY IN REHABILITATION: THE NEED FOR INDIVIDUALIZING TRANSCRANIAL DIRECT CURRENT STIMULATION IN STROKE

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Technological advancement promises to enhance current rehabilitation strategies to obtain better outcomes in stroke. Such promising technologies include rehabilitation robotics, virtual reality training, and non-invasive brain stimulation such as TMS and tDCS. Experience has also learned, however, that these techniques must be very precisely tailored to what stroke patients need to succeed. For example, an early Lokomat trial on gait training in stroke showed that this training was inferior to conventional gait training (Hilder et al., 2009), and many years of further robotic development were needed to make robotic training more successful. Such optimization may require more general technological improvement as well as individualization to meet individual patient needs, recognizing the relevant between-subject variation.

In this lecture, I will discuss transcranial direct current stimulation (tDCS) as a promising tool to improve and speed up motor rehabilitation after stroke. The rationale behind tDCS in post-stroke motor rehabilitation is to drive an electric current through regions involved in a specific motor task, such as the primary motor cortex (M1) or premotor cortex (e.g., Hamoudi et al., 2018), thereby decreasing or increasing the excitability of these networks (Nitsche & Paulus, 2000). However, several meta-analyses show inconsistent effects of tDCS on motor recovery after stroke, with a wide range of effect sizes between studies (e.g., Bornheim 2020). Moreover, our research group and others have repeatedly failed to replicate some of the key findings in the literature (e.g., Horvath et al., 2016; Jonker et al., 2020).

One of the reasons for the inconsistent tDCS effects in stroke randomized controlled trials may be differences in the electric current pathways in the brain between healthy subjects and subjects with stroke and within subjects with stroke. Since stroke lesions have a different conductivity than grey and white matter, these differences in current pathways depend on the stroke lesion location, size, and conductivity (Minjoli et al., 2017). A second reason may be that stroke lesions cause functional reorganization, which may change the brain areas that tDCS should target (Jones et al., 2015). Both differences in structural pathways and functional organization between patients may require the tDCS application to be individualized to achieve a consistent effect.

In this presentation, I will review what we know from the literature and our own research on the effects of tDCS in stroke patients. I will show how considering individual brain structure and functional motor targets is vital to applying tDCS in patients with chronic stroke and, to a lesser extent, also in healthy subjects (Van der Cruijsen et al., 2022). I will describe techniques to improve the accuracy of tDCS stimulation using conductor models of stroke brain (Van der Cruijsen et al., 2021; Piastra et al., 2021). We found that without simulating tDCS in individualized head models, the electric field strength is lower and more variable in stroke patients, as may be the tDCS effects on clinical outcome measures at the patient and group level.

In summary, this presentation will show how a technique such as tDCS is promising for stroke rehabilitation but needs careful development and tailoring to stroke patients to be successful.

Keywords: stroke, rehabilitation, brain stimulation, transcranial direct current stimulation, technology, upper extremity

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