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Plastic Changes in Cortical Representation Induced by tDCS in Mild Chronic Stroke: fNIRS and EEG

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Introduction

Transcranial direct current stimulation (tDCS) facilitates cortical excitability and neuroplasticity after stroke. However, longitudinal evidence demonstrating sustained neurophysiological modulation using multimodal brain activation measures in mild chronic stroke remains limited. This study investigated plastic changes in cortical representation induced by a 4 weeks tDCS intervention using simultaneous functional near infrared spectroscopy (fNIRS) and electroencephalography (EEG).

Methods

In this single center, randomized, assessor blinded trial, 30 patients with mild chronic stroke (≥ 6 months post onset) were allocated to active (n=15) or sham (n=15) tDCS (Fig. 1). Active stimulation (1 mA, 20 min/session) was applied for 20 sessions over 4 weeks with the anode over ipsilesional M1 and cathode over contralesional M1. Sham stimulation was ramped down after 30 seconds. Simultaneous fNIRS–EEG recordings were obtained at baseline, post intervention, and 4 weeks follow up during resting state and two motor tasks (unilateral and bimanual upper limb task). Primary outcomes were longitudinal changes in fNIRS derived hemodynamic responses (oxyhemoglobin (HbO) and deoxyhemoglobin (HbR)) recorded over the primary motor cortex (M1), and EEG band power, which was averaged across the frontal, temporal, parietal and occipital regions.

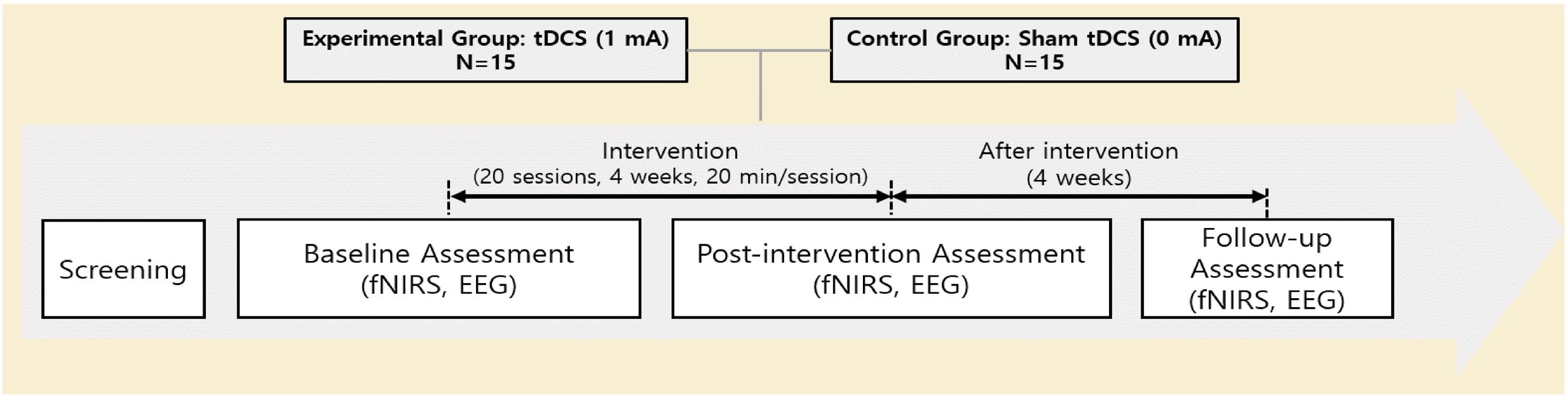

Figure 1. Flow diagram of the study design and assessment timeline

Results

The results of the fNIRS analysis were as follows (Fig. 2). No significant group differences were observed in HbO across all conditions (p>0.05). In contrast, HbR showed a significant group × time interaction during rest (t = -2.37, p=0.026) and unilateral upper limb task (t = -2.98, p=0.007). The results of EEG analysis were as follows (Fig. 3). For EEG, significant group × time interactions were observed in the mu, and beta bands across all conditions (p<0.01). Specifically, the active tDCS group showed relatively stable or decreasing trends in band power over time, whereas the sham group exhibited marked increases, indicating divergent longitudinal patterns between groups.

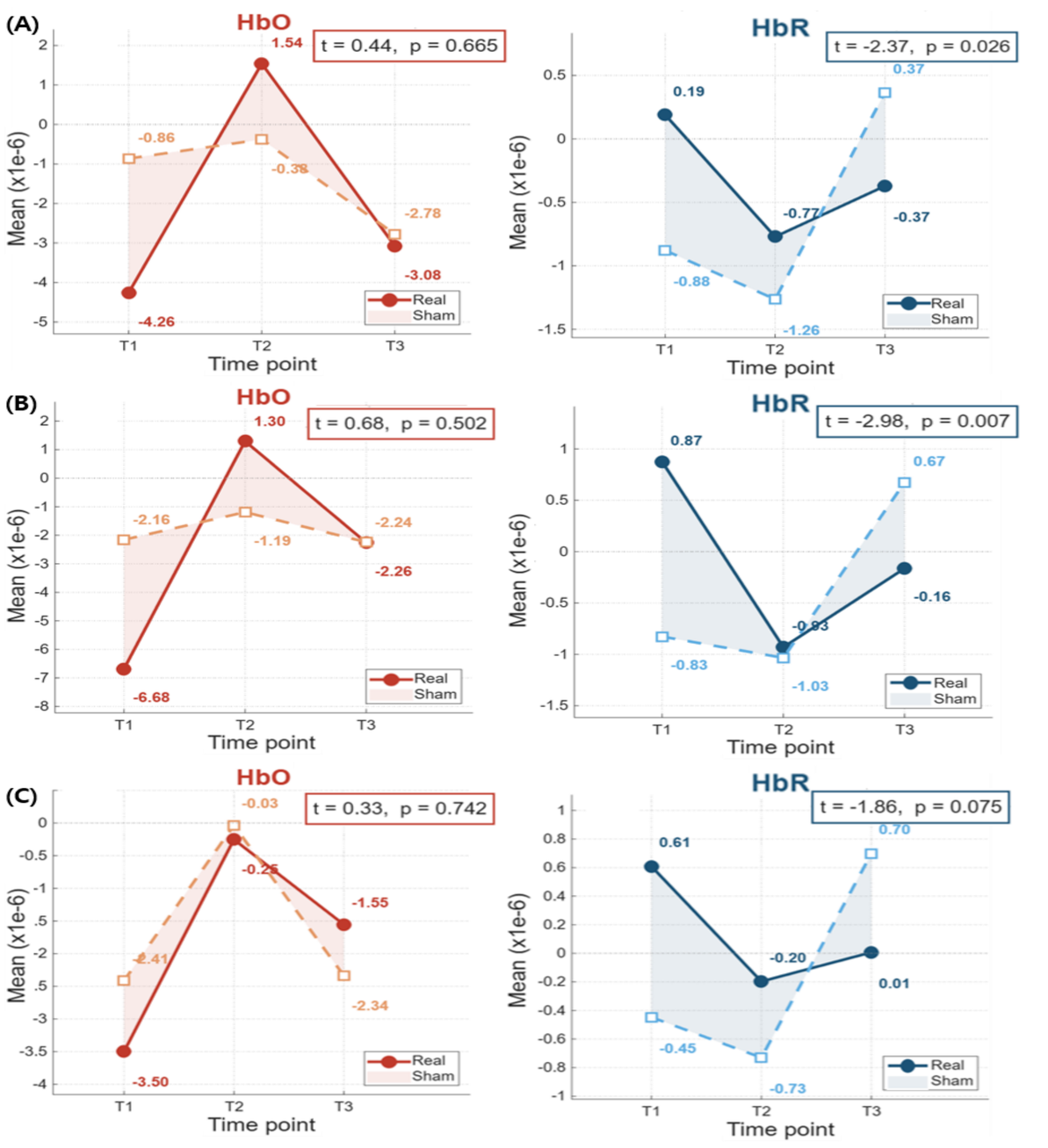

Figure 2. Longitudinal changes in fNIRS showing significant group x time interaction. (A) resting state, (B) unilateral upper limb task, (C) bimanual upper limb task

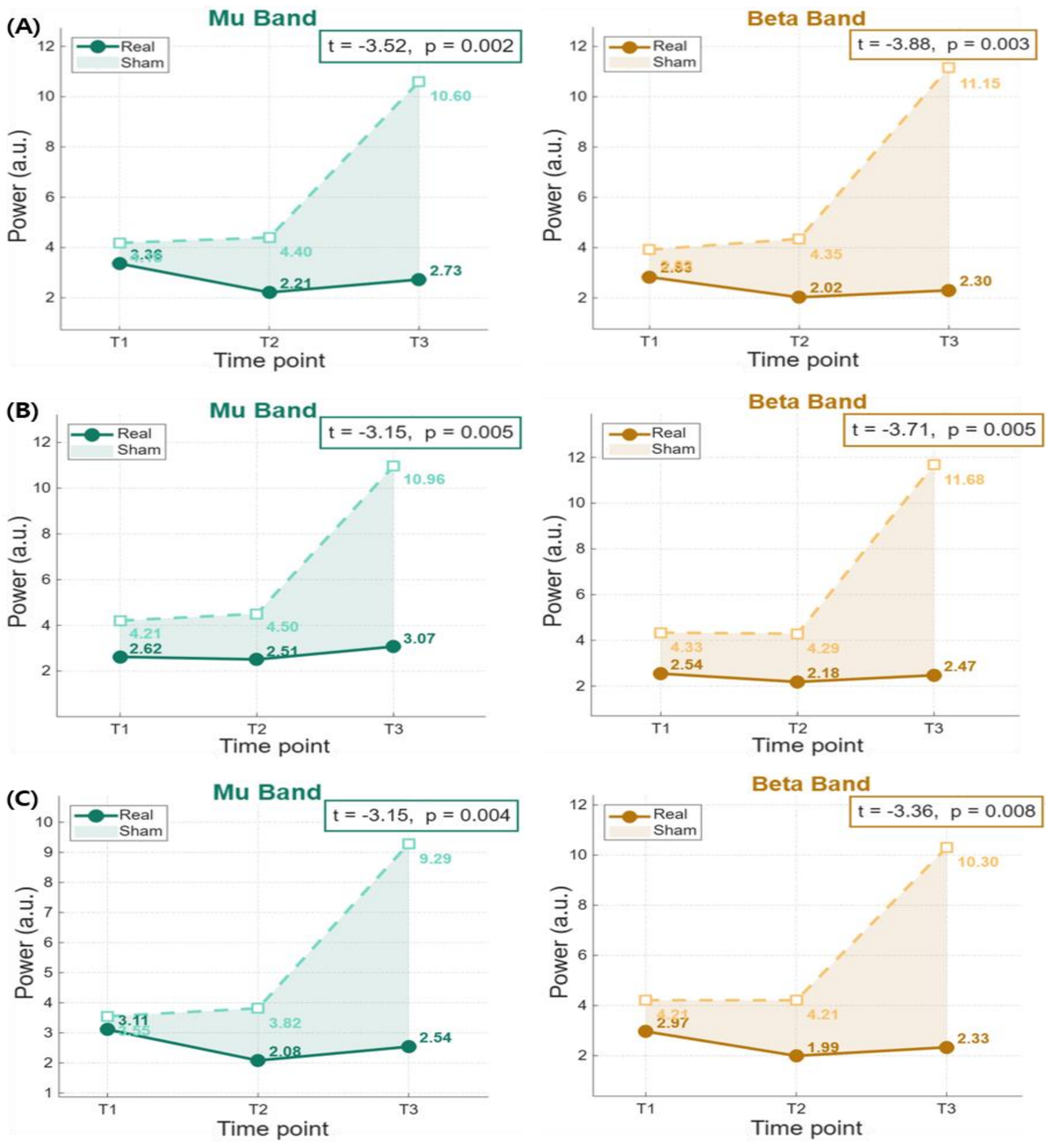

Figure 3. Longitudinal changes in EEG showing significant group x time interaction. (A) resting state, (B) unilateral upper limb task, (C) bimanual upper limb task

Conclusion

Active tDCS for 4 weeks was associated with sustained multimodal neurophysiological modulation, characterized by HbR reduction/stabilization and stable EEG power across conditions, suggesting more efficient cortical processing compared with sham stimulation. Repeated tDCS appears safe and may support durable cortical plasticity in patients with mild chronic stroke.

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* Acknowledgment; this work was supported by the Industrial Strategic Technology Development Program (RS-2024-00407994, Development of Decision Supporting System for Cerebrovascular Disease during Ambulance Care Using Vital Signs) funded by the Ministry of Trade, Industry & Energy (MOTIE, Korea).