Novel Imaging Approaches for the Quantification of Changes in Perivascular Space Volume and Morphology in Response to Transcranial Direct Current Stimulation

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Purpose: Though the behavioral effects of transcranial direct current stimulation (tDCS) are well-documented, a gap exists in current literature on its effects on glymphatic system dynamics and perivascular space (PVS) structural features. This is an issue of particular importance due to the relationship between PVS enlargement and impairments in waste clearance. Methods: Structural MRI data was gathered for 5 neurologically healthy patients before and within one hour after receiving anodal tDCS (lasting 20 minutes) in the primary motor cortex at Brigham and Women's Hospital. Structural MRI data for 30 control group patients were also gathered from the Human Connectome Project. For each subject and session pairing, the T1w and T2w images were coregistered, upsampled, masked, corrected, and segmented. The PVS visibility enhancement procedure described in Sepehrband et al., (2019) was utilized. PVS masks for white matter (WM) and basal ganglia (BG) were generated and analyzed using the Quantitative Imaging Toolkit and ImageJ. Analyses were made using unpaired t-tests. Results: BG PVS volumes demonstrated significantly greater increases between before and after scans in the tDCS group compared to the control group ($p=0.0078$). ImageJ analysis of BG PVS cross-sectional areas demonstrated significant PVS dilation in response to tDCS ($p=0.0033$). Analysis of various individual BG suggests the significant changes were isolated to the right nucleus accumbens and left putamen (both $p<0.05$). No significant changes were observed in any WM PVS features, nor in the total volumes of BG. This may point to unforeseen consequences of neuromodulation on structural characteristics of the glymphatic system.

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