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Development of a Corticospinal Excitability Model During Non-Invasive Brain Stimulation

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In recent years, there has been a growing interest in non-invasive brain neuromodulation for diagnosis and rehabilitation. Non-invasive stimulation techniques (NIBS) generate/induce an electric current in the brain via coils placed near the scalp or electrodes attached to the scalp. Recent studies have shown recovery of brain functions, improvement of cognitive processes, or treatment of major depression disorders [1], [2]. The corticospinal tract, as well as the brainstem-spinal pathways, have been suggested to contribute to skilled motor function and functional recovery after brain injury, which suggests a critical role of cortical plasticity [3]. However, there is limited evaluation of the optimal electric current in the brain to target these areas, and less is known about the relationship between the electric current features (e.g., intensity, distribution, duration) and physiological responses in part due to lack of in vivo measurements of the electric current distributions in the brain.

Computational modelling has permitted estimating the generated electric currents in the brain as the physical agent of neuromodulation [4], [5]. For more accurate predictions, digital human head models accounting for anatomical features have been employed [6] that can be used to determine the electric field at the individual level. Incorporating the stimulation process of corticospinal neurons is a pending and necessary step for explaining and optimizing external stimulation for motor-related rehabilitation [7].

In this study, we develop a corticospinal model to investigate transcranial electrical stimulation. The implemented volume conductor model of the human head is coupled with a corticospinal model in agreement with experimental strength-duration curves. Finally, the model was used to investigate different neurostimulation techniques for more accurate activation of corticospinal structures.

References

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