Analysis of Cortical Connectivity using EEG during Self-paced Treadmill Rehabilitation after Stroke

Hyeon-Chan Chei[1], Jiwoo Oh[1], Seong-Jin Hong[2], ByungUk Rho[1], Geon Woo Park[1], Hyung-Soon Park[2†], Keonyoung Oh[1*]
[1]School of Mechanical Engineering, Kyungpook National University, Daegu, Republic of Korea
[2]School of Mechanical Engineering, Korea Advanced Institute of Science and Technology (KAIST), Daejeon, Republic of Korea
Email: [†]hyungspark@kaist.ac.kr, [*]kyoh@knu.ac.kr

Summary

This study examined the cortical activity and connectivity of stroke survivors during gait rehabilitation using a self-paced treadmill, distinguishing between different gait states (slow and fast constant speed, acceleration, and deceleration). Event-related desynchronization (ERD) and event-related synchronization (ERS) were observed within the 0-50 Hz range, particularly in the premotor cortex and supramarginal gyrus. Additionally, connectivity between these brain regions was also found in the β-band (10-30 Hz). These findings suggest that self-paced treadmill training may serve as an effective rehabilitation method by stimulating essential neural activity and connectivity crucial for promoting neuroplasticity.

Introduction

Facilitating neuroplasticity is essential for effective gait rehabilitation in post-stroke patients [1]. Maximizing cortical activation and interregional brain connectivity plays a crucial role in this process; however, whether self-paced treadmill gait training enhances cortical activity and connectivity in stroke survivors, particularly during acceleration and deceleration, remains unexplored. Therefore, this study aims to investigate the connectivity between brain regions in post-stroke patients using electroencephalography (EEG).

Methods

Seven stroke survivors (four males and three females; 67.85 ± 9.40 years old) participated, including five with acute (13.4 ± 5.2 days post-stroke) and two chronic cases (2.5- and 26-years post-stroke). Participants performed two gait modes (self-paced and fixed speed) walking with EEG recorded via a 64-channel system(BrainProduct, Germany) and classified into four gait states based on actual walking speed [2]. The average walking speeds for slow and fast gait were 0.28 ± 0.14 m/s and 0.41 ± 0.15 m/s, respectively, while the speeds in self-paced and fixed modes were 0.42 ± 0.00 m/s and 0.25 ± 0.00 m/s. Preprocessed EEG data were clustered for cortical activity and connectivity analysis (IRB: B-1608/358-004).

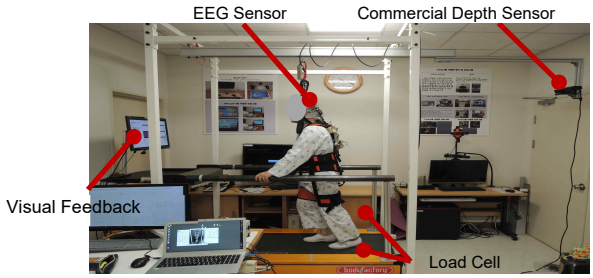

Figure 1: A treadmill that allows users to adjust speed according to their intentions.

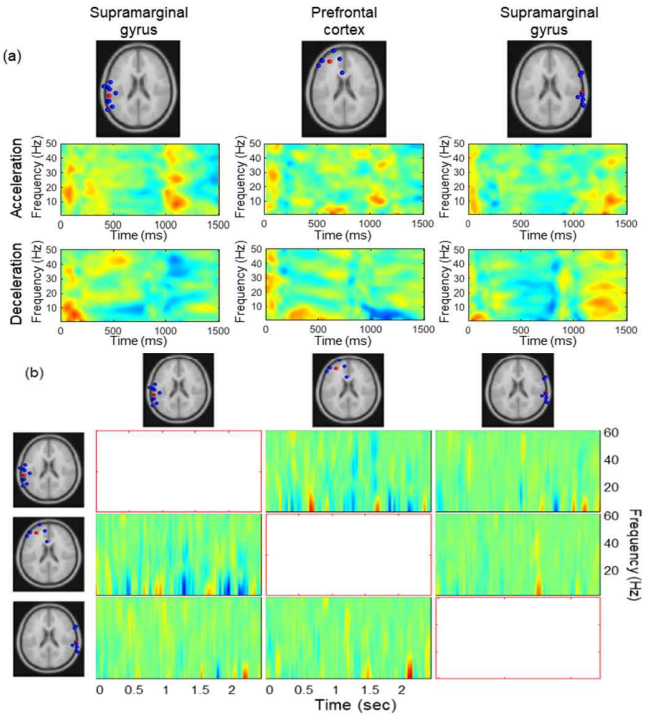

Figure 2: (a) ERSP during acceleration and deceleration in brain regions. (b) Connectivity between brain regions.

Results and Discussion

ERD and ERS were observed across most frequency ranges in the supramarginal gyrus and prefrontal cortex (Figure 2-(a)). Connectivity between premotor cortex and supramarginal gyrus was evident in the β-band range (Figure 2-(b)).

Conclusions

During self-paced rehabilitation, stroke survivors exhibited enhanced interregional brain connectivity. The enhancement may facilitate neuroplasticity, suggesting the potential for developing rehabilitation programs that specifically stimulate connectivity between brain regions involved in motor planning and musculoskeletal control during rehabilitation.

Acknowledgments

This work was supported by the National Research Foundation of Korea (NRF) funded by the Korea government (MSIT) (No. RS-2023-00252471, RS-2024-00406223).

References

[1] Hong, Seong-Jin. (2018). KAIST (master's thesis).
[2] Oh K et al. (2021). J NeuroEngRehabil. **18**: 1-12.