EEG Biomarker for Functional Recovery in Patients with Incomplete Spinal Cord Injury

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Summary

Functional changes after spinal cord injury (SCI) are related to changes in cortical plasticity. These changes can be measured with electroencephalography (EEG) and has potential to be used as a clinical rehabilitation assessment biomarker.

Introduction

SCI is one of the most important causes of permanent disability with a major social and economic impact on the affected population. Understanding the brain mechanisms of functional recovery in SCI and rehabilitation evaluation biomarkers of are crucial for the development of innovative approaches and tailored treatments for SCI patients.

Methods

In this longitudinal study participants underwent a total of 72 sessions of Brain Computer Interface (BCI) exoskeleton robotic-assisted gait training over a course of 12 weeks. The duration of each session was 25 min. Resting state EEG, motor and sensor index score was recorded before and after 72-session rehabilitation therapy.

Results and Discussion

This study included 12 participants with incomplete spinal cord injuries (SCI), classified as AIS B or C based on the American Spinal Cord Injury Association Impairment Scale. The mean age was 42 years (range: 27-65), and the mean time since injury was 14 months (range: 8-18). All participants demonstrated clinical improvement following a rehabilitation program. For analysis, five horizontally arranged regions of interest (ROIs) were selected: PreFrontal Cortex (PFC: Fp1, Fp2), Frontal Cortex (FC: F3, Fz, F4, FCz, FC3, FC4, F7, F8, FT7, FT8), Parietal Cortex (PC: C3, Cz, C4, CP3, CP4, CPz, P3, P4, Pz), Temporal Cortex (TC: T3, T4, T5, T6, TP7, TP8), and Occipital Cortex (OC: O1, O2, Oz). Results showed that, compared to pre-12 weeks, Alpha Relative Power (ARP) and Peak Alpha Frequency (PAF) increased in all brain regions post-12 weeks of treatment. Significant differences in ARP were observed in all regions except FC, while significant differences in PAF were found in all regions except FC and TC. Correlation analysis revealed that ΔARP in the PFC positively correlated with ΔMIS (p=0.032; β coefficient: 0.257; r^2: 0.38) and ΔSIS (p=0.027; βcoefficient: 0.173; r^2: 0.29). ΔARP in the PC and OC also showed positive correlations with ΔMIS (PC: p=0.045; β coefficient: 0.364; r^2: 0.43; OC: p=0.019; βcoefficient: 0.395; r^2: 0.48). Furthermore, ΔPAF in the OC positively correlated with ΔMIS (p=0.024; β coefficient: 0.151; r^2: 0.37) and ΔSIS (p=0.035; βcoefficient: 0.134; r^2: 0.25).

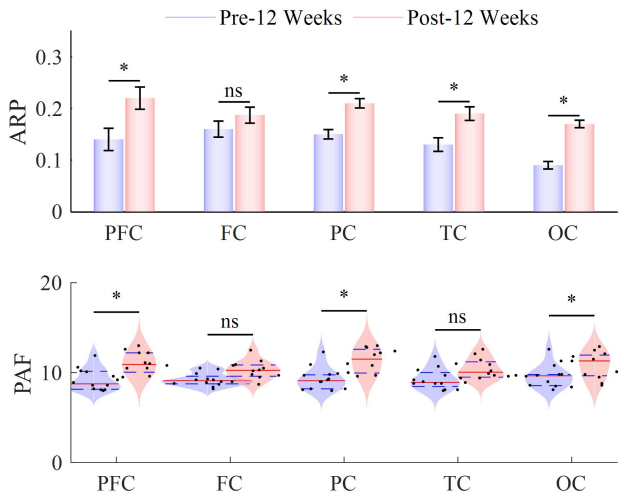

Figure 1: Comparison of ARP and PAF of rest EEG in Pre-12Weeks and Post-12Weeks. (ns: none significant, *: p<0.05)

Table1. Changes in EEG feature predicted by improvement in motor and sensor functional outcomes (*p* value).

	ΔMIS				ΔSIS			
	PFC	**PC**	**TC**	**OC**	**PFC**	**PC**	**TC**	**OC**
ΔARP	**0.032**	**0.045**	0.053	**0.019**	**0.027**	0.064	0.127	0.214
ΔPAF	0.136	0.232	0.126	**0.024**	0.242	0.133	0.163	**0.035**

Conclusions

In SCI, functional impairment and subsequent improvement following rehabilitation therapy with motor and sensor index score correlated with the change in cortical activity measured by EEG. Our results suggest that ΔARP and ΔPAF may be a potential surrogate marker of functional improvement during rehabilitation.

Acknowledgments

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References

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