Aberrant Topology of Brain Network is Associated with the Dynamic Balance in Chronic Ankle Instability

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Summary

Compared with healthy controls, chronic ankle instability (CAI) exhibited worse dynamic balance and significantly aberrant topological properties in resting-state brain functional networks. Moreover, these aberrant topological properties were significantly associated with the dynamic balance, suggesting that the brain network in CAI may emerge as a potential target for future rehabilitation.

Introduction

Nearly 50% of initial ankle sprains result in chronic ankle instability (CAI). A recent paradigm shift suggests that CAI involves alterations at the supraspinal level, rather than being merely a peripheral musculoskeletal disorder [1].

However, current studies on brain plasticity in CAI populations have only focused on local brain activation, neglecting the communication and interaction between brain networks. Therefore, this study aims to explore the differences in topological properties of brain functional networks between CAI individuals and healthy controls (HC).

Methods

In this cross-sectional study, 40 CAI (20 males/20 females, age: 20.5±1.5 yrs, height: 172.1±8.6 cm, weight: 66.0±11.7 kg) and 40 HC (16 males/24 females, age: 21.2±2.2 yrs, height: 168.5±9.5 cm, weight: 61.4±12.8 kg) were recruited. The main inclusion criteria for CAI were CAIT scores ≤ 24 and IdFAI scores ≥ 11.

The normalized reach distances in the anterior (ANT), posteromedial (PM), and posterolateral (PL) directions of the Y-balance test were utilized to assess the dynamic balance of each participant. The resting-state functional magnetic resonance images (rs-fMRI) of each participant were acquired. Based on the Dos-160 template [2], the GRETNA package was used to calculate the global and regional network metrics of the resting-state brain functional networks [3]. The differences between CAI and HC, as well as the correlation between dynamic balance and network metrics were examined.

Results and Discussion

Compared to the HC, the CAI group had significantly lower normalized reach distances in the ANT, PM, PL directions. Furthermore, CAI had significantly lower nodal degree centrality (Dc) in the right precentral gyrus, the right temporal cortex, and the left parietal cortex. Note that the nodal efficiency was significantly higher in the left post cingulate cortex in CAI (**Table 1**). In the CAI group, the Dc of the left parietal cortex was positively correlated with the reach distance in the PL direction (**Figure 1**, $rho = 0.363$, $p = 0.021$), while the Dc of the right precentral gyrus was negatively correlated with the reach distance in the ANT direction ($rho = -0.352$, $p = 0.026$).

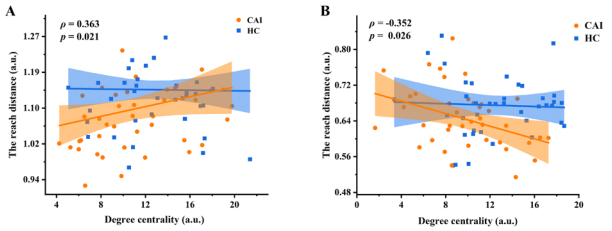

Figure 1: The association between A) the Dc of the left parietal cortex and the reach distance in the PL direction, B) the Dc of the right precentral gyrus and the reach distance in the ANT direction. Note: a.u., arbitrary unit.

Conclusions

The aberrant topological properties of the brain functional networks in the CAI are associated with the dynamic balance, which may reflect the compensation mechanisms at the supraspinal level, potentially influencing the recurrence of sprains. The brain network of CAI may emerge as a potential target for future rehabilitation.

Acknowledgments

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References

[1] Maricot et al. (2023). *Sports Med.*, **53**(7): 1423-1443.
[2] Dosenbach et al. (2010). *Science*, **329**(5997): 1358-1361.
[3] Odkhuu et al. (2023). *Mol Psychiatry.*, **28**(9): 3717-3726.

Table 1: Differences in the regional network metrics between CAI and HC groups.

Metrics	Label	Regions	Subnetwork	MNI-coordinates (mm)	*t*-value	*p*-value
Dc	101	Right precentral gyrus	sensorimotor	44, -11, 38	-2.95	0.0041*
Dc	105	Right temporal cortex	sensorimotor	59, -13, 38	-3.03	0.0033*
Dc	107	Left parietal cortex	sensorimotor	-47, -18, 50	-2.82	0.0061*
Ne	26	Left post cingulate cortex	default	-11, -58, 17	2.86	0.0054*

Note: *, significant difference between CAI and HC; Dc, degree centrality; Ne, nodal efficiency.