Alterations in Resting State Functional Connectivity in Patients with Traumatic Brain Injury Following a 3-Month Pilot Cognitive Intervention Program

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Background

Traumatic brain injury (TBI) often results in cognitive impairments related to alterations in brain structure and function. Facilitating functional recovery following TBI is a primary goal of neurorehabilitation, however the changes to the underlying neurobiological functional connections are not fully understood. Advances in neuroimaging techniques with the use of resting-state functional magnetic resonance imaging (rs-fMRI) have provided insight into the functional connectivity changes in TBI and their correlation to functional outcome following neurorehabilitation.

Objectives

The purpose of the pilot study was two-fold:

1. To assess the differences in rs-functional connectivity in patients with TBI compared to healthy controls
2. To assess the recovery in functional connectivity following an intensive three-month cognitive intervention program in the patients with TBI
3. To assess changes in rs-fMRI with changes in cognitive function following intervention.

Methods

Volunteers between the ages of 18-55 years who sustained a non-penetrating (mild to severe) TBI were recruited for the cognitive intervention program (n=8); all TBI participants had injuries occurring a minimum of 1 year prior to the start of the intervention, with persistent symptoms and disability for over 1 year. Healthy controls were recruited based on age, gender and education, and were screened to ensure that they had no history of head trauma, neuropsychiatric disorders, substance abuse or any other neurological conditions (n=8). MRI scans were completed on a 3T Philips scanner and collected at baseline and at the 3-month time point, following intervention.

Results

Group Differences at Baseline

Group ICA demonstrated significant differences in voxel-wise connectivity in 10 of 30 identified components, between the TBI patients and healthy controls. The differences included not only declines in functional connectivity, but also augmentations. The decreases in functional connectivity were observed in the regions of the SMN and DAN (p = 0.006 to 0.036), where the enhancements were observed in the regions of the visual network and the DFM (p = 0.005 to 0.015). No changes were observed in the EFN, FPN, auditory or cerebellar networks.

Changes in TBI Patients Following the Three-Month Cognitive Intervention

Analyses indicated that functional connectivity was higher in the SMN and DAN following the pilot three-month cognitive intervention program (p = 0.001 to 0.039). There were no changes observed in the visual or DFM networks.

Changes in Cognitive Function Following the Three-Month Cognitive Intervention

Following the intervention, there was a statistically significant increase in the composite cognitive score in the TBI participants (p = 0.0002).

Discussion

Our findings suggest that there are multiple functional connectivity disturbances in patients with TBI, compared to controls. The data shows that while there are deficits in particular regions (as one might expect), there are enhancements in others. This suggests that there are possible compensatory mechanisms occurring in neuronal processes, exemplified further given that the patients are classified with chronic TBI. Following the pilot three-month cognitive intervention, there was a statistically significant increase in functional connectivity networks that had shown reduced connectivity compared to healthy controls. There was no change in the enhanced regions, suggesting that the compensatory mechanisms are still being implemented. The changes in cognitive scores in conjunction with the change in resting state connectivity gives evidence of changes in brain-behaviour relationship following intervention. The results from this pilot study provide preliminary evidence for functional network reorganization after cognitive rehabilitation in individuals with chronic TBI.

Limitations

Given the small sample size of this pilot study, larger studies are warranted to validate the findings outlined above.

References


Acknowledgements

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