Comparing self-reporting concussion assessments with an objective neuroimaging-based approach

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Background

Concussion is a common and devastating condition that severely affects millions around the world. To evaluate concussions, traditional self-reporting tools have limitations due to subjectivity[1]. Neuroimaging modalities such as magnetic resonance imaging (MRI) are an exciting alternative that can provide objective evaluation of the brain. Therefore, an objective neuroimaging-based approach is proposed in this research to identify potential trends and pitfalls in traditional PCSS and if there exists promise with an MRI-based objective assessment approach.

Patient & Methods

26 concussion patients (0-6months post-trauma) were analyzed. 10 males (33±12yrs) and 16 females (38±12yrs) were recruited and a traditional PCSS (22 symptoms) was administered prior to an MRI scanning session (GE MR750 Discovery 3T, 1hr duration) with the following sequences:

- High Resolution T1-weighted
- 60 direction diffusion tensor imaging (DTI)
- Resting state functional MRI (rsfMRI)

A minimum of 88 MRI dataset pairs (T1w, DTI, rsfMRI) of healthy age (±2yrs) and sex matched controls were acquired from public data repositories[2,3,4,5]. A homebuilt python processing pipeline was used to perform DTI anisotropy[6] and rsfMRI complexity analysis[7,8]. Fractional anisotropy (FA), mean diffusivity (MD), axial diffusivity (AD), and radial diffusivity (RD) were the DTI metrics evaluating structural integrity of the brain whereas temporal complexity (TC) assessed functional integrity. The brain was further segmented into traditional regions of interest (ROIs) including 24 white matter tracts and 91 gray matter regions. A Z-score statistical approach was performed on the MRI data to identify abnormal ROIs with Z-scores >2.5. Then, a weighted mean calculation scaled statistically significant Z-scores into a 6-point scale (x represents Z-scores, and w represents the weighting of Z-scores):

- $$MRI\_Score = \frac{1}{2}\left(\frac{\sum(x_{DTI} * w_{DTI})}{\sum w_{DTI}} + \frac{\sum(y_{fMRI} * w_{fMRI})}{\sum w_{fMRI}}\right)$$

Total PCSS scores (i.e. sum of scores) were then compared to the MRI_Score results. Overall trends were investigated along with age and sex effects (Male/Female, Over/Under 35 yrs).

Results

- Each concussion patient had an MRI-based abnormality (i.e., Z-score>2.5); *(Figure 1).*
- No trends were found within the sum of scores (self-reported vs. MRI-based); *(Figure 2).*
- Age and sex analysis showed that young men (<35yrs) underreport their symptoms (i.e. lower self-reported scores than the MRI-based scores), whereas older women (>35yrs) overreport their symptoms; (Figure 3).
- This corroborates with literature where younger men tend to underreport their symptoms due to societal and/or other influences[9,10].
- This MRI-based approach shows promise as an objective concussion assessment tool.

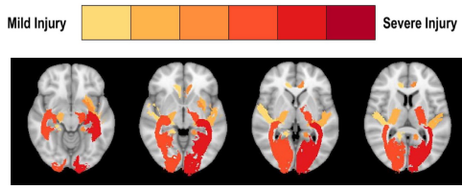

Figure 1. Axial slices of colour-coded Z-score overlays showing abnormalities in the visual cortex & optic radiation in a single patient.

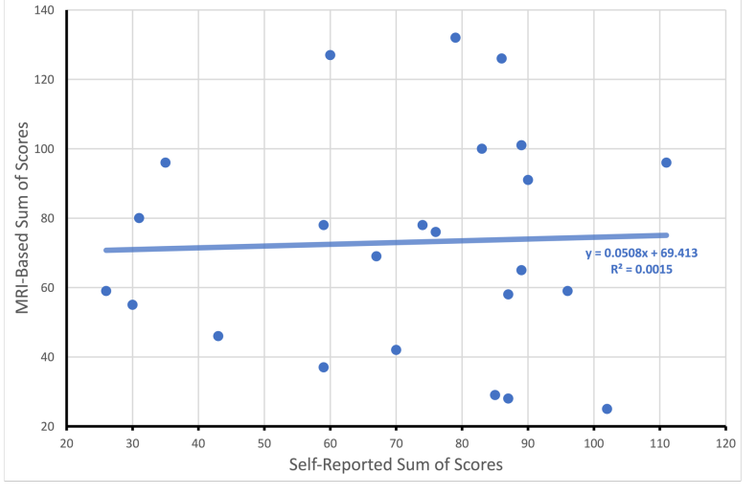

Figure 2. Scatter plot of all 26 concussion patients evaluating their Self-Reported Sum of Scores (x-axis) against the calculated MRI-Based Sum of Scores (y-axis). Overall, no trend.

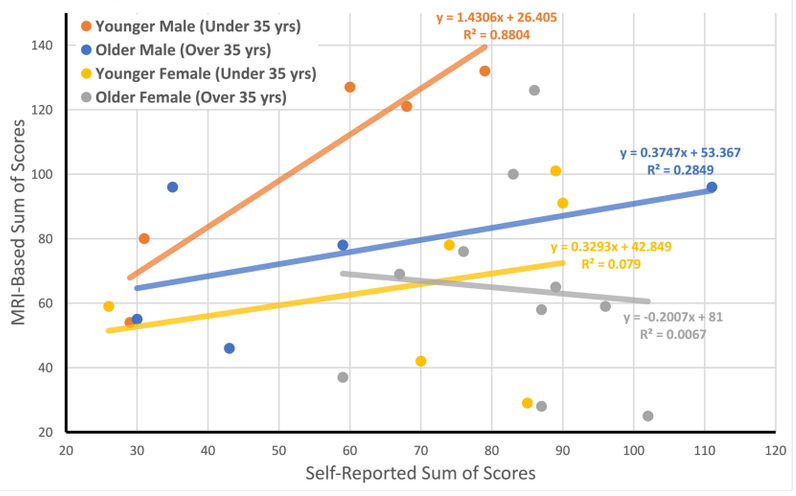

Figure 3. Scatter plot of all concussion patients, represented by 4 different labels respective of age and sex, <35yrs Male (n=5, red), >35yrs Male (n=5, blue), <35yrs Female (n=6, yellow), >35yrs Female (n=10, grey).

Discussion

This MRI-based approach can help assess concussion patients and their symptoms more objectively. Future work must be performed to identify how self-reporting and MRI-based findings change in a longitudinal fashion. Our results found that sex plays a significant role in self-reporting and that societal effects most likely confound self-reporting results. Together, these factors clearly indicate why objective measures for concussion must be investigated and why inherent biases in subjective tools are propagating challenges in concussion evaluation. Furthermore, objective methods can improve traditional clinical workflows and reduce healthcare costs.

References

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