

($p < 0.0001$) and patients whose mechanism of injury was not a fall ($p = 0.039$), when controlling for GCS score ($p = 0.0014$).

Conclusion: The cost of hospitalization for TBI is significantly increased by longer hospital stay, lower survival chance and higher GCS score, while cost is significantly lower for patients who sustain a TBI due to fall vs motor vehicle collision.

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Regional metabolite profiles in chronic sports-related concussion

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Objective: To establish an ante-mortem biomarker profile of repetitive brain trauma (RBT) in professional athletes in contact sports.

Background: Professional athletes in contact sports suffer thousands of concussive and sub-concussive blows to their heads over the course of their career. The direction and points of impact are widely distributed; therefore, the long-term effects of injury in different regions of the brain is unknown. Four regions which have been established as acutely vulnerable in previous magnetic resonance spectroscopy (MRS) studies of more severe brain injury were selected to determine the chronic effects of milder injury that occurs in professional contact sports.

Methods: Short-echo proton spectroscopy (TE = 30 milliseconds, TR = 2 seconds, $2 \times 2 \times 2 \text{ cm}^3$, 128 averages) was acquired in the posterior (PGM) and anterior grey matter (AGM) in the cingulate gyrus and posterior (PWM) and anterior white matter (AWM) at the periventricular sub-cortical WM of the parietal and frontal lobes on a 3 T MRI (Siemens Verio) in five retired professional athletes including ex-NFL players with history of concussions and cognitive symptoms associated with RBT and chronic traumatic encephalopathy (CTE) and age and size-matched controls. Data was analysed using a linear combinations model analysis (LCmodel) and relative metabolite concentrations were quantified.

Results: MRS showed glycerophosphorylcholine (GPC) and total choline (tCho; GPC + phosphocholine) to be significantly increased ($p < 0.05$) across the PGM, PWM and AWM. Increased concentrations of GPC and tCho have been shown to be markers of diffuse axonal injury, which appears to be reflected across both cortical and sub-cortical brain regions. Glutathione (GSH), an important anti-oxidant in the brain, decreased across all brain regions in athletes, which may be indicative of neuroinflammation. Counter-intuitively, N-acetyl aspartate (NAA), a putative marker of neuronal density, decreased in severe TBI and was increased in athletes compared to controls across all brain regions, although not significant. This is reported also in sub-acute sports-related concussion and may be the result of over-correction. Results of this preliminary study show strong and long-persistent regional increases in choline. Other trends including decreased glutathione as a result of inflammation and increased NAA may be further in a larger study or other MRS methods. Metabolite changes which were found in both grey and white matter were surprisingly less obvious in the anterior grey matter.

Conclusion: Differences in regional brain metabolite profiles may provide a personalized ante-mortem diagnostic tool for RBT, potentially predictive of autopsy diagnosis of CTE.

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An investigation of factors that influence socioemotional and academic gains in the classroom

for students living with the effects of ABI

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Objectives: Acquired brain injury (ABI) is not an identified classification with the Ministry of Education in the province of Ontario and, as such, children and youth with ABI are not acknowledged formally within the school system and, as a result, cannot gain access to adequate ABI-targeted support. This research examines both subject-based (student, family) and systems-based (school/policy, educator) factors that predict performance outcomes for academic, emotional, psychosocial variables in an attempt to identify and ameliorate barriers of successful return to and completion of school for children and youth who have sustained a moderate-to-severe ABI.

Method: Children's Treatment Centres, province-wide, assisted in the identification of students (6-18 years, 1-5 years post-injury, have returned to school) to participate in this study. Questionnaires, and for students, neuropsychological measures, were administered to students, parents and their respective teachers and principals. Each of these variables were entered into multiple regression analyses in order to examine the relative influence and contribution of each in terms of its contribution to the successful re-integration of students with their school environment.

Results: Analyses indicate that student-based factors are important predictors of performance, particularly when assessed in terms of cognitive, as opposed to physical, indicators of capacity and function. Importantly, the variables that are 'modifiable', namely, systems-based factors (e.g. as measured variously in terms of teachers' knowledge of ABI and its sequelae), and, in certain circumstances, school policy (the types of supports that are provided, e.g. additional supports for teachers; or policy promoted, in terms of e.g. views on inclusion) were significantly predictive of social-emotional and academic outcomes.

Conclusions: Measures of injury severity are more informative for treatment intervention and rehabilitation/school re-integration if they are based on cognitive status upon recovery, rather than on physical trauma at time of injury. Further, recommendations and opportunities for more effective assistance for the students who have experienced an ABI and are returning to the classroom can be derived based on teacher instruction and inclusion policy, particularly in the domains that go beyond academic performance and include social-emotional success of the student.

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The impact of traumatic brain injury on reading efficiency: Reading rate correlates with Trail Making Test performance in patients with mild-to-moderate TBI

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Objectives: The current research investigated the consequences of traumatic brain injury (TBI) on reading. Past research has shown that even mild TBI can result in perceptual deficits. This scenario often involves oculomotor difficulties in tracking and scanning of the visual field, such as accommodative dysfunction, versional loss and convergence insufficiency. These conditions hamper the motility and co-ordination of the eyes and are profoundly debilitating to sustained reading. To better understand this problem, the current research evaluated reading ability in patients with mild-to-moderate TBI. Neuropsychological testing assessed the extent of brain injury while time tests measured reading performance. Statistical analyses identify correlations between these measures.

Methods: Approximately 30 patients diagnosed with mild-to-moderate TBI participated in the study. Patients were recruited from the War Related Injury and Illness Study Center (WRIISC) of the Palo Alto Veterans Healthcare System (VAPAHCS) as well as the Santa Clara Valley Medical Center. All participants were screened with a battery of neuropsychological measures before further testing. Accuracy and maximum reading rate were quantified with the Pepper Visual Skills for Reading Test (VRST), the Test of Word Reading Efficiency (TOWRE) and International Reading Speed Texts (IREST).

Results: Reading rate performance scores were calculated by multiplying the speed in seconds in which a participant could complete a passage or word list by the percentage accuracy (i.e. number correctly read words divided by the total number of words). This study found significant negative correlations between a neuropsychological measure of attention and visual scanning, the Trail Making Task and the reading measures: VRST ($r = -0.50$), TOWRE ($r = -0.61$), IREST ($r = -0.69$).

Conclusions: These results indicate that reading rate is significantly affected by the extent and nature of traumatic brain injury. Further research is necessary to understand the neurology that underlies these deficits. Damage to specific white matter fascicles may hamper eye movement, but a general cognitive slowing may also contribute. Future work will attempt to relate these findings to diffusion tensor imaging (DTI) data which quantifies the integrity of white matter pathways.

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The relationship between executive functioning, working memory and speed of processing

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Objectives: Impairments in executive function and working memory (WM) are among the most common cognitive processes affected in patients with traumatic brain injury (TBI). This study investigated the relationship between measures of executive functioning, verbal working memory, visual working memory and speed of processing in a group of patients with chronic severe traumatic brain injury (TBI). **Methods:** A group of 17 males (range = 21–60 years, mean age = 33.6) with a primary diagnosis of a moderate-to-severe closed head injury were tested in a battery of paper-and-pencil neuropsychological and language tests. All patients were native speakers of Greek language

and all tests were translated and adapted in Greek language. The battery was designed to assess executive functioning (The Symbol Digits Modalities Test, The Verbal Fluency Test, Trail Making Test Part B, Rey Complex Figure Test), verbal working memory (Rey Auditory Verbal Learning Test, The Digit Span Test, Logical Memory sub-test of the Wechsler scale), visual working memory (Rey Complex Figure Test Copy, The Visual Span Test) and measures of speed of processing (Trail Making Test Part A, response time in the Verbal Fluency Test, experimental tasks of attention and reaction time). Scores from the neuropsychological tests assessing were combined into composite scores assessing each construct of interest. Each of the measures was converted into a Z-score and valenced such that lower scores indicated poorer performance. The resulting Z-scores for the measures within each construct were then averaged to derive a score for the constructed measure.

Results: The executive functioning composite score exhibited a significant positive correlation with the visual and verbal WM scores and the speed of processing composite score. The verbal and visual WM score also exhibited a significant positive correlation. However, speed of processing was not correlated with either the verbal or the visual working memory score.

Conclusions: These findings suggest that executive functioning depends on the capacity of both verbal and visual working memory as well as the speed of processing of an individual. Moreover, the findings indicate that verbal and visual WM capacity share common resources but these are independent from the speed with which information is being processed.

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Do risk factors differ for concussion and prolonged recovery following concussion in elite youth ice hockey players?

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Background: Identifying risk factors for concussion and prolonged recovery will inform the development of prevention strategies.

Objective: To examine risk factors for concussion and prolonged recovery amongst elite youth ice hockey players.

Design: Cohort study.

Setting: Community ice rinks and sport medicine clinic (2011/2012 season).

Participants: Male and female elite youth ice hockey players [781 Bantam (13–14 years) and Midget (15–17 years)].

Assessment of risk factors: Baseline age group, sex, previous concussion history and baseline total symptoms score (TSS), balance error score (BES) and standardized assessment of concussion (SAC) score were evaluated.

Main outcome measurements: Players with a suspected concussion were referred to a sport medicine physician by the team therapist. Concussions with >10 days time loss were defined as prolonged recovery.

Results: Concussion incidence rate ratios (IRR) were estimated using multivariate (concussion) and univariate (concussion with prolonged recovery) Poisson Regression analyses (cluster and exposure hour adjusted). Males were at greater risk of concussion than females