

# North American Brain Injury Society

## Abstracts



Dear Colleagues,

It is with great pleasure that we present the accepted scientific abstracts from the North American Brain Injury Society's *15th Annual Conference on Brain Injury* in this issue of the *Journal of Head Trauma Rehabilitation*. The conference was held in New Orleans, February 26–29, 2020.

This year we were delighted to have received over 170 abstracts from investigators, clinicians, and researchers from around the world including some of the world's leading clinical, academic, and research institutions. Moreover, we are proud of the high quality of research submitted and the broad range of relevant, interdisciplinary topics reflecting current advances being made across the continuum of care in the field of brain injury.

For those of you who were unable to attend the NABIS 2020 meeting, we are pleased to present accepted scientific abstracts in the *Journal of Head Trauma Rehabilitation (JHTR)*. In addition, to the scientific oral and poster abstracts, NABIS 2020 had over 50 invited speakers presenting on the latest advances in ABI neuroscience and rehabilitation research. The conference planning committee developed a dynamic educational program under the theme of enhancing "evidence informed" multidisciplinary education designed for clinicians, researchers, administrators, and other brain injury professionals. This four-day multi-track event covered a variety of brain injury topics including medical best practices, rehabilitation, research, life-long living, pediatrics, neuroethics, and advocacy. The conference program is posted on the NABIS website, [www.abi2020.org](http://www.abi2020.org).

This past year, NABIS was pleased to showcase four exciting full day Pre-conference Courses. Pre-eminent leaders presented on Evidence Informed Management of Mild TBI's, Disorders of Consciousness: Multidisciplinary Clinical Implementation of the recently published DOC guideline recommendations and Novel Approaches for Motor Rehabilitation aimed at maximizing recovery and function. Finally, a potpourri of cutting-edge pediatric ABI rehabilitation (PABI) topics were presented in a full-day event, which segued to the main conference. The main conference also featured leading experts presenting on essential ABI topics for every practicing clinician as well as researchers. Interactive sessions on Mild TBI, Disorders of Consciousness, Neuroplasticity, and Recovery Best Practices Rehabilitation were components of the broad-based program. Examples of practical education included but were not limited to headache evaluation management, pharmacologic rehabilitation, vision and vestibular current practices, neurologic music therapy and a context for applied complementary/alternative and integrative therapeutics. The educational offerings were rounded out with updated approaches to maximize community integration, lifelong living, and how best to manage ABI as a chronic condition to maximize one's quality of life.

We hope that you were able to join us this past February and otherwise look forward to seeing you at future NABIS/IBIA meetings. We also thank you for your support of this multi-disciplinary dynamic organization and are hopeful for new membership growth in the upcoming year. Please watch your inbox for a link to the revised website that will be unveiled soon. We welcome your feedback on how we can do things better. Whether it is in the area of research or clinical care, NABIS stands behind the premise that advances in scientific research and translational clinical care will ultimately provide the best outcomes for those individuals and families affected by brain injuries as well as the community as a whole.

Sincerely,

Alan Weintraub, MD  
Conference Chair

Mariusz Ziejewski, PhD  
NABIS Chair

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The North American Brain Injury Society is entirely responsible for the scientific content of these abstracts. These abstracts have undergone peer review by NABIS to determine suitability for their national conference. No additional peer review of these abstracts was performed by the editor or editorial board of *Journal of Head Trauma Rehabilitation*.

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E156

**0001****A Diagnostic Tool for Assessing Concussion Neuromarker Abnormalities and Treating PCS in mTBI Patients**

Fong A, Allen M

*Cognitive FX, Provo, United States***Purpose**

fNCI (functional neurocognitive imaging) is an fMRI-adapted technology used in the effective diagnosis of post-concussion symptoms (PCS). With fNCI, 60 brain areas consistently affected by concussion were identified as PCS neural markers, which were validated on large samples of concussion patients and healthy controls. These neuromarkers, including attentional, subcortical, visual processing, language processing, and executive functioning, provide an objective measurement to identify the brain regions that need to be treated. These measurements have proven valuable in making pretreatment decisions, monitoring treatment efficiency, and assessing long-term stability of outcomes.

**Methods and Materials**

After being scanned while performing various cognitive tasks, 600 concussed patients received a severity index score (SIS) based on the neural dysregulation of the 60 previously identified brain regions. The SIS and information from the fNCI were used to develop individualized therapy incorporating cognitive, occupational, and neuromuscular modalities. SIS scores were also used to establish pretreatment benchmarks and measure posttreatment improvement. Patients also self-reported their symptoms during their treatment using the Post-Concussion Symptom Scale (PCSS) to subjectively measure their improvement as well.

**Results**

Changes in their SIS scores were calculated in percent change from pre- to posttreatment. Patients showed a mean improvement of 77.5%, and over 80% of patients showed at least 60% improvement. Longitudinal reassessment of 24 of the patients, measured an average of 7.6 months posttreatment, shows their score improvement is maintained and improved, with an average of 90.6% improvement from their original scan.

**Conclusions**

fNCI provides a reliable measurement of neural dysregulation allowing for identification of concussion pathology. Additionally, fNCI-derived scores direct tailored therapy to help treat deficits in attentional, subcortical, visual processing, language processing, and executive functioning; subsequently resolving chronic PCS resulting from mTBI.

**0003****Addressing the Neuro-inflamasome: Interplay Between Omega Fatty Acids and the Endocannabinoid System in Neuro-protection and Repair**

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Omega-6 and omega-3 long-chain polyunsaturated fatty acids (LCPUFA) are essential components of membrane phospholipids and also precursors to a number of bioactive lipid mediators. Arachidonic acid (ARA) and docosahexaenoic acid (DHA) are essential for optimal brain development and function. Dietary enrichment with DHA and other long-chain n-3 PUFA, such as eicosapentaenoic acid (EPA), has shown beneficial effects on learning and memory, neuroinflammatory processes, and synaptic plasticity and neurogenesis. ARA, DHA, and EPA also are precursors to endocannabinoids. The endocannabinoid system comprises cannabinoid receptors, their endogenous ligands, the endocannabinoids, and their biosynthetic and degradation enzymes. Anandamide (AEA) and 2-arachidonoylglycerol (2-AG) are the most widely studied endocannabinoids and are both derived from phospholipid-bound ARA. The endocannabinoid system also has well-established roles in neuroinflammation, synaptic plasticity, and neurogenesis, suggesting an overlap in their neuroprotective effects. There exists a complex interplay between omega-3s and omega-6s and the endocannabinoid system. DHA and EPA supplementation reduces AEA and 2-AG levels, with reciprocal increases in levels of the analogous endocannabinoid-like DHA and EPA-derived molecules. The landscape of brain health is rapidly evolving. Nutritional therapy with omegas and cannabinoids targeting the inflammasome is essential to maintain or regain brain health after injury. Brain health is complicated. A one-size-fits-all approach is not going to work. While targeted rehabilitation remains the mainstay of concussion care, a return to the basics, providing a neuropermissive environment offers hope for those suffering a decrement in brain health.

**0004****LoveYourBrain Yoga for People With Traumatic Brain Injury and Caregivers: Impact on Quality of Life and Barriers and Facilitators to Access in the United States and Canada**Donnelly K<sup>1,2</sup>, Pierce R<sup>2</sup>, Baker K<sup>2</sup>, St. Ivany A<sup>1</sup>, Barr P<sup>3</sup>, Bruce M<sup>1</sup><sup>1</sup>The Dartmouth Centers for Health and Aging, Lebanon, United States,<sup>2</sup>LoveYourBrain Foundation, Windsor, United States, <sup>3</sup>The Dartmouth Institute for Health Policy and Clinical Practice, Lebanon, United States**Background**

People with traumatic brain injury (TBI) often face significant barriers to community integration, which can lead to poor quality of life (QOL). To address this gap, the LoveYourBrain Foundation developed a 6-week manualized yoga with a psychoeducation program for TBI survivors and caregivers delivered through yoga studios across North America. The program curriculum modifies movement, meditation, breathing exercises, and group discussion topics to address TBI symptoms. This study aimed to assess the LoveYourBrain Yoga program's impact on QOL and identify barriers and facilitators to access.

**Methods**

This mixed-methods, pre-post, retrospective study evaluated data collected by the LoveYourBrain Foundation via online surveys up to 3 weeks before and after participation in

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LoveYourBrain Yoga. Participants were eligible if they had participated in LoveYourBrain Yoga between September 2016 to December 2018, experienced a TBI or were a caregiver, were 15 to 70 years of age, ambulatory, open to participating in group discussion, and able to follow instructions. Directed content analysis explored barriers and facilitators to participation described in open-text responses. Mixed-effects linear regression assessed changes in scores on the Quality of Life After Brain Injury Overall scale from baseline to postprogram for TBI survivors.

## Results

A total of 1905 eligible people with TBI and caregivers signed up for LoveYourBrain Yoga. One hundred fifty-six programs were delivered by 45 yoga studios across 3 Canadian provinces and 18 US states. Eighty-two percent ( $n = 1563$ ) of people participated in at least one class and 18.0% ( $n = 342$ ) canceled or were “no shows.” Participants with TBI ( $n = 705$ ) experienced significant improvements in QOLIBRIOS ( $\beta$  9.70, 95% CI: 8.51, 10.90). Overall, mean satisfaction was 9.3 out of 10 (SD 1.0); content analysis revealed that satisfaction was attributed to the integration of movement, relaxation, group conversation, and meaningful quotes, the perceived safety and “nonjudgmental” tone of the environment, and the inclusion of only the TBI community. Other factors that facilitated participation included being free of cost, providing a routine schedule, sending e-mail reminders to attend, use of certain modifications (ie, head above heart), use of props (ie, chairs, blankets, blocks, wall), the slow, step-by-step, and repeated instruction, and use of landmarks instead of left/right (ie, “leg closest to the windows”). Barriers to participation included class scheduling (ie, work hours, peak traffic, morning), and travel distance (ie, >hour). A few participants with more recent injuries reported select poses caused dizziness, discomfort, and/or cognitive fatigue, and suggested shorter classes with more breaks, minimizing pressure on the head, or incorporating more restorative poses.

## Conclusions

LoveYourBrain Yoga improved participants’ QOL. Its structure and delivery facilitated high satisfaction and participation on a large scale in diverse community settings. Other community-based services may benefit from considering these facilitators and barriers to bolster community integration for TBI survivors and caregivers.

## 0006

### Evaluating Implementation of the Massachusetts Sports Concussion Law: Results From a Survey of Athletic Directors

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## Purpose

In 2010, Massachusetts (MA) enacted legislation with regulations for the identification, treatment, and return-to-activity targeting middle and high school student athletes with mTBI or other brain injury. School nurses (SNs), licensed athletic

trainers (ATs) and athletic directors (ADs) play pivotal roles in responding to students with head injury and managing their recovery. To assess implementation of the law, the Massachusetts Department of Public Health (MDPH) has conducted focus groups and surveys with these stakeholders.

## Methods

Focus groups with ADs were conducted in 2018. Based on the results, a survey instrument was developed with participation from investigators at the Boston Medical Center Injury Prevention Center, brain injury researchers at the Boston University School of Medicine, ADs, and injury prevention experts at the MDPH. In November 2018, with follow-up in April 2019, the link to the electronic survey was sent to all AD members of the MA Interscholastic Athletic Association, the MA ADs’ professional organization.

## Results

Response rate was 75% (260/346). The mean rating on a 0- to 10-point scale on importance of the law for student safety was 9.24 (10 being “very important”); the mean rating on a 0- to 10-point scale of the law’s impact on workload was 1.44 (0 being “not at all”). Most respondents (88%) reported that their school had a concussion management team consisting of ADs, ATs, SNs, and guidance counselors (GCs), and 74% of ADs reported that they were informed “always” (31%) or “often” (43%) when a student athlete experienced an mTBI in a venue other than extracurricular sports. Most respondents (95%) endorsed that “all” or “most” of SNs were “very knowledgeable” about the law and regulations; 42% endorsed that “all” or “most” of teachers were “very knowledgeable” about the law and regulations; 59% endorsed that “all” or “most” of GCs were “very knowledgeable” about the law and regulations; 76% endorsed that “all” or “most” of the students’ physicians were “very knowledgeable” about the law and regulations; 59% endorsed that “all” or “most” of students’ parents were “very knowledgeable” about the law and regulations; 66% endorsed that student athletes with concussion “often” (10%) or “sometimes” (56%) misrepresent their mTBI symptoms to accelerate return-to-play; and, 70% perceived that student athletes with concussion “often” (15%) or “sometimes” (55%) misrepresent their mTBI symptoms to avoid academics. A significant negative correlation ( $r = -0.25$ ,  $P = .015$ ) between school economic disadvantage and availability of school-based neuropsychological testing indicated disparities such that less resourced schools are less apt to perform baseline imPACT testing for their students.

## Conclusions

ADs perceive the sports concussion legislation as very important to student safety and positively assess implementation of the law and associated regulations. More effort is needed to increase understanding of the law among some stakeholders, including teachers, parents, and physicians.

## 0007

### The Hope Network Acuity Scale (HAS): Development, Validation, and Utility of a Neurorehabilitation Acuity Measure

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## Objective

To quantify caregiving needs and protective supervision support required in neurological rehabilitation, the Hope Network Acuity Scale (HAS) was developed. This study provides a preliminary analysis of the psychometric properties of the HAS, an 8-item 2-factor (behavioral and medical) scale designed to measure demand on caregiver effort in postacute brain injury and neurological rehabilitation settings.

## Setting

Residential rehabilitation center for postacute (primarily brain injury) neurorehabilitation.

## Design

The study details measurement tool development and psychometric analysis. Scale items were developed by an interdisciplinary team of experts and screened for comprehension by direct service staff. Current long-term and transitional supervised residents, and newly admitted transitional patients were followed up through discharge using the HAS. Reliability (internal and interrater), validity (content, construct, discriminant, and concurrent), and sensitivity to change were investigated.

## Participants

HAS data collected from a convenience sample of 203 clients receiving postacute transitional or long term residential neurological rehabilitation (average age: 49.7 years; 69% male) were used to assess interrater reliability, internal reliability, and construct validity. A smaller cohort of 105 consecutive transitional residential clients (average age: 46.9 years; 61% male) was followed up from admission through discharge (average length of stay: 76.7 days) to assess concurrent and discriminant validity and sensitivity to change.

## Interventions

Not applicable.

## Main Outcome Measure(s)

Hope Network Acuity Scale (HAS), Mayo-Portland Adaptability Inventory-4 (MPAI-4), and Supervision Rating Scale (SRS).

## Results

Initial results indicate generally acceptable internal reliability (Cronbach  $\alpha$  for medical acuity = 0.84, for behavioral acuity = 0.70) and excellent interrater reliability (ICC = 0.95; 95% CI = 0.93-0.97). Exploratory factor analysis resulted in a 2-factor solution supporting the proposed correlated medical and behavioral factors (explaining 62.97% of variance), providing evidence of construct validity. The HAS correlated highly with other outcome measures at both admission and discharge (MPAI-4:  $r = 0.79-0.82$ ; and SRS:  $r_s = 0.53-0.66$ ). Additionally, the HAS demonstrated sensitivity to change from admission ( $M = 11.29$ ) to discharge ( $M = 7.81$ ;  $t(101) = 7.04$ ,  $P < .001$ ). The HAS discharge Total Acuity scores also discriminate between discharge placements (Kruskal-Wallis H test,  $X_2(2) = 26.42$ ,  $P < .001$ ).

## Conclusions

Preliminary development of the HAS shows it to be a promising measure of demand on caregiver effort in postacute neurological rehabilitation treatment and a practical, relevant

measure of outcome. The HAS displays generally sound psychometric properties and potential clinical utility for staffing, supervision, and placement decisions. The use of the HAS can improve clinical communication, resource allocation, and placement decisions by providing a standardized, quantifiable descriptor of actual required care and direct supervision demands in neurological rehabilitation. Clinical, research, and administrative examples of applicability are to be outlined in the presentation.

## 0008

### Brain Injury: Voices of a Silent Epidemic

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Long-term outcomes from brain injury are difficult to predict and more challenging to fully understand. We see athletes who have been concussed, soldiers coming back from war with brain injuries, even political figures who have sustained brain injuries through assault who have lived to tell their stories. Even though traumatic brain injuries now receive unprecedented attention in popular media, the common perception of recovery still tends to gloss over the longer-term struggles that many face. What can we do to help others really understand what they are going through and to encourage successful reintegration?

The video guides viewers on a journey about the brain injury—its causes and effects on people who are injured and those around them. This video was designed to help laypersons understand the impairments and changes in abilities that occur following brain injury. Viewers are guided through primary functions of the brain by active professionals in the field, supported by personal testimonials from survivors of brain injury regarding daily challenges and successes they face.

Individuals who view this video gain a better understanding and perspective regarding what individuals with brain injury experience by seeing and feeling their brain injuries through their personal experiences. The professional narration assures clear scientific and clinical grounding, something that is often absent from such intimate examinations. The video has also been recognized for its potential to teach a number of professions, such as clinicians, caregivers, attorneys, and policymakers.

Many survivors of brain injury can appear to be completely uninjured in their day-to-day lives, but the fact remains that altered brains often result in persistent hidden challenges that can have adverse and dramatic daily effects. Just as advances in neurology have improved the survival rate of those who sustain a brain injury, increased awareness and understanding of these injuries by laypersons and professionals will help improve recovery and reintegration of brain injury survivors. By exploring the cases presented in this video and tying them back to today's understanding of the brain, this silent epidemic is given a new voice that can speak to people unfamiliar to brain injury.

## 0009

### Emergency Preparedness and Ensuring the Safety of Persons With Brain Injuries

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The most lethal part of an emergency is the lack of preparedness in dealing with it: people are caught off guard, becoming confused, frightened, and disoriented; and these challenges are even more pronounced for those with disabilities—particularly hidden ones such as brain injuries. This has become apparent in recent natural disasters, when thousands of evacuated people simply fall through the cracks. After critical analysis of what goes wrong, and under new legislation mandating precise procedures, we now have more refined means of guiding people through emergency situations, the efficacy of which can be seen in more recent disasters.

For example, the major failings in dealing with Hurricane Katrina were lack of communication, education, and resources for dealing with large-scale chaos. Notably, emergency service providers were simply ill-prepared for handling the volume of shocked people. As the result of responsive education and protocols put in place to solve these problems, we are now seeing fewer casualties in disaster scenarios.

The key indicators of this process improvement are that supplies are being made accessible more quickly, emergency workers are better prepared to guide citizens out efficiently, and increased trust in preparedness protocols and evacuation processes has yielded more collected attitudes through disaster scenarios.

We can be better prepared for future emergencies by distilling the lessons learned over the last decade into these 4 steps of prevention:

- Why don't we prepare?
- Understanding people with disabilities
- Accommodating people with disabilities in an emergency
- Preparing for an emergency

It is possible for us all to have a clearer understanding of why we should prepare before an emergency hits and what to do when that happens. This also dramatically improves aid to persons with disabilities, especially persons with brain injuries. The following questions can help us be better prepared:

- Do you have a “go kit” ready?
- Do you have an emergency plan, or know where to go if you are evacuated?
- Hospitals and shelters: Is your facility fully accessible to people with disabilities in a disaster?
- Service providers: Do you have the means of providing accessible transportation in an emergency?

## 0010

### Cognitive Rehabilitation for Concussion/Mild TBI: Turning on the Lights

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Current research into mild traumatic brain injury (mTBI) is more in the public eye since the National Football League and the Chronic Traumatic Encephalopathy issue became more prominent.

Research into biologically based treatment, biomarkers for outcomes, mechanisms of injury, predictors of outcomes, vestibular treatment with physical therapy, and cognitive behavioral therapy with psychologists for the anxiety and depression secondary to the trauma associated with the mTBI (Mittenburg et al, 2001) are becoming more common. The

prevalence of persistent concussion symptoms or syndrome is also in the forefront and now the research points to 15% to 30% of those with concussion experiencing symptoms past the 3-week mark generally accepted as time of recovery (McCrea et al, 2013). Cognitive rehabilitation focuses on hierarchical treatment of cognitive areas such as attention, memory, problems solving/reasoning, executive functions, and word retrieval that are the basis of independence and instrumental activities of daily living (IADLs), that has been well-established and is evidence-based practice in treatment of neurological disorders (Cicerone et al, 2011). However, though cognitive deficits such as attention, memory, executive function, and word retrieval disorders are reported in this persistent profile, research into cognitive-linguistic assessment and treatment is scarce. And generally, the studies that do exist are case studies or with small samples. This area of research may have significant impact not only on assessment and treatment for this population, but also on delivery of care in schools, hospitals, and clinics.

Research in treatment of mTBI previously focused on “rest” and avoiding all physical and cognitive activity (McCrorry et al, 2008, 2013). More recently, landmark research asserted that too much inactivity created more deficits and problems for some (Silverburg & Iverson, 2013) while a recent random control trial found that prolonged rest not only slowed down recovery but increased the severity of the symptoms (Thomas et al, 2015). The focus has shifted to graded increase in physical and cognitive activity and there is a great need for research into these areas (Hardin, 2015; Schneider et al, 2016). Several studies relating to mTBI in the military have demonstrated improvement in cognitive domains in mTBI with cognitive rehabilitation approaches (Helmick et al, 2010; Cornis-pop et al, 2012), and with college-age students (Kennedy et al, 2017).

This presentation will review all of the current research in cognitive-communication rehabilitation for concussion/mild TBI. Preliminary results from a current and ongoing RCT cognitive rehabilitation study for concussion/mild TBI will be discussed. Current guidelines for assessment and treatment of concussion/mild TBI will be presented and case studies will be reviewed.

## 0011

### Transcranial Doppler Ultrasound Use in Pediatric Penetrative Traumatic Brain Injuries

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#### Purpose

To increase awareness of the usefulness of transcranial Doppler (TCD) ultrasound as a noninvasive neuromonitoring device in pediatric patients who have suffered a penetrative traumatic brain injury (TBI) as a result of a gunshot wound.

#### Introduction

TCD is currently not standard of care for neuromonitoring in pediatric TBI patients. TCD is a noninvasive and portable ultrasound study that can be performed in any care environment. TCD studies in pediatric TBI patients have been useful in identifying abnormalities in cerebral blood flow velocity,

autoregulation, and embolic events, all of which have been associated with poor neurocognitive and functional outcomes. Because gunshot wounds to the brain have been associated with ongoing vascular injury, there is increased risk for cerebral vasospasm and infarction, which can lead to additional neurologic sequelae.

## Methods

We examined the use of daily TCDs in 60 children admitted to a level 1 trauma center. We were particularly interested in describing the use of daily TCD in penetrating TBI. Of the 60 children, 2 children sustained a penetrating TBI as a result of a gunshot. Both children were admitted to the pediatric intensive care unit for TBI treatment. Both children were male, ages 4 and 14 years, one experienced an accidental gunshot wound whereas the other experienced a self-inflicted gunshot wound. Insonation was performed by a certified TCD sonographer at the patient's bedside. The bilateral middle cerebral arteries and basilar arteries were insonated using a standard TCD approach to detect abnormal blood flow velocities and embolic signals as "high-intensity transient signals" (HITS). The insonation of these vessels and approach is well documented in the adult and pediatric TBI literature.

## Results/Discussion

While these 2 patients vary in age, injury location, and in their clinical course, both patients' TCD results captured unique findings that were not appreciated by clinical observation or basic bedside neuromonitoring. In one patient, HITS were appreciated on TCD as early as day 1 of hospitalization. The other patient experienced an ischemic event that later converted into a cerebral hemorrhage. While TCD is not standard of care in pediatric TBI, these findings illustrate the usefulness of including TCD at the bedside for neurovascular surveillance after TBI. TCD is a portable, noninvasive, nonradiation diagnostic tool unlike a CT or MRI; therefore, it allows for safe and quick neurodiagnostics at the bedside. This case report provides early evidence for the use of TCD as a neuromonitor for ongoing vascular injury in pediatric penetrating TBI. Studies using TCD in pediatric TBI continue to report TCD's utility in adding valuable information to help providers consider strategies when managing children with TBI.

## 0012

### Who Hijacked My Brain? A Case Series of Atypical Symptoms and Functional Impairments in TBI

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## Introduction

Pathologies in traumatic brain injury can present with puzzling sequelae for affected individuals. While effects and deficits across domains are commonly reported, the topic of atypical symptomatology, concomitant with unique functional impairments and their respective, specialized treatment demands, appears underdiscussed in the scientific literature.

Patients seeking comprehensive outpatient treatment for TBI report a myriad of confusing, even bizarre, neuropatho-

physiological outcomes. Although challenging to precisely etiologically discern, these curious profiles represent indications of the site and extent of TBI-related, neural inflammatory processes resulting from injury-inflicted anatomical mechanics. Multiple domains, including pathophysiological, emotional, and activities of daily living feature, complicate functional disturbances attributable to neuropathological adversities. The perplexing nature of these atypical symptoms can amplify TBI-induced comorbid trauma, steering individualized treatment targets, arguing the rationale for a collaborative, multifaceted treatment approach.

## Case Series

Ten self-reports were gathered from adult, either attorney or self-referred, outpatients involved in personal injury cases. Unusual neuropathophysiological impairments resulted from motor vehicle accidents (MVAs) and motorcycle accidents (MCAs), with varying collision dynamics; a slip-and-fall; trip-and-fall, blast, and a postmorbid seizure in TBI. Peculiar pathophysiological symptom cases included (1) MVA-induced, persistent, posttraumatic fibromyalgia, fecal impaction, dyspareunia, and hyperhidrosis; (2) fall-induced interstitial cystitis and hematuria; (3) apraxia of eyelid opening following prolonged inversion in an MVA; (4) teeth cracking and edentulism following a rear-end/rollover MVA; (5) coital cephalalgia with syncope following chemical blast exposure. Functional atypicalities included (6) compulsive online shopping and gambling following subarachnoid hemorrhage from a slip-and-fall on ice; (7) hyperverbiosity and daily apparel shopping to avoid decision-making following a trip-and-fall incident; (8) unprovoked, violent assault during a latent seizure following an MCA-induced subdural hematoma; (9) laryngopharyngeal reflux-induced chronic throat clearing and vocal tics following a wind-wrecked parachute jump and harsh landing; and (10) excoriation, self-mutilation, and gender identity confusion following an MVA with near-miss decapitation.

## Management/Outcomes

Patient-centered multimodal treatments included skill-based, didactic cognitive behavioral therapy, eye movement desensitization and reprocessing, and psychoeducation. Timely referrals to specialists ruled out somatic exaggeration and confirmed TBI injury-related presentations. Adjunct medical and neuropsychological assessments clarified TBI-linked symptomatology, addressed permanence versus transience, and influenced intervention(s). Patients demonstrated measurable benefit from individualized coping strategies, aimed at symptom management and reasonable functional restoration.

## Conclusions

Protocols in TBI symptom management should involve comprehensive assessment of multisymptom constellations, tailored treatments, and ancillary, multidisciplinary consults aimed at distilling enigmatic symptoms. Complexities in overlapping TBI-induced symptoms are essential to distinguish to fully appreciate biopsychosocial impact of injuries. The undeniably ambiguous effects of acquired brain injury may be clinically misunderstood and litigiously underestimated, especially where atypical manifestations exhibit. Providers are urged to redouble efforts in analyzing TBI-related anomalies to be better informed regarding symptomatic dilemmas and, moreover, to improve patient outcomes.

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## Reference

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## 0013

### Perinatal Neurotrauma: A Fresh Etiological Perspective in Pediatric Brain Injury Research

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Pediatric brain injury, well-recognized in child neurodevelopment, could involve perinatal atmospheric incompatibilities. Epidemiological studies associate early environmental exposures with neuropsychiatric outcomes, yet the etiological conceptualization of perinatal neurotrauma has been understudied. Plausibly, fetal diffuse axonal injury could result from a constellation of interacting complexities involving exposure mechanisms and elevated maternal body mass index (BMI), conferring a disruptive cascade of neural events, which risk future functional and behavioral childhood impairments.

Diagnoses of attention-deficit hyperactivity disorder and autism (ASD) demonstrate rising prevalence and a childbirth complication link. Concomitant symptoms persist into adulthood, including emotional dysregulation, social/academic deficits, and neurocognitive dysfunction. Precise etiology is unclear, yet complex genetics, epigenetics, environmental factors, and pregnancy complications appear involved; genetics alone are inefficient to account for these outcomes. Logically, environmental influences introduced during highly sensitive developmental periods may adversely impact the less resilient, still-developing fetal brain with risky downstream effects, influencing neurodevelopment.

One specific prenatal exposure, synthetic oxytocin (sOT), a neuropeptide-based uterine stimulant, is fundamentally relied upon to induce/augment labor in more than 50% of all US childbirths. Established repercussions include fetal distress, low Apgar scores, uterine hyperactivity, fetal heart rate abnormalities, NICU admissions, and ischemia/asphyxia/hypoxia. Putative neuropathophysiological models include poor fetal tolerance to dose-dependent thresholds; prolonged labor impact; epigenetic triggering, especially in familial neuropsychiatric predisposition; neurological kindling effects, hyperstimulating and/or oversaturating oxytocin receptors; excitotoxicity; neuroinflammatory reactions; hypertonic uterine contraction pressure contributing neuropathogenic alterations; disharmonious epidural anesthesia, GABA downregulation; blood-brain barrier/placental permeability compromising fetal neuroprotection; and pharmacokinetics of sOT synthesis, involving reagent properties potentially threatening to placental integrity.

While neuropathogenic alterations linked to perinatal sOT lack confirmation, research directly associates this exposure to neuropsychiatric phenotypic presentations with mixed evidence. Exponential increases in sOT intervention, including elective inductions, and dosage inconsistencies, amplify concerns regarding potential consequences to child neurodevelopmental trajectory. Labor duration and sOT exposure duration are important algorithms to disentangle, since sOT use is a modifiable exposure.

Interestingly, maternal BMI/adiposity increases odds for newborn large for gestational age/macrosomia and sOT child-

birth induction/augmentation due to diminished uterine contractility in overweight/obese mothers. The shared impact of maternal BMI and perinatal sOT exposure and its 2-fold effect on offspring brain development is uninvestigated. A temporal relationship could exist between sOT-assisted childbirths, especially in elevated BMI mothers, and disrupted pediatric neurodevelopment.

Common sense biology informs us that the vulnerable fetal brain, if perinatally burdened by multiple overlapping factors, could shape its neurodevelopmental trajectory, collectively fostering pediatric neuropathophysiological sequelae. Lacking evidence elucidates this important child public health issue.

Practically speaking, clinicians should mindfully consider this proposed etiology of pediatric brain injury, especially during developmental intakes, where child neurodevelopmental/neurocognitive symptomatology exhibits.

## Reference

Kurth L. The emerging role of perinatal neurotrauma: A new frontier in pediatric brain injury. Accepted Abstracts from IBIA's 13th World Congress on Brain Injury. *Brain Inj.* 2019;33(suppl 1):0259.

## 0014

### Variability in Day-to-Day Pulsatility Index May Provide Early Signs of Cerebral Vascular Disturbance in Children With Traumatic Brain Injury

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In the United States, over 475 000 children sustain a traumatic brain injury (TBI) and of those over 7400 die annually. Children who survive a TBI experience higher rates of developmental delay, mental health disorders, physical disabilities, and neurologic impairment when compared to the general pediatric population. Therefore, a rapid noninvasive neuromonitoring option to monitor ongoing brain injury and cerebral vascular responses to that injury is necessary. Transcranial Doppler ultrasonography (TCD) is a noninvasive, portable, safe, and inexpensive imaging modality that allows clinicians to measure cerebral circulation and cerebral perfusion. By examining the right and left middle cerebral arteries (MCA) and deriving a measured pulsatility index (PI), we can better assess for cerebral blood flow disturbances. To our knowledge, there is no prospective research describing the day-to-day variability of PI in children with TBI. Day-to-day variability is a concept that describes the change in the maximum PI measurement from 1 day to the subsequent day. Our study examined 40 children with mild, moderate, or severe TBI who were admitted to a tertiary level I trauma center children's hospital and who had daily TCDs performed. We evaluated sequential TCD PI measurements of day-to-day variability. We identified several consistencies among the TBI severity groups. Moderate and severe injury ( $n = 15$ ) was associated with a higher average day-to-day variability (40% vs 21%) when compared to mild injury ( $n = 24$ ). Right-sided injury was associated with a higher average day-to-day variability of the left MCA (26%) versus the right MCA (18%). Additionally, the day-to-day variability of the PI was correlated with a change in the Glasgow Outcome

Scale-Extended Pediatrics (GOS-E Peds) scores overtime. In mild injury, the greatest day-to-day variability was seen in children whose GOS-E Peds score worsened between discharge and a 1-month follow-up (25%) compared to children who had no change in GOS-E Peds score (23%) and those who had an improved GOS-E Peds score (19%). In moderate and severe injury, the greatest day-to-day variability was seen in children whose GOS-E Peds score did not change between discharge and a 1-month follow-up (42%) when compared to children who had an improved GOS-E Peds score (37%). This study is the first to report day-to-day PI variability in children with TBI and findings in GOS-E Peds scores over 2-time points. Although this is a single-center small convenient sample, the preliminary data suggest that day-to-day PI variability may provide additional neuromonitoring at the bedside of pediatric patients with TBI. Although further research is needed, TCD PI variability may provide early insights as to ongoing cerebral blood flow disturbances after TBI and add information to aid in medical decision-making to promote improved outcomes.

## 0015

### Patients With Chronic Mild or Moderate Traumatic Brain Injury Have Abnormal Longitudinal Brain Enlargement

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#### Introduction

There have been many studies of longitudinal brain volume change in patients with traumatic brain injury (TBI), although relatively few of these involved patients with mild TBI. Even fewer examined more than a handful of brain regions. The purpose of this study was to comprehensively study MRI brain volume changes in patients with chronic mild or moderate TBI.

#### Methods

Thirty-four patients underwent MRI brain scanning. NeuroQuant was used to measure brain volume, and NeuroGage was used to measure volume change over time. The patients' brain volume changes were compared to those of the NeuroQuant normal control database, which contains thousands of age- and sex-matched normal controls.

#### Results

The patients had abnormal longitudinal enlargement of many parenchymal brain regions, including whole brain, cortical gray matter, subcortical nuclei + infratentorial regions (SCN+IFT), nucleus accumbens, and several cortical gray matter subregions (medial parietal region, middle temporal gyrus, and fusiform gyrus). Similarly, the patients had abnormal longitudinal diminution of the superior and inferior lateral ventricles.

## Discussion

In contrast to most previous studies, the current study found extensive longitudinal parenchymal enlargement, although some other studies also have reported volume enlargement in patients with mild (but not severe) TBI. These findings extended our recent findings, which were based on cross-sectional data, and which also found extensive abnormal enlargement. Taken together, our findings suggest that the volume enlargement is due to compensatory hypertrophy of gray matter regions (in response to initial white matter injury), and this hypertrophy can persist for months to years after injury.

## 0016

### Eating the Rainbow: Micronutrients and Cognitive Change in the General Population and TBI

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#### Introduction

The impact of poor nutrition on physiological health in the general population is well understood; however, less is known about the effects of diet on brain function and cognition and there is little understanding of the role specific micronutrients may play when neurological function is compromised. Essential micronutrients (vitamins, minerals, and omega-3 fatty acids) are required by the brain for normal function and for repair; following TBI certain micronutrients are depleted through increased utilization and through renal clearance, in addition to hypermetabolism of up to 200% of normal. Within hospital individuals' diets are tailored to meet additional requirements following a TBI; however on discharge no dietary advice is given, despite evidence of poor dietary choices following injury as a direct consequence of cognitive deficits.

#### Methods

Sixty healthy adults were recruited from the general population, age range 21 to 59 years, with participants randomly allocated to conditions (multivitamin, vitamin D, or vitamin C) in a double-blind protocol. Participants also completed a 14-day food diary to gather information on micronutrient intake. The cognitive test battery included measures of IQ, memory, executive function, and implicit and explicit learning. For the TBI study (ongoing) individuals with mild-moderate deficits 3 to 24 months postinjury were recruited into a double-blind cross-over study (multivitamin/omega-3) with the parallel placebo group. Food diary data were collected, and a similar cognitive test battery administered.

#### Results

Findings in the normative group showed deficiency in dietary intake of a number of micronutrients, specifically minerals, fat-soluble vitamins, and some B-vitamins. Significant improvements were found across groups on a number of measures (visual and verbal memory, processing speed). The multivitamin group additionally showed significant improvements on visual strategy generation (along with the vitamin C group),

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working memory, motor planning, and implicit and explicit learning. Preliminary new clinical data from the TBI group will also be presented.

## Conclusions

When taken together evidence suggests that suboptimal micronutrient intake may have a negative effect on cognition across the lifespan, rather than during specific life stages (eg, development or older age). These findings provide a proof of concept that individuals are not reaching recommended dietary allowance amounts from diet alone, and in those who have graver requirement for optimal micronutrient intake like individuals following a TBI there is the potential that supplementation could support reparative mechanisms and improve cognitive outcome.

## 0017

### Finding the Mind in the Eye: Retinal Imaging as a Biomarker for Concussion

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## Introduction

The retinal nerve fiber layer (RNFL) can be noninvasively visualized using retinal imaging techniques, giving access to central nervous system changes through the eye, an extension of brain tissue formed in utero. Research in multiple sclerosis, Alzheimer's, disease and Parkinson's disease has shown that the RNFL is sensitive to pathological brain change. In addition, our first in human study showed greater retinal arteriolar and venular tortuosity in people with postconcussive symptoms following mild to moderate TBI when compared to matched controls. The subtle histological, biochemical, and neuronal changes that follow mild to moderate TBI cannot be captured using traditional neuroimaging techniques, making it impossible to monitor progressive brain changes. This is particularly important in contact sports where repetitive concussive and subconcussive events can lead to devastating cognitive changes. Retinal imaging offers a possible solution for long-term monitoring of brain health in those at risk of head trauma.

## Methods

Anonymized secondary retinal imaging data of both eyes from 16 Olympic boxers (12 male), from mandatory screening, were collected 18 months apart using optical coherence tomography (OCT), providing longitudinal data of retinal change over time. Sedentary healthy controls ( $n = 20$ , 8 male) with no history of TBI were screened using comparable OCT systems at the time of the second boxer eye screening to provide comparison of cross-sectional data. Images were acquired for mapping of retinal layers and the macula in 8 sectors of each eye.

## Results

Significant macula changes were observed in the boxers over the 18-month period in 75% of right and 50% of left eye sectors. For RNFL, left eye inferior quadrant was significantly thickened and temporal quadrant significantly thinner. For right eye, RNFL superior and inferior quadrants were significantly thicker with the nasal quadrants significantly thinner. Cross-sectional results showed thinner macula sectors and RNFL quadrants in Olympic boxers compared to controls.

## Conclusions

Significant change to macula and RNFL densities, occurring over an 18-month interval, is an unexpected finding in otherwise healthy elite sportspeople. In addition, macula and RNFL were thinner than healthy sedentary controls. These changes are suggestive of biomechanical forces occurring following side-to-side head jarring occurring during boxing bouts or sparring. OCT may prove clinically useful as a candidate retinal biomarker of neuropathological change after mTBI and/or repeated head blows.

## 0018

### Chiari Malformation in the Concussion Clinic: Diagnosis and Management of Confounding and Overlapping Symptoms—a Case Report

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## Case Description

A 20-year-old woman presented to our outpatient clinic with 2.5 years of postconcussive symptoms after a head injury in a cheerleading accident. Primary symptoms included a frontal headache, occipital headache, photo- and phonophobia, vestibular symptoms, anxiety, and visual disturbance. Neurologic examination was unremarkable with the exception of a small palpable cranial defect and vestibular and ocular dysfunction in the form of dizziness and nausea during vestibular/ocular-motor screening. She was given behavioral strategies for postconcussive symptoms and was referred to vestibular therapy, exertion therapy, and neuro-optometry. She was started on propranolol for headache prophylaxis and rizatriptan for migraine abortion. MRI brain demonstrated Chiari malformation type I (CMI). While most of her symptoms improved with therapies and pharmacologic management targeting concussion, a posterior occipital headache persisted and was attributed to the previously undiagnosed CMI. She was referred to neurosurgery.

## Conclusion

Providers for concussion must be aware of CMI as a potential etiology of persistent headache and symptoms unresponsive to therapies and medications.

## Financial Disclosures

None.

**0019****Feasibility of Early Attended Polysomnographic Sleep Assessment After TBI and Comparison of Completers Versus Non-completers**

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**Background**

Sleep apnea (SA) occurs among 2% to 4% of the adult population in community-based studies (American Academy of Sleep Medicine). It is thought to occur in one-third of TBI survivors (Webster, Bell, Hussey, Natale, Lakshminarayan, 2001; Holcomb, Schwartz, McCarthy, Thomas, Barnett, Nakase-Richardson, 2016). The current study found that 67% of TBI survivors had SA. SA has been linked to increased risk of cardiac diseases and stroke; cognitive impairments; decline in emotional well-being; and greater healthcare utilization due to poor physical health. Untreated, SA could slow functional recovery and prolong rehabilitation efforts. Yet, sleep disorders are not typically assessed during the acute medical rehabilitation course.

**Participants**

Consecutive admissions of TBI survivors to 1 VA and 5 civilian inpatient medical rehabilitation services in the United States between May 2017 and February 2019, screened for eligibility and able to sleep 2 or more contiguous hours (Final  $n = 248$ ).

**Design**

Sample comparisons using nonparametric statistics.

**Procedure**

Completion of bedside polysomnography.

**Results**

In this sample, of the 896 individuals with TBI screened for eligibility, 452 were eligible and 348 consented (78% consented). Additional screening found 14 patients to be ineligible for polysomnography due to medical instability, and another 48 patients did not receive polysomnography due to a change in discharge date or unavailability of sleep technologists. In total, 248 individuals with TBI underwent polysomnography, after excluding those with technical malfunctions ( $n = 3$ ) and those unable to sleep 2 contiguous hours during the night of the sleep study ( $n = 12$ ; American Academy of Sleep

Medicine criterion). Statistical comparison of patients completing polysomnography ( $n = 248$ ) compared with non-completers ( $n = 12$ ) was not meaningful due to small sample sizes in the excluded group; however, trends indicated non-completers had greater levels of agitation as measured by the Agitated Behavior Scale (ABS;  $Z = 4.08$ ,  $P < .0001$ ; median ABS score of 22 for non-completers vs 14 for completers), were older at the time of polysomnography ( $Z = 1.87$ ,  $P = .03$ ; median age 56 vs 40), and were more likely to be male (92% vs 82%). More completers tended to have emerged from posttraumatic amnesia (PTA) by the time of polysomnography compared with non-completers (85% vs 67%, respectively). Injury severity at emergency department admission, as measured by the Glasgow Coma Scale, and time from injury to polysomnography were similar in the 2 groups.

**Conclusion**

Current findings indicate that polysomnography can be completed with a majority of individuals during inpatient rehabilitation for moderate to severe TBI (94%). Information regarding feasibility of conducting bedside polysomnography is important, given that 67% of TBI survivors were diagnosed with SA via level 1 polysomnography in the current study. Understanding variables associated with barriers to completion of polysomnography is necessary to facilitate medicoeconomic advocacy efforts in favor of early SA diagnosis and treatment as standard of care for TBI survivors.

**0020****Predictors for 30-Day Re-admissions After Traumatic Brain Injury (TBI)**

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**Objective**

To examine predictors for 30-day readmission postonset of traumatic brain injury (TBI) after initial trauma hospitalization.

**Design**

Retrospective cohort.

**Participants**

The sample included 4148 patients admitted to an acute trauma facility with a diagnosis of TBI from January 1, 2003, through June 30, 2014.

**Methods**

Demographic and clinical data after initial onset of TBI were extracted from the local trauma registry. Subjects' data were matched with the Dallas-Fort Worth Hospital Council registry, which tracks admissions data for regional hospital systems. Multiple logistic regression was used to determine which factors were significantly associated with 30-day readmission. Top diagnosis codes for 30-day readmission were also described.

## Results

Subjects were primarily male (64.9%) with private insurance (33.0%) aged  $50.0 \pm 21.9$  years. A total of 324 patients (7.8%) of 4148 had a 30-day readmission, and there were a total 372 30-day readmissions among these patients. Median cumulative charge for each of the 324 patients that were readmitted was \$32 989 (interquartile range: \$17.683, \$62 407). Factors significantly associated with 30-day readmission were longer length of stay ( $P = .0007$ ), fall as cause of injury ( $P = .0396$ ), and discharge to a long-term acute facility or skilled nursing facility ( $P < .0001$ ). Top counts for diagnosis codes among the 377 readmission visits included cardiac codes (58.3%), dehydration (53.2%), and hypertension (50.0%).

## Conclusion

This data highlights those at risk for 30-day readmission across a diverse population of TBI at a large medical center. Interventions such as health literate education or patient navigation may help mitigate 30-day readmission for at-risk patients.

## 0021

### Rod-Cone Dysfunction in Blunt Traumatic Brain Injury

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## Case Description

A 41-year-old man presented to hospital after motor vehicle collision at 30 to 40 miles/hour where he was stationary and restrained. Loss of consciousness was undetermined. Post-traumatic amnesia lasted less than 24 hours. Initial Glasgow Coma Scale score was 14, and head CT was negative. The patient reported occipital and posterior cervical pain, blurred and double vision, photosensitivity, mood instability, and cognitive symptoms. The patient had no history of traumatic brain injury (TBI) or family history of ocular disease.

Developmental optometry diagnosed moderate convergence insufficiency with tendency for OS suppression and retinal pigmentary changes. The patient was prescribed glasses with prism and tint and referred to occupational therapy for vision rehabilitation and to ophthalmology. Over the course of 3 months, the patient developed reduced peripheral vision and night blindness (nyctalopia). MRI of the orbits with and without contrast was unremarkable. Electroretinogram performed by a retina specialist after a neuro-ophthalmology evaluation demonstrated severe rod-cone dysfunction. His peripheral vision showed mild improvement with syntonin phototherapy. He also utilized medical transportation due to limited tolerance to driving.

## Discussion

Up to 90% of patients report visual disturbance after TBI. This patient's initial visual complaint of blurred and double vision, photosensitivity, and visual fatigue is consistent with visual disturbance commonly observed in TBI. However, nyctalopia, severely constricted visual field, and pigmentary changes are atypical and prompted ophthalmology assessment. Low amplitudes on electroretinogram suggest severe loss of rod/cone function. The etiology of nearly all documented

rod-cone dysfunction is related to genetics or autoimmune disease. This case demonstrates electrodiagnostic evidence of this diagnosis after blunt traumatic brain injury. Retinal trauma with photoreceptor degeneration is only reported in blast TBI animal models. In this case, trauma may be a possible cause leading to or exacerbating his rod-cone dysfunction. Blunt trauma resulting from motor vehicle collision may have caused eye injury with neuronal inflammation, leading to photoreceptors loss. Through a multidisciplinary approach with physical medicine and rehabilitation, developmental optometry, ophthalmology, neuro-ophthalmology, and retinal specialist, the patient is diagnosed with rod-cone dysfunction with mild improvement through neuro-optometric rehabilitation. He also required additional transportation resource for his impaired activity daily living due to this condition.

## Conclusion

Rod-cone dysfunction in TBI is a very rare occurrence. We describe one such case in a patient with no significant history or family history of ocular disease following a blunt TBI. Rod-cone dysfunction may be considered as one of rare etiology to cause visual dysfunction after TBI, which may impair activities of daily living. Augmented-vision devices that superimpose minified images over natural vision are the treatment option for severely constricted visual fields.

## 0022

### Decreased Linguistic Function and Self-reported Symptomatology After Sport-Related Concussion

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## Background

Changes in cognition can occur after mTBI, though little attention has been paid to potential changes in communication functionality. Anecdotally, individuals report vocational, academic, and social deficits after mTBI, but causalities remain unclear. Woodcock-Johnson (WJ) tests are used to assess cognitive-linguistic and academic function, yet, despite published literature in mTBI, they have not been explored pre-post sport-related concussion (SRC). Self-reported symptom measures such as the Acute Concussion Evaluation (ACE) are gold standards in mTBI assessment, but lack content on linguistic functioning and/or communication status.

## Hypothesis

WJ testing would be sensitive to change postinjury in collegiate athletes sustaining sport-related concussion, but the association between cognitive-linguistic performance and self-reported symptoms would be limited.

## Methods

In this prospective cohort study, 467 nationally competitive club-sport athletes were given preinjury assessments using targeted subtests from the WJIII Tests of Cognition and Achievement. Participants included male and female athletes, aged 17

to 25 years, playing rugby, lacrosse, ice hockey, soccer, freestyle skiing, and taekwondo. Baseline battery included WJ subtests of word finding, speeded reading comprehension, verbal story retell, verbal working memory, and visual matching. Assessments were completed by trained, supervised speech-language pathology graduate students over 3 years and followed longitudinally. After sustaining medically diagnosed SRC, 74 participants met criteria for postinjury testing and were given repeat WJ measures and the ACE. Days postinjury were not significant ( $\bar{x} = 6.3$  days, 5.9 SD). All medical clearance was physician-directed. For analysis, participants' ACE symptom scores were dichotomized for the cognitive domain and total symptom score. Multivariable linear regression was used to analyze pre-post injury change on WJIII. Kappa analysis was used to gauge the association between cognitive-linguistic status and symptom self-report.

## Results

After adjusting for age, sex, race/ethnicity, baseline performance, and clearance status, performance on all WJ cognitive and linguistic subtests decreased pre-post injury: Visual Matching ( $r^2 = 0.38$ ,  $F(6,63) = 6.48$ ,  $p = 2.32e-05$ ), Decision Speed ( $r^2 = 0.40$ ,  $F(6,62) = 6.76$ ,  $p = 1.53e-05$ ), Numbers Reversed ( $r^2 = 0.25$ ,  $F(6,61) = 3.34$ ,  $P = .007$ ), Retrieval Fluency ( $r^2 = .44$ ,  $F(6,63) = 8.20$ ,  $p = 1.43e-06$ ), Sentence Fluency ( $r^2 = 0.50$ ,  $F(6,18) = 2.69$ ,  $P = .034$ ), and Story Recall ( $r^2 = 0.34$ ,  $F(6,35) = 2.97$ ,  $P = .019$ ). For linguistically-loaded measures (word finding, reading comprehension, story recall, and verbal working memory), lack of medical clearance and elevated baseline performance were predictive of poorer performance post-SRC (all  $P$  values  $\leq .016$ ). Kappa statistic comparing decreased WJ performance and self-reported cognitive dysfunction was poor-fair ( $\kappa = 0.28$ , 95% CI = 0.02-0.53). The kappa for the ACE total symptom score and decreased WJIII subtest performance was moderate ( $\kappa = 0.50$ , 95% CI = 0.29-0.72).

## Discussion

This is the first study to document changes in cognitive-linguistic functioning pre-post SRC using WJ. It is highly clinically relevant to master's-level clinicians who struggle with appropriate mTBI assessment measures. The limited relationship between WJ testing and the ACE reinforces the lack of representation of cognitive-communication symptoms on gold standard symptom scales. Future clinical research must address the gap on symptom self-report and cognitive-communication dysfunction.

### 0023

#### Eight Years Later: Long-Term Outcomes From Mild Traumatic Brain Injury in Adults

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Traumatic brain injury (TBI) is a leading cause of long-term disability in adults. The majority of injuries are classed as mild but can still result in adverse outcomes. Despite the high rates of mild TBI, the long-term consequences of these injuries are not well understood. This study sought to address this by

examining the long-term outcomes (8 years postinjury) of a cohort of adults with TBI, originally identified as part of the Brain Injury Outcomes New Zealand in the Community study (BIONIC) in 2010-2011 ( $n = 151$ ; mean age = 45.4 years; 51% male). An age- and gender-matched cohort free from TBI in their lifetime were recruited for comparison purposes ( $n = 211$ ; mean age = 45.0 years; 49% male). Participants completed a series of questionnaires (online or in-person) about their current health, mood, perceived cognitive functioning, postconcussion symptoms, and employment.

At 8 years postinjury, adults with mild TBI reported significantly more postconcussive symptoms, particularly in the cognitive and emotional domains ( $P$ s  $< .01$ ) and had poorer planning abilities ( $P = .03$ ) than the comparison group. There were no significant group differences for anxiety, depression, posttraumatic stress, overall self-reported cognitive functioning, or somatic symptoms ( $P > .05$ ). Nearly one-third (30.5%) of the TBI group rated 4 or more postconcussive symptoms as at least a "moderate" problem as compared with only 14.6% of the control group.

From 1 to 12 months postinjury, we observed significant decreases in depression ( $P = .02$ ), anxiety ( $P = .007$ ), and postconcussive symptoms ( $P < .001$ ). However, between 12 months and 8 years, depression scores showed a significant increase ( $P < .001$ ). There were no significant changes in anxiety ( $P = .97$ ) or postconcussive symptoms ( $P = .09$ ) from 12 months to 8 years. Regression analyses revealed that older age at injury, female gender, higher levels of anxiety and depression at 1 month postinjury, and a greater number of lifetime TBIs predicted 31% of the variance in postconcussive symptom scores at 8 years postinjury.

These findings suggest that a mild TBI may result in poorer long-term outcomes particularly for cognitive (forgetfulness/poor memory; poor concentration; taking longer to think) and emotional (irritable, easily angered; feeling depressed or tearful; feeling frustrated or impatient; restlessness) symptoms. Older age at injury, female gender, poorer mental health, and higher number of TBIs are linked to poorer outcomes. Overall the findings suggest that provision of mental health support and education/intervention to reduce the number of recurrent TBI may improve long-term outcomes following mild TBI.

### 0024

#### Diagnostic Utility of Electromyography to Assess Consciousness in Patients With Disorders of Consciousness

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## Background

There is a growing interest in diagnostic tools for the assessment of consciousness in patients with a disorder of consciousness (DoC). Currently, the gold standard for assessment of consciousness is the Coma Recovery Scale-Revised (CRS-R), a behavioral assessment that often relies on examiner experience and observed behaviors. Recent studies and literature reviews have focused on the use of fMRI and EEG to assess consciousness and identify patients who are covertly conscious. Among the available diagnostic tools to assess consciousness, electromyography is underreported in current

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literature reviews. Given the significant ethical and rehabilitation implications of an accurate diagnosis of consciousness in patients with DoC, there is a necessity to review the effectiveness and potential clinical use of electromyography in the assessment of consciousness in patients with DoC.

## Methods

A comprehensive review of the literature was performed. Multiple databases including PubMed, MEDLINE, Embase, Cochrane, and CINAHL were searched with no timeframe restrictions. Search terms included “electromyography” and “disorders of consciousness” in all fields. Inclusion criteria included human subject patients with a diagnosis on the DoC spectrum, comparison of EMG to CRS-R (gold standard), and electromyography response as an outcome measure. Exclusion criteria included nonhuman studies, editorial commentaries, and literature reviews. The Quality Assessment of Diagnostic Accuracy Studies-2 (QUADAS-2) was used to assess the quality of the reviewed literature.

## Results

A total of 183 studies were identified from the initial literature search, 72 of which studied human subject DoC patients. Nineteen articles remained after duplicates removed and 6 articles used EMG response as an outcome measure. Five articles compared EMG to CRS-S. One article was excluded as it was an editorial commentary. A total of 4 studies examining the use of electromyography as a diagnostic tool to assess consciousness were included in this review.

## Conclusions

There is great variability in the methods of assessing EMG response in the reviewed studies. While 3 out of 4 studies examined EMG response to a command, 1 study examined facial electromyography to assess emotional response to humor. All 4 of these studies identified patients who were behaviorally nonresponsive on CRS-R but demonstrated a significant clinical EMG response to either command or to a joke. All 4 studies demonstrated a high risk of bias on the QUADAS-2. Given that electromyography can potentially identify subclinical behaviors, there are significant diagnostic implications for the use of electromyography in the assessment of consciousness, but further studies with designs that limit the risk of bias are needed. While there are limitations to using EMG as an assessment tool, it can potentially be utilized by the interdisciplinary team concurrently with standard rehabilitation treatments and assessments such as the CRS-R to enhance the diagnostic accuracy of patients on the DoC spectrum.

## 0026

### Rehabilitation Outcome of Patients Suffering From Posterior Reversible Encephalopathy Syndrome (PRES)

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## Objective

To describe the rehabilitation outcomes of 4 patients suffering from posterior reversible encephalopathy syndrome (PRES).

## Background

PRES is an increasingly recognized clinico-radiologic syndrome caused by dysfunction of the brain capillary endothelium resulting in vasogenic edema mainly in the occipital lobes. The etiologies of PRES include acute hypertension, eclampsia, immunosuppressive therapy, and renal disease or following surgical procedures. The main symptoms are related to the visual system including hemianopsia, visual neglect, or cortical blindness. The rehabilitation outcome of patients with PRES has not been described previously.

## Methods

Four patients with PRES were treated in our department in the last years. PRES was diagnosed according to clinical and radiological findings in MRI. Rehabilitation and cognitive outcomes were evaluated using the motor and cognitive FIM. An fMRI using specific paradigms for activating the visual cortex was done in 3 patients.

## Results

There were 1 male and 3 females, 71, 65, 60, and 40 years old, respectively. Three patients developed PRES after surgical procedures and 1 following streptococcal pneumonia. CT scan demonstrated symmetric occipital lesions and MRI revealed symmetric, hyperintense lesions on T2-weighted images, involving posterior white matter regions of the brain characteristic of PRES. All patients showed significant functional and cognitive improvement, as noted by the improvement in FIM as well as other cognitive tests; however, little improvement was found in visual functions.

## Conclusions

Although patients with PRES syndrome improved significantly in most of cognitive and ADL functions, they are left with severe visual field disturbances affecting their independence. It is important to recognize the symptoms of PRES early to prevent unnecessary interventions and to initiate specific rehabilitation treatments.

## 0027

### Stretch-Induced Deformation as a Model to Study Dopaminergic Dysfunction in Traumatic Brain Injury

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Traumatic brain injury (TBI) is defined as damage to the brain that consequently disrupts normal function. Neuronal death, a hallmark of TBI, has also been related to the development of neurodegenerative disorders like Parkinson's disease (PD), where loss of dopaminergic neurons and dopaminergic dysfunction are observed. To date, no in vitro model exists in which the dopaminergic damage observed in TBI is replicated.

In the present study, we evaluated the effects of in vitro simulated TBI on human dopaminergic neurons. To simulate TBI, neurons were subjected to 0%, 5%, 10%, 15%, 25%, and 50% deformation. Twenty-four hours after injury, cell viability and apoptosis were determined by lactate dehydrogenase (LDH) release and DNA fragmentation, as well as ethidium homodimer and caspase 3/7 staining. Dopamine (DA) levels were determined by ELISA. Only 50% stretch increased LDH release and ethidium homodimer staining, suggesting the induction of necrosis. On the contrary, 25% and 50% stretch increased DNA fragmentation while 15%, 25%, and 50% increased caspase 3/7 staining, suggesting that moderate and severe TBIs promote neuronal apoptosis. Finally, levels of intracellular DA decreased in a stretch-dependent manner with 15%, 25% and 50% stretch, while extracellular levels were increased only at 50%. These data support the use of stretch as a model to simulate TBI in vitro in human dopaminergic neurons, replicating the acute effects of TBI in the dopaminergic system. This method can be used to study the long-term consequences of TBI, including PD and other neurodegenerative disorders.

### Funding

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### 0029

#### TBI Case Studies: Effectiveness of Home and Community-Based Rehabilitation Services Using Consumer-Driven Goal Planning

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Throughout the country, 29 states have traumatic and/or acquired brain injury Home and Community Based (HCBS) Waivers or 1115 Demonstration Programs available through Medicaid. The effectiveness of an intensive home and community-based service program is an understudied and unfamiliar approach. Previous research has failed to address the outcomes resulting from synergy between intensive HCBS therapy, consumer-driven goal planning, and community reintegration facilitated by a collaborative team of rehabilitation professionals. We will review how person-centered goal planning coupled with a natural rehabilitative environment can decrease costs and increase a person's quality of life utilizing case studies.

A model that incorporates a high intensity and collaborative approach between therapists and the consumer is successful in allowing individuals to attain functional outcomes of their choice. This method resulted in overall increased participation in their communities and improved life satisfaction. We applied the International Classification of Functioning (ICF) model as a framework to guide a retrospective biopsychosocial analysis. The Mayo Portland Adaptability Index-4 (MPAI-4), and the Behavioral Rating Inventory of Executive Function-Adult Version (BRIEF-A) were employed to assess functioning at the outset and completion of rehabilitation. These assessments were chosen because of their relevance to the brain injury population. Areas assessed include, but are not limited to, physical, cognitive, communication, social, emotional, behavioral, and vocational.

Rehabilitation services included a mixture of skilled health professionals working together with the individuals to achieve

their independent living outcomes. Services included cognitive therapy, behavioral therapy, occupational therapy, speech therapy, physical therapy, and independent living skills.

Further research is needed to document the effectiveness of this specific rehabilitation approach across a wider population of participants.

### 0030

#### Influence of Stress and Cortisol on Refractory Postconcussion Symptomology

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Postconcussion syndrome, also known as postconcussive syndrome or PCS, is a set of symptoms that may continue for weeks, months, or a year or more after a concussion—a minor form of traumatic brain injury (TBI). PCS symptoms include headaches, chronic pain, dizziness, fatigue, memory problems, and insomnia.

It is supported in literature that cortisol and sympathetic stress are related to cognitive decline and refractory concussion symptomology. It is theorized that head traumas activate persistent tone in the sympathetic nervous system, negatively influencing the hypothalamic-pituitary-adrenal (HPA) axis and cortisol secretion, and prolonging postconcussion symptomology.

This lecture will report the scientific influence of microcurrent point stimulation applied trans-cranially has on neuromodulation, cortisol reduction, and improved postconcussion symptomology when applied to a 35 sample PCS patients.

### Relevance of Lecture

Saliva cortisol measurement is an effective tool for real-time stress analysis stress relating to PCS and TBI symptomology. The positive influence of cortisol reduction on postconcussion symptomology opens up will have profound influence on future postconcussion management programs.

### Objectives

1. Review scientific literature supporting the relationship of sympathetic stress activation and refractory concussion symptomology.
2. Identify the (gender specific) interrelationships between cortisol reduction and postconcussion TBI symptomology.
3. Discuss how microcurrent applied transcranial direct stimulation (tcMPS) can impact health recovery and functionality of post-TBI and concussion patients.

### 0031

#### Concussion Experiences in a Sample of New England Private Preparatory High School Students Who Played Sports or Recreational Activities

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## Background

Sports- and recreation-related activities are a major cause of concussions among adolescents. Most adolescent sports- and recreation-related concussion research has been conducted among public school students. As private schools are qualitatively different from public schools (eg, location, socioeconomic status, and sports played), this study explores the concussion experiences of a large group of private high school students.

## Methods

We surveyed 2047 New England private preparatory high school students who played sports or engaged in a recreational activity in 2018 about the sports they played, and their self-reported concussion experiences (eg, age at first concussion, if concussions were sports- or recreation-related). Descriptive, bivariate, and multivariate statistics are presented.

## Results

One-third (33.0%) of students, who reported engaging in sports- or recreation-related activities, self-reported experiencing a concussion in their lifetime. A higher percentage of males, students who played contact sports, and those who played multiple seasons of school sports reported a concussion. Sex, contact level of primary sports played, and age of first concussion were also significantly associated with reporting a sports- or recreation-related concussion.

## Conclusions

A sizeable proportion of private preparatory high school students reported experiencing a concussion, with some students at higher risk. Private preparatory high school-specific concussion prevention strategies may be needed.

## 0032

### Novel Concepts and Treatment Approaches of a Multifaceted Vestibular Vision-Based Rehabilitation Program for Military Veterans With Persistent Symptoms Related to Mild Traumatic Brain Injury

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The rate of mild traumatic brain injury (mTBI) in US military Veterans of wars in Iraq and Afghanistan is considerable, with reports of 40%. Persons with mTBI often present with persistent postconcussive symptoms (PCS). In a large epidemiologic study ( $n = 1273$ ), it was reported that 70% of persons with mTBI reported 1 or more PCS at 1 year postinjury, with impaired postural control, impaired vision, and dizziness being among the most common. For approximately 20% of US military Veterans with mTBI, PCS-related problems continue well beyond injury onset. In order to maintain an asymptomatic, physiological state of homeostasis, the human brain needs to successfully receive and process a multitude of incoming information simultaneously. Persons with mTBI have impaired reweighting of sensory input (eg, vestibular, sensation from trunk and limbs—somatosensation, vision) during different environmental challenges. The ability to maintain postural

control and orientation while standing and walking in varied environmental contexts during routine daily functional tasks is paramount to safe and efficient participation in personal and societal activities and requires intact cortical and subcortical brain function. Mild TBI and mental illness including posttraumatic stress (PTS) are often concurrently prevalent in military Veterans, contributing considerably to the complexity of the persistent nature of PCS in this patient population.

The mTBI subtypes (mood/anxiety, posttraumatic headache, ocular, vestibular, cognitive, and cervical) developed by the University of Pittsburgh are clinically helpful to categorize patients with mTBI. However, patients with prior mTBI are likely to present with multiple subtypes. At the Marcus Institute for Brain Health (MIBH), our patients with mTBI (primarily US military Veterans) carry multiple concomitant PCS and mental illness (eg, anxiety and PTS) resulting in complex overlapping of subtypes. As such, a highly collaborative interdisciplinary team is required to effectively improve outcomes originating from multiple subtypes simultaneously. Physical therapy-related treatment approaches are required to directly improve subtypes such as ocular, vestibular, posttraumatic headache, and cervical. However, a novel concept is that it can be postulated that problems with ocular motor control and postural control-related to vestibular integration may result in elevated symptoms in other subtype domains such as irritability, fatigue, reduced stimuli thresholds, adaptive/avoidance behavior, and that by treating ocular, vestibular, and cervical-related subtype impairment positive changes in other associated subtypes (eg, cognitive and mood/anxiety) are possible.

Sensory integration and processing are central to the Physical therapy programming at the MIBH. Treatment includes computerized platform-based random perturbation postural control training with added progressive complexities including speed and degree of perturbations, head movements (yaw, pitch, and roll), eyes open and closed, and physical and cognitive dual-task interference. Programming also includes ocular motor (eg, pursuit, saccades, and vergence) and optokinetic stimuli exposure and desensitization training. Patient examples will be presented to demonstrate how providers can apply these concepts.

## 0034

### Interdisciplinary Approach to Social Cognitive-Communication Deficits in Adults With Moderate to Severe Acquired Brain Injury: A Clinical Perspective

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## Background

Deficits in social cognition and social communication (pragmatics) are among the most detrimental outcomes of moderate to severe traumatic brain injury (TBI), often persisting into the chronic stage postinjury. These changes may result in unfavorable social outcomes impacting participation in everyday activities including ability to maintain social relationships, ability to maintain employment, and ability to participate in leisure activities (Spikman et al, 2012; Finch et al, 2016).

Current research, albeit limited, examines social cognition and social communication following TBI as 2 distinct interpretations. However, examination of available research combined with our clinical experiences suggests interplay between these 2 definitions, warranting further exploration of the assessment and treatment of social cognitive-communication skills as a whole.

Further, the heterogeneity of TBI and its variable impact upon social cognitive-communication poses a unique challenge for the medical and rehabilitation team. The array of complex impairments associated with TBI calls for services from a collaborative team of specialized healthcare providers to analyze and synthesize assessment results, develop an effective and functional intervention, and implement individualized and context-sensitive methods to achieve optimal functional outcomes (Speicher et al, 2014; Lefebvre et al, 2007; Stergiou-Kita et al, 2012). Healthcare settings are becoming aware of the need for a holistic, interdisciplinary approach on an international scale, highlighting the importance of assessing and treating an individual as a global entity (Rizzi and Tapia, 2016; McElligott, et al, 2011; Lefebvre, Pelchat, & Levert, 2007).

In this oral presentation, we will:

- describe the nature of the rehabilitation research on social cognition and social communication skills following TBI, individually and as a proposed unified term,
- offer suggestions for the development of an individualized, context-sensitive, and comprehensive treatment approach for individuals with social cognitive-communication impairments, utilizing an interdisciplinary treatment model,
- explain the crucial role of the physician in medical management of both pre- and postinjury emotional and behavioral changes, and
- provide direction for future research in this complex area of rehabilitation.

## 0035

### The mTBI Patients Demonstrate Perceptual and Sensorimotor Time Processing Deficits Years After Injury

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Years of investigating cognitive and motor deficits after mild traumatic brain injury (mTBI) yielded much understanding of impaired attention, executive functions, and processing speed, as well as visuomotor control and balance. However, little is known about timing abilities (processing duration and rhythm), which are critical to planning and coordinating actions (eg, when to cross a crowded street). The brain's mechanisms of timing are complex and involve subcortical and cortical regions. These networks may be compromised after mTBI, as they overlap with areas frequently affected by focal cortical and diffuse axonal injuries and are susceptible to neurotransmission malfunctions. The timing deficits, if left untreated, may result in a sustained disability (eg, Parkinson's disease). Our pilot study aimed to test perceptual and sensorimotor timing skills in patients with mTBI and reveal the associations with other cognitive functions (memory, attention,

and executive) to improve mTBI management and patient's quality of life.

We tested 15 adults with chronic mTBI (military veterans and athletes, 1-7 years postinjury) and matched controls. Tests from standardized batteries were administered: (1) the Battery for the Assessment of Auditory and Sensorimotor Timing Abilities (BAASTA), and (2) The NIH Toolbox Cognitive, Sensory, Motor Batteries, using mobile tablet/iPad versions that provide state-of-the-art adaptive methods of evaluation. Independent-samples *t* tests and mixed-design ANOVAs were used to compare mTBI and controls.

The individuals with chronic mTBI showed general difficulties in time processing when they perceive the regular sequence (ie, beat) [ $t(28) = 3.68, P < .001, d = 1.43$ ] or move to regular sequence of metronome or music [group  $\times$  stimulus interaction,  $F(1,28) = 18.22, P < .0001, \eta^2$  partial = 0.26; stimulus difference for mTBI,  $t(14) = 6.28, P < .001, d = 1.04$ ; for controls,  $t < 1$ ]. Extracting a musical beat appeared to be a particularly challenging task. Moreover, the beat-tracking skills in chronic mTBI were closely linked to deficits in inhibition (Flanker Inhibitory Control and Attention Test) and flexibility (Dimensional Change Card Sort Test), 2 cognitive functions often impaired after mTBI. Additionally, impaired gait was identified (4-m walk gait speed test). Finally, the beat-tracking deficits were not linked to auditory perception (words-in-noise).

These pilot results provide insight into timing deficits in mTBI. The chronic patients demonstrate persistent perceptual and sensorimotor timing impairments linked to motor and executive functioning that should be addressed in therapy. The time processing deficits after mTBI require systematic and sequential postinjury investigation, as findings may resolve some challenges of mTBI intervention and boost neurorehabilitation outcomes.

## 0036

### Clinical Changes Associated With Head Impact Exposure in High School Football

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Our recent studies in football athletes identified a possible second mechanism for concussion that involves repetitive subconcussive head impact exposure (HIE). Athletes may experience a more gradual onset of concussion symptoms, associated with progressive changes in brain function resulting from the combination of a high number and severity of repetitive head impacts over a longer period, as opposed to a single concussive event. This study measured repetitive HIE during a football season and identified cognitive, postural, and physical disturbances in athletes without diagnosed concussion using repeated clinical assessments.

Head impact accelerations were monitored during all contact activities using the Head Impact Telemetry System (Riddell SRS) for 13 high school football athletes during the 2018 season. Clinical assessments were performed prior to initiation of contact activities (baseline), 1 month into the season (mid-season) and after the conclusion of the season (post-season).

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The following clinical assessments were compared between baseline and mid-season/post-season. SCAT Symptom Severity score was the cumulative score for all 22 symptom scores. BESS total score was the cumulative number of errors for all stance and surface conditions. SAC total score was the number correct across all orientation, memory, concentration, and recall trials. ImPACT verbal memory, visual memory, and reaction time composite scores were analyzed separately. Athletes with significantly worse performance (80% CI) from baseline to the mid-season/post-season assessments were identified. HIE in the “symptomatic” group was then compared to the “asymptomatic” group, using the total number of head impacts and Risk-Weighted Exposure (RWE) from the beginning of the season until the mid-season/post-season assessment.

Thirteen athletes received mid-season and 10/13 athletes received post-season assessments. Significant worsening from baseline was more common at mid-season. Midseason assessment of SAC total score, SCAT symptom severity, and ImPACT visual memory had the most athletes with significant changes from baseline. Only SAC total score and ImPACT reaction time were significantly worse in some athletes post-season. Biomechanical metrics were greater for athletes demonstrating significant mid-season SCAT symptom severity and SAC total scores. Only RWE for the greater SCAT symptom severity group was significantly different ( $P < .01$ ) at mid-season. The 2 athletes demonstrating worse post-season SAC total score sustained a greater number of head impacts ( $P > .05$ ).

This study provided evidence of clinical changes in some nonconcussed football athletes throughout the course of a season. Head impact burden was greater in athletes that demonstrated some clinical changes (ie, SCAT and SAC). However, a novel aspect was incorporation of a mid-season assessment. Interestingly, the percentage of athletes demonstrating significant clinical changes was greater at mid-season than post-season assessments. This may be attributable to higher head impact density (# impacts/time) during pre-season. However, given the limited sample size, these data represent preliminary findings and further validation is required.

### 0037

#### Emergency Department Visits for Sports- and Recreation-Related Traumatic Brain Injuries Among Children—United States, 2010-2016

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Traumatic brain injuries (TBIs), including concussions, are at the forefront of public concern about athletic injuries sustained by children. Caused by an impact to the head or body, a TBI can lead to emotional, physiologic, and cognitive sequelae in children. Physiologic factors (such as a child’s developing nervous system and thinner cranial bones) might place children at increased risk for TBI. A previous study demonstrated that 70% of emergency department (ED) visits for sports- and recreation-related TBIs (SRR-TBI) were among children. Because surveillance data can help develop prevention efforts, the Centers for Disease Control and Prevention analyzed data from the National Electronic Injury Surveillance System—All Injury Program (NEISS-AIP) by examining SRR-TBI ED visits during 2010-2016. An average of 283 000 children younger than 18 years sought care in EDs each year for SRR-TBIs,

with overall rates leveling off in recent years. The highest rates were among males and children aged 10 to 14 and 15 to 17 years. TBIs sustained in contact sports accounted for approximately 45% of all SRR-TBI ED visits. Activities associated with the highest number of ED visits were football, bicycling, basketball, playground activities, and soccer. Limiting player-to-player contact and rule changes that reduce risk for collisions are critical to preventing TBI in contact and limited-contact sports. If a TBI does occur, effective diagnosis and management can promote positive health outcomes among children.

### 0038

#### Return to Learn Concussion Management: Investigation of Knowledge, Beliefs, and the Fidelity of Implementation

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Following a concussion, students return to the classroom and can experience a range of minimal to severe cognitive, behavioral, physical, emotional, and social deficits, which interfere with their ability to learn (Babikian, Merkley, Savage, Giza, and Levin, 2015). Additionally, returning to the full demands of school too soon can increase symptom severity and duration of recovery. Therefore, students with concussions should be immediately academically supported by school staff (McAvoy, Eagan-Johnson, and Halstead, 2018). Also, academic and symptom progress monitoring data should drive all educational decisions (Zirkel and Eagan-Brown, 2015). However, many school staff lack self-efficacy in their ability to generate fluid decisions regarding return to learn (RTL) processes, symptom-based academic adjustments, and the general management of a concussed student’s needs. This lack of efficacy reflects a shortage of concussion training and information available to school staff.

The purpose of this study was to determine the effectiveness of a Return to Learn Concussion Management Team (RTL CMT) training intervention. The study investigated RTL CMT fidelity of implementation (FOI) that included barriers and adaptations made by school teams. The secondary focus was on participant knowledge and confidence outcomes related to student school-based concussion management. The intervention consisted of (a) a 5.5-hour online, on-demand concussion RTL training; (b) RTL protocol; and (c) an RTL concussion academic and symptom monitoring toolkit.

The following research questions guided the study:

- RQ1. To what degree of fidelity was the RTL protocol implemented by teams?
- RQ2. Do RTL CMT training participants demonstrate increased knowledge of concussion and RTL management practices?
- RQ3. Does prior training in concussion lead to better pre- and posttest scores?
- RQ4. Do high posttest scores lead to better confidence and FOI?
- RQ5. Do participants who have prior formal training in concussion or prior RTL CMT training obtain higher pre- and posttest scores?

- RQ6. Do high posttest scores lead to better confidence and FOI?

### Research Design

The study employed a mixed-method design. The methods included a knowledge pre- and posttest, beliefs and process feedback postassessment, 3-month FOI, 3-month beliefs and confidence postassessment, and 9-month beliefs and confidence postassessment.

### Discussion

The RTL CMT study aligned with findings from Davies and Tedesco (2018) stating that concussion online trainings are effective to increase school staff knowledge and efficacy. The results of this study sufficiently demonstrate that this training intervention is a successful tool to increase school staff knowledge, beliefs, and confidence. This study also provided a foundation as the first study to investigate protocol components implemented by RTL CMTs following a statewide training model.

### 0039

#### Daily Contextual Manipulations Are Critical for Success in a Hippocampal Dependent Rehabilitation Task Following Experimental TBI

Law L

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Traumatic brain injury (TBI) is not a transient event from which all people recover; the resulting damage can evolve into neurological disease. As with patients, experimental TBI disrupts rodent memory circuits, evident as impaired cognitive performance. Experimental rehabilitation strategies, such as enriched environment and exercise, have partial success in alleviating symptoms. New rehabilitation strategies are necessary to demonstrate therapeutic efficacy and explore cellular mechanisms that promote recovery. Diffuse brain injury by midline fluid percussion leads to cognitive impairments by 1 month postinjury, permitting a timeframe to implement and investigate delayed interventions. Rehabilitation occurs in a box with a peg-board floor that allows for 10-cm plastic pegs to be inserted at 2.5-cm intervals in designated layouts—termed Peg Forest Rehabilitation (PFR). Brain-injured rats were exposed to PFR (15 min/day), allowing free navigation through either random daily layouts or the same layout daily in the peg-filled arena for 10 days over 2 weeks. The current study compared random daily PFR (dynamic) layouts versus the same PFR (static) layout for 2 weeks in male and female brain-injured rats. We hypothesized that dynamic daily arrangements, not static, are necessary to prevent the onset of injury-induced memory impairments by challenging the limbic memory circuit. Previous results show that 2 weeks of PFR prevents the onset of cognitive deficits in injured rats for short-term, long-term, and working memory. Preliminary data revealed no differences between males and females, so they were combined for analyses. As previously shown, brain-injured rats exposed to the dynamic PFR did not exhibit any deficits on 3 cognitive assessments. Interestingly, rats exposed to the static PFR were

significantly impaired when compared to the dynamic rats. Thus, passive, dynamic, and intermittent rehabilitation targeting specific circuitry can prevent cognitive symptomatology. The Peg Forest is a viable rehabilitation strategy to explore cellular and molecular mechanisms to preserve neurological function.

### 0040

#### Cannabis Use and Potential Predictors Among University Students With and Without a History of Mild Head Injury

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There is compelling evidence that the rates of alcohol misuse/use disorders are elevated among individuals with traumatic brain injuries (TBIs; Corrigan et al, 2013). Even among those with a history of mild head injury (MHI), higher rates of use per outing have been found and linked to injury-related physiological dysfunction (Alcock, Gallant, and Good, 2018). It has been proposed that physiological underarousal postinjury may serve as a mechanism of increased substance use due to dampened anticipatory signaling of risk (Bechara, Dolan, and Hinds, 2002). However, despite evidence that cannabis use may further reduce arousal (Phan et al, 2008), few studies have investigated rates, and predictors, of cannabis misuse after TBI. This research investigated whether MHI is associated with cannabis use and examined the role of sympathetic arousal in this relationship.

Eighty-four undergraduates with ( $n = 51$ ) and without a history of MHI ( $n = 33$ ) participated in this study. All participants completed a demographic questionnaire, assessing their head injury history and current and past cannabis use, the Personality Assessment Inventory (PAI; Morey, 1991), the State Trait Anxiety Inventory (STAI; Spielberger, 2010), and the HEXACO-Personality Inventory Revised (Lee and Ashton, 2004). Responses to head injury history items were used to create an injury severity composite; electrodermal activity (EDA), assessed at baseline and in anticipation of an unexpected event, was used to index physiological arousal.

A greater proportion of those with a history of MHI reported smoking cannabis,  $\chi^2(1) = 9.58, P = .002$ , and smoked more frequently in the last 30 days,  $\chi^2(2) = 11.34, P = .003$ , compared to those without a history of MHI. Injury severity was found to correlate positively with the drug problem subscale on the PAI, and relative to those with a history of a single MHI, those endorsing multiple MHIs reported greater cannabis use and had higher PAI drug scores. Moreover, those with a history of multiple MHIs were found to exhibit lower levels of baseline arousal compared to those with a single MHI,  $P = .03$ , and there was a trending effect of MHI status on anticipatory physiological arousal,  $P = .06$ . Accordingly, lower levels of arousal were found to be associated with a longer duration of cannabis use and greater cannabis use in the last 30 days, while no associations were found between cannabis use and anxiety, depression, extraversion, and emotionality. Interestingly, when MHI and no-MHI groups were examined independently, higher state anxiety levels were associated with less cannabis use in the no-MHI group only. Together, these results mirror the alcohol abuse literature and indicate that a history of MHI is associated with increased cannabis use, which may be due to sympathetic dysfunction.

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**0041****I'm Not Finished Yet: Lessons Learned From a TBI Survivor on Community Integration**

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The acquisition of a traumatic brain injury (TBI) can be devastating to some, and life changing. While we are well advised about rehabilitation strategies, short-term and evidence-based rehabilitation strategies, what do we know about adaptation across the life span and into older adulthood? This presentation will address some of the rehabilitation and community integration strategies utilized for successful integration back into the community and strategies to ensure quality of life.

**Methods**

This retrospective case study will provide insights into strategies for successful adaptation of a TBI young woman (aged 30 years at the time of a severe car accident), and view community NGO and other supports and interventions that have been utilized over the past 40 years. Through an interview-style presentation, this presentation will address various life domains such as physical, social, spiritual, vocational, and financial arenas, and showcase how adaptations have enabled a full and active life. Ms K, who was a social worker at the time of her injury, has been able to come full circle back to using these skills as a foster parent offering emergency foster placement services for children and youth. She has also successfully raised a college graduate son as a single mother, provided nurturing as a sister and daughter and been active in a variety of social connections and community services over the past 30 years. While we know much through the scientific literature about short-term rehabilitation and intervention strategies, this presentation will provide an overview of some long-term interventions to promote quality of life and long-term success stories with TBI survivors utilizing community resources and supports.

**0043****A Multicenter, Randomized Controlled Trial of Social Competence Treatment After Traumatic Brain Injury: Interactive Group Treatment Versus Noninteractive Treatment**Bell K<sup>5</sup>, Braden C<sup>1</sup>, Eagye C<sup>1</sup>, Hammond F<sup>8,9</sup>, Harrison-Felix C<sup>1,2</sup>, Howe L<sup>10</sup>, Ketchum J<sup>1,2</sup>, Malec J<sup>8,9</sup>, Millis S<sup>6,7</sup>, Morey C<sup>1</sup>, Walker W<sup>3,4</sup>, Newman J<sup>1,2</sup>, Hawley L<sup>1</sup>

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**Objective**

To evaluate the effectiveness of a dual-disciplinary group treatment program for improving social competence after traumatic brain injury (TBI).

**Design**

Multicenter randomized controlled trial comparing 2 methods of implementing a social competence skills program: (1) an interactive group format versus (2) a classroom lecture combined with individual treatment sessions.

**Setting**

Community and veteran rehabilitation centers.

**Participants**

Civilian, military, and veteran adults with TBI and social competence difficulties ( $n = 179$ ), who were at least 6 months after injury.

**Interventions**

The experimental intervention (GIST) consisted of 13 weekly group interactive sessions (1.5 hours) with structured and facilitated group interactions to improve social competence, and the control condition consisted of 13 classroom sessions using the GIST curriculum with supplemental individual sessions, without structured group interaction. GIST was found to be efficacious in a previous single-site study for individuals with moderate to severe TBI who were living in the community and endorsed social competence challenges.

**Main Outcome Measures**

Profile of Pragmatic Impairment in Communication (PPIC), an objective behavioral rating of social communication impairments after TBI; LaTrobe Communication Questionnaire (LCQ); Goal Attainment Scale (GAS); Satisfaction with Life Scale; Posttraumatic Stress Disorder Checklist-C (PCL) civilian version; Brief Symptom Inventory 18 (BSI-18); Scale of Perceived Social Self-Efficacy (PSSE).

**Results**

Social competence goals (GAS) were achieved and were maintained for most participants regardless of treatment condition. Significant improvements in the primary outcome (PPIC) and 2 of the secondary outcomes (LCQ and BSI) were seen immediately posttreatment and also at 3 months posttreatment in the alternative treatment arm only. However, these improvements were not significantly different between the group interactive structured treatment and alternative treatment arms. Similar trends were observed for PSSE and PCL-C.

**Conclusions**

Social competence skills improved for persons with TBI in both treatment conditions. In this study, the group interactive format was not found to be a superior method of treatment. However, in both treatment conditions, social competence improved for a heterogeneous group of individuals with chronic TBI participating in treatment based on the GIST curriculum.

## Questions for Future Research

Did the primary measure capture the broad range of social skills addressed in the treatment condition, such as social confidence, increased social activity, or interactions with family? Was the control condition too similar to the treatment condition, using the same curriculum and goal setting? Did the control condition offer the unintended opportunity for the participants to interact as a group, share experiences, and develop relationships?

## 0044

### Return to Learn Experience of Undergraduate College Students Who Sustain a Concussion Versus a Musculoskeletal Injury

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## Background

Concussion impacts people of all ages but can be especially detrimental to college students that often need to advocate for their own physical, emotional, and academic wellbeing. Studies have found near 50% of college students with concussion return to the classroom prematurely, which can increase symptom severity and lengthen the recovery process. However, little is known about the overall return-to-learn (RTL) experience in this group and how it compares to those with musculoskeletal (MSK) injury.

## Purpose

This study aimed to describe the RTL experience of undergraduate students that sustained a concussion compared to those that sustained a musculoskeletal (MSK) injury while enrolled in a large Midwestern university.

## Methods

An electronic survey was e-mailed to all undergraduate students ( $n = 29\ 125$ ) in the fall of 2016. Of the 1950 respondents, 76 (3.9%) participants reported sustaining a concussion and 168 (8.6%) reported an MSK injury. Only participants who responded to study-specific survey items were included.

## Analysis

Descriptive statistics characterized the study sample and response proportions.  $\chi^2$  tests examined the differences between concussion and MSK injury responses specific to the areas of: return-to-learn processes, utilization of campus-based services, academic-specific student concerns, and academic consequences of injury.

## Results

Overall, 74 participants who sustained a concussion (72.9% female,  $n = 54$ ) and 159 participants who sustained an MSK injury (69.18% female,  $n = 110$ ) were retained for analysis. Mean age was similar in both the concussion and MSK group

(20.2 years,  $SD = 2.4$ ; 20.6 years,  $SD = 3.0$ , respectively); the majority self-reported as white (85.71%,  $n = 60$ ; 89.94%,  $n = 143$ , respectively), and non-Hispanic (>95% in both groups). A significant difference was noted in school days missed for concussion versus an MSK injury (mean = 1.96 days vs 0.34 days,  $P = .02$ ). Although nonsignificant, just 30.3% ( $n = 17$ ) of students with concussion versus 45.76% ( $n = 54$ ) with MSK injury sought care from University Health Services (UHS). In both groups, few sought support from an academic advisor (<6%). Those who sustained a concussion were more likely to report academic-specific concerns with grades (56.25% vs 32.98%,  $P = .0112$ ), ability to learn (59.57% vs 20.43%,  $P < .0001$ ), amount of work (56.25% vs 23.55%,  $P = .0002$ ), headaches (75.47% vs 7.95%,  $P < .0001$ ), fatigue (56.25% vs 36.96%,  $P = .0326$ ), and difficulty concentrating (64.71% vs 22.58%,  $P < .0001$ ). Although nonsignificant, differences were also noted regarding consequences of concussion injury, with a higher proportion reporting a reduction in credits, a change in their major, and a change in career goals because of their injury.

## Conclusion

Students with concussion missed more school days and were more concerned with their ability to learn in the classroom compared to students with MSK injury. Utilization of campus services was reported as low. Increased awareness of these services could mitigate student concerns and effects of concussion injury.

## 0045

### Central Auditory Processing and the Intersection of Brain Function and Injury: Developing a Multidisciplinary Approach to Reduce Cognitive Disability

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## Background

Diagnosis of cognitive disorders due to brain injury or disease can be hampered when symptoms of clinical disorders overlap. This may be more likely in populations that experience multiple comorbidities that simultaneously impact cerebral functions (eg, traumatic brain injury [TBI] and migraine). Effects of one disorder can be confused with those of another. An example is Veterans who report problems understanding speech and receive routine audiological testing, which comes back normal. Affected individuals may have a central auditory processing disorder (CAPD) that impairs speech perception, which is misconstrued as hearing loss (common in Veterans), delaying diagnosis. Attention and memory may be affected. Identifying features that link seemingly diverse disorders through shared pathobiology can promote communication and collaboration between providers to reduce fragmented specialty-driven care and suggest treatment opportunities.

## Methods

Veterans evaluated by a neurologist, who reported problems understanding speech in noisy environments (reporting a tendency to frequently state "What did you say?"), with

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normal/near normal hearing were referred for evaluation for CAPD. Veterans with a CAPD reporting neurological complaints (eg, TBI or migraine) were referred for neurological evaluation. Cognitive ability was generally assessed with the Montreal Cognitive Assessment (MOCA). A diagnosis of CAPD was made when patients were found to have at least 2 tests of central auditory processing that were abnormal (most commonly these included the SSW and SCAN test). Evaluations identified comorbidities that might relate to cognitive complaints and also CAPD. Exclusion criteria included active substance abuse, psychotic behavior, and significant peripheral hearing loss.

## Results

Of the Veterans evaluated, 22/36 (61%) had a CAPD. Multiple comorbidities were common in Veterans with and without a CAPD. Some conditions (eg, migraine headaches) had not been adequately treated or, like sleep disorders, had never been formally evaluated. Referrals for sleep studies resulted in many new diagnoses of obstructive sleep apnea. The comorbidities identified independently may impact cognitive functions, including central auditory processing. Average MOCA scores were lower in Veterans with CAPD (23.5/30) versus those without CAPD (26.5/30) [ $P$  value is .003 by 2-sample  $t$  test]. Among Veterans with CAPD, the SSW and Scan Test were most often positive.

## Conclusions

Our results suggest CAPD may be highly prevalent but underdiagnosed in Veterans. Detection of affected individuals may be facilitated by the MOCA, but further study is needed to confirm this hypothesis. The model developed in this study suggests comorbidities common in Veterans that can cause or contribute to cognitive and behavioral deficits, may share pathobiology that can cause or contribute to a CAPD. Recognizing shared pathobiology may promote a more multidisciplinary-based model of care among providers from diverse disciplines. Comprehensive management of multiple morbidities may more effectively address related cognitive deficits that may include contributions from CAPD.

## 0046

### Self-Reported "Legal Consciousness" in Adults With and Without Traumatic Brain Injury

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## Background

The phenomenon of legal consciousness, or lay persons' understanding of the law, has been the subject of sociolinguistic research for decades, but although this research has revealed compelling descriptions of the social dynamics that underlie and influence this understanding, the cognitive constructs that contribute to legal consciousness remain generally unknown. A population for whom the interaction between cognition and legal consciousness is particularly salient is individuals with traumatic brain injury (TBI): Individuals with TBI often experience deficits in cognition that lead to poor social outcomes, and the overrepresentation of individuals with TBI in incarcerated populations suggests that individuals with TBI are poorer

equipped to navigate legal contexts than their uninjured peers. A clearer understanding of how individuals with TBI report legal knowledge, and what cognitive constructs might influence that knowledge, would help illuminate the relationship between cognition and legal consciousness and identify possible interventions to improve legal outcomes for persons with TBI.

## Objective

The purpose of this study was (1) to obtain qualitative and quantitative measures of legal consciousness in adults with and without TBI, and (2) to assess whether measurements of cognitive function could predict legal consciousness.

## Methods

I conducted semistructured interviews with adults with moderate-to-severe TBI ( $n = 20$ ) and a comparison group ( $n = 21$ ). The participants were asked to self-report their knowledge of laws and legal systems in the United States. I analyzed the interviews using grounded theory qualitative methodology to identify key concepts and ideas within the self-reported legal knowledge. I then obtained quantitative measures of linguistic content (eg, clausal density) and conducted linear regression analysis using standardized assessments of cognitive function (Common Data Elements for TBI research) as independent variables.

## Results

Results suggest that both groups' legal consciousness contains themes that encompassed both rule-oriented and relation-oriented concepts. For individuals with TBI, however, legal knowledge was frequently framed around the injury. There were between-group effects of quantitative measures, with individuals with TBI using shorter, less-dense language than individuals without TBI. Working memory predicted language density ( $P < .001$ ) in both groups.

## Conclusion

Results of this study identified themes and ideas that describe legal consciousness in adults with and without TBI. Although individuals with TBI displayed quantitatively poorer language when self-reporting their knowledge, there did not appear to be a qualitative difference in the underlying content of that knowledge. These findings point to the importance of intact cognitive mechanisms in the construction and delivery of legal knowledge and highlight the need for legal approaches that accommodate individuals with cognitive disability.

## 0047

### Making Meds Make Sense: A Collaboration of Speech Therapists and Pharmacists

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## Introduction/Background

After experiencing a catastrophic injury, patients are challenged with significant and overwhelming lifestyle changes, including managing multiple new medications. Many of these medications are used off-label with insufficient educational resources, creating a challenge for therapists, patients, and caregivers. As gaps in medication education have been identified

through postdischarge surveys and follow-up, pharmacists expanded services to include participating in team rounds, progressive patient and family medication education throughout the inpatient stay and facilitating procurement of discharge medications. These services are enhanced by collaboration with speech therapists who specialize in supporting new learning through eliciting understanding, memory, and problem-solving strategies for patients with deficits from brain injury. This collaboration helps prepare patients and their families for a more successful transition home.

### Method/Approach

Each member from the interdisciplinary team meets weekly to discuss goals met from the previous week, barriers encountered, and goals for the next week. During this time, pharmacists determine how medications contribute or create barriers to patient progress and collaborate with providers and therapists to adjust medication therapy and provide education. As patients progress in their neurorecovery, they become more involved in their care, including medication management. Medication management in the inpatient setting includes testing with speech-language pathologists to assess attention, memory, language, and executive function and to determine strategies to optimize new learning. These strategies are then utilized in individuals and coteatments with speech therapy and pharmacy, including preparation of the patient's actual medications for the return home. Patients review name, indication, dose, and frequency of each medication, as well as strategies for medication management at home. Patients are assessed on level of independence based on percentage of medications accurately identified and organized.

### Results

Interdisciplinary team members monitor the efficacy of medications started for sequelae of brain injury. Interdisciplinary communication and collaboration through team rounds improves identification and reporting of progress and medication adverse events. As patients progress in their recovery, speech therapists identify goals and strategies related to medication management, and pharmacists provide education and tools on how to monitor effects from specific medications. The collaboration contributes to improved observation; optimal medication management in the inpatient setting, including identification and reporting of adverse drug reactions; and increased understanding and independence with medication management for discharge. A lack of published literature on speech therapist and pharmacist collaboration indicates our approach to educating patients on medications is unique.

### Conclusion

Interdisciplinary collaboration optimizes medication use for patients. Supervised pill box loading activity provides practice and a final assessment for executive functioning and activities of daily living skills for patients prior to discharge. Further study will help determine the impact of speech therapist and pharmacist contribution after discharge.

**0048**

### Getting Real: Interdisciplinary Medication Management in Polypharmacy Patients

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### Purpose

After experiencing a catastrophic injury, patients are challenged with significant and overwhelming lifestyle changes, including managing multiple new medications. Conclusions from a project following patients home upon discharge identified gaps in execution of adequate medication management despite extensive and repetitive education as inpatients. Patients and caregivers were confused by the medication list and unsure of where medications were packed for travel home. Patients and caregivers reported that they observed medications being given in the hospital but never had the opportunity to practice medication management and administration on their own. Additional education with an interdisciplinary focus and supervised, independent pill box loading the day prior to discharge was implemented to provide a more successful transition to home, including having medications readily available, being prepared for travel delays, cultivating independence, and fostering safety-oriented goals.

### Methods

Inpatient pharmacy staff facilitates getting prescriptions for take-home medications filled by a community pharmacy of the patient's choice. The medications are picked up by a caregiver or delivered to the patient's room the day prior to discharge. Patients discharging to home on at least 2 medications that are filled and available prior to discharge are scheduled for an appointment with a pharmacist, pharmacist intern, nurse, occupational therapist, or speech therapist. Staff supervises the patient and available caregivers while the patient organizes and fills a pill box with the first weeks' course of medications. Patients review name, indication, dose, and frequency of each medication, as well as strategies for organization and memory at home. Patients are assessed on level of independence based on percentage of medications accurately identified and organized. Number of medications, amount of time needed for pill box fill, and errors caught are also documented.

### Results

During a 12-month period, 130 out of 285 discharged patients completed a supervised pill box load. Patients returned home on an average of 7 scheduled medications. Fifty-five percent of patients were assessed as being able to independently identify and organize medications with at least 75% accuracy at the time of discharge. The average length of time to complete the pill box load was 33 minutes. Patients left the hospital with a clear, precise medication list and a weeks' supply of medications sorted in a pill box and readily accessible. Patients and staff incidentally identified 18 errors filled by the community pharmacies.

### Conclusion

Supervised pill box loading activity provides practice and a final assessment for executive functioning and activities of daily living skills for patients prior to discharge. Further study will help determine impact of supervised pill box loading after discharge.

**0049**

### The Role of the Personal Support Worker Revisited

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In this poster presentation we explore the concepts of personal support workers and enhanced personal support workers (PSW).

Traditional community rehabilitation models include the use of personal support workers for medical model attendant care supports. These supports typically include assistance with personal care, meal preparation, and other activities of daily living as prescribed by the treating occupational therapist. While highly valuable the role of the PSW is naturally limited in its function within the rehabilitation team, whereas the enhanced personal support worker has the ability to provide an additional level of care.

Enhanced personal support workers are skilled in providing psychosocial supports as well as activity of daily living support to the survivor. The role of a skilled enhanced personal support worker can be utilized in such a manner that they function as an integral part of the rehabilitation team—Offering many advantages to the client who receives such complementary care and the day-to-day insights to the treatment team.

Enhanced personal support workers are skilled at providing cognitive and behavioral supports, which allows them to provide exemplary care to clients who demonstrate concerns with their executive functioning—the ability to provide guidance and support with judgment and problem-solving such as assistance planning, organization, sequencing, and risk assessment. Enhanced personal support workers are able to provide behavior supports in assisting clients with their emotional regulation, having the ability to support a client when they note they are becoming overwhelmed and/or agitated.

Individuals with acquired brain injuries/traumatic brain injuries often require assistance with communication as a result of cognitive and speech impairments, as well as not being able to self-report due to lack of awareness and insight. Communication is essential to the client receiving the proper supports as well for the treating professionals to prescribe the most appropriate therapies. The enhanced personal support worker is able to act as an interpreter, observer, and advocate of the client, as they support them on a day-to-day basis—thereby allowing the treating professionals an additional view into the client's health and safety from a holistic view. While this role is essential it is considered ancillary support to the rehabilitation therapists and treatment team.

In summary, enhanced personal support workers are able to provide an exemplary level of care and adjunct support to the client in addition to the rehabilitation team, thereby allowing the treatment team to provide the best in wholistic care to the survivor, allowing for the best possible neurorehabilitation outcome.

## 0050

### Understanding Characteristics of Concussion Sustained by Undergraduate Students While Enrolled in a Large Public University

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#### Background/Significance

Preventable traumatic brain injury (TBI) of all severities is a significant public health concern in the United States, specif-

ically among young adults. Traditional college-aged students, 18 to 22 years old, are known to have a heightened risk for mild to severe TBI. In 2017, greater than 200 000 TBIs were reported among this age group in the United States, with the majority representing mild TBIs, otherwise known as concussion. However, little is known about the characteristics of concussions sustained by undergraduate students while attending college, most especially in the nonstudent athlete. The purpose of this study was to examine the characteristics of self-reported concussion, including mechanism of injury and possible associations to age, sex, race, ethnicity, and educational level, sustained by undergraduate students while enrolled in a large public midwestern university.

#### Study Design

This mixed-methods project is a secondary analysis of data collected from a cross-sectional online survey sent to all undergraduate students ( $n = 29\ 125$ ) enrolled at a large Midwestern university in the fall of 2016. A total of 1951 students responded (6.7%). Only subjects who stated their injury was a concussion and completed all survey items specific to this study were included in this project.

#### Analysis

Descriptive statistics were utilized to characterize the sample. Qualitative content analysis was applied to identify main TBI mechanism groups in addition to subgroups from text description of injury. Binary logistic regression was used to examine potential associations between mechanism of injury group and age, sex, race, ethnicity, and academic status.

#### Results

Overall, 164 (8.4%) nonathlete undergraduate students (71.95% female,  $n = 118$ ; mean age = 20.63 years [SD = 2.87; range = 18–41]) reported an injury while enrolled at the university. The majority self-identified as Caucasian (91.25%,  $n = 146$ ) and non-Hispanic (96.1%,  $n = 148$ ). Academic status was evenly distributed. Of these subjects, 49 reported a concussion injury and were included in this study. No demographic differences were found between those included versus those excluded. Qualitative analysis resulted into 2 main concussion mechanisms of injury groups: (1) nonsport/physical activity-related ( $n = 39$ ; 80%) and (2) sport/physical activity-related ( $n = 10$ ; 20%). The most common mechanism of injury in the non-sport-related group was falling ( $n = 14$ ; 28.57%), whereas running ( $n = 2$ ; 4%) was the most common in the nonsport/physical activity group. No association was found between the participant's mechanism of injury group and age, sex, ethnicity, and academic status.

#### Conclusion

Based on the author's knowledge, these results represent the first study of self-reported concussion in nonstudent athlete undergraduate students in the United States. The results contribute an early understanding of the characteristics of concussion in the nonathlete college population. Initiatives to decrease falls may reduce concussion injury. The results provide a foundation for larger-scale investigations that assess injury intending to suggest prevention strategies for this high-risk college population.

**0051****Taking Action for Children With TBI: Year 1 Report From the Galveston Brain Injury Conference (GBIC)**

Haarbauer-Krupa J

*Centers for Disease Control and Prevention, Atlanta, United States***Introduction**

The Centers for Disease Control and Prevention (CDC) Report to Congress on the Management of Traumatic Brain Injury in Children (RTC) was released in February 2018. This report was developed through a collaboration between CDC scientists and researchers that specialize in the medical and educational management of traumatic brain injury (TBI). The report includes a summary of the scientific evidence related to TBI management in children, as well as recommendations to support action in 3 areas related to the management of TBI in children: recognize, monitor, and care.

**Methods**

The Galveston Brain Injury Conference (GBIC) is an invitation-only 2-day workshop held in Galveston, Texas. Each year, a problem-solving group is invited to engage in brainstorming to develop actions to address gaps and issues that have been identified on topics of interest about persons who have sustained a TBI. For the next 2 years, the topic will be pediatric TBI, concentrating on developing a follow-up plan of action for the scientific community and pediatric TBI stakeholders to address each of the areas identified in the CDC RTC. Recognize refers to medical diagnosis, discharge instructions, and screening for TBI in children. The group addressing this area is currently examining existing locations where children can be identified in healthcare, school, and community settings to determine how to improve recognition and diagnosis of children with TBI. Monitor indicates a follow-up pathway after the initial diagnosis in both healthcare and school settings and relates to the healthcare-to-school transition. Participants addressing this area are creating tools to monitor children over time. Care refers to the type of services children need following TBI and how they are funded/supported. In the Year 1 meeting held in May 2019, the Galveston group devised plans to address key issues in each area.

**Results**

This presentation will address the top priorities identified within the RTC related to the diagnosis and management of TBI, improving access to services and supports, and efforts to improve the scientific evidence related to long-term outcomes for children with brain injury. Strategies for tracking and monitoring youth into adulthood will be described. Finally, the Year 1 GBIC plan to address children's issues and gaps in care following TBI will be presented.

**Conclusions**

The identification and management of TBI in children is complex, and dependent upon multiple service delivery systems. These systems are not optimally coordinated to provide care across the child's lifespan. The RTC identifies opportunities for action that the GBIC working group employed as a framework to address the areas of recognize, monitor, and care.

**0052****Concussion and Academic Impairment Among US High School Students**

Haarbauer-Krupa J

*Centers for Disease Control and Prevention, Atlanta, United States***Introduction**

Sports and physical activities are a frequent cause of traumatic brain injury, primarily concussions, among adolescents. These concussions may adversely affect students' ability to learn and can impair academic achievement in educational settings.

**Methods**

The 2017 national Youth Risk Behavior Survey, conducted among a nationally representative sample of 14 765 US high school students, was analyzed in 2018 to examine associations between self-reported sports- and physical activity-related concussions (SPAC) in the preceding 12 months and postinjury symptoms of cognitive impairment (difficulty concentrating, remembering, or making decisions) and self-reported academic grades (mostly A's = 4.0; mostly B's = 3.0; mostly C's = 2.0; mostly D's = 1.0; mostly F's = 0.0). Adjusted prevalence ratios (APRs) and differences in self-reported estimated grade point average (GPA) were adjusted for sex, race/ethnicity, grade, and athlete status (participation on sports teams) and considered to be statistically significant if  $P < .05$ .

**Results**

Male students were more likely than female students (17.1% vs 13.0%) and athletes were more likely than nonathletes (21.4% vs 7.6%) to have a self-reported SPAC in the 12 months preceding the survey. Students with a reported SPAC were more likely than students without a SPAC to report symptoms of cognitive impairment whether they were male (APR = 1.49), female (APR = 1.37), athletes (APR = 1.45), or nonathletes (APR = 1.42). Self-reported GPA was significantly higher among students who reported no concussions (3.14) compared to students who reported a single concussion (3.04) and students who reported 2 or more concussions (2.81).

**Conclusions**

School-based programs are needed to monitor students' academic performance and provide educational support and resources to promote academic success following a concussion.

**0053****Enhancing Interdisciplinary Care for Patients With Mild Traumatic Brain Injury (TBI): Implementing Shared Vocabulary to Improve Outcomes**

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Patients with mild traumatic brain injury (mTBI) often present with numerous subjective and objective problems

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that are often chronic and complex. This multifactorial presentation often requires interdisciplinary interventions, although the most effective care modeling for those with persistent symptomatology remains elusive. One reason for this quandary is the often limited interdisciplinary collaboration in various rehabilitation settings. Failure to identify key outcomes and implement a unified team lexicon (beyond traditional medical terminology) that can guide treatment to a better outcome is a common barrier to effective interdisciplinary care for persons with mTBI. This concept is predicated on the knowledge that poor health literacy and health advocacy are known predictors of poor clinical outcomes. In the intensive outpatient evaluation and treatment setting at the Marcus Institute for Brain Health (MIBH), we utilize an interdisciplinary care approach to treat persistent symptoms related to mTBI, primarily in military Veterans typically at least 5 years removed from injury. Our model is rooted in pattern recognition of common clinical manifestations by our patients (eg, fatigue, frustration, irritability, and attention/memory problems). This principal step acts as a common thread among the team and is essential to the execution of a cohesively targeted treatment plan involving tools and techniques from each specific discipline (eg, physical therapy, speech language pathology, behavioral health, integrative therapies, art therapy, case management, and behavioral neurology). Complementing the use of standard medical terminology, this approach improves communication regarding details of treatment between providers and with patients. The use of shared vocabulary has significantly augmented our collaborative efforts, leading to more effective approaches to improving the collectively identified outcomes. Moreover, as the patients adopt this shared language, they are better able to grasp important health concepts and principles guiding their recovery.

Examples of shared vocabulary at the MIBH include bandwidth, threshold, grounding, place in space, fatigue, overwhelm, noise (visual, auditory, internal), clarity, and dissociation. These terms illustrate how our approach to patient-centered interdisciplinary care augments more traditional discipline-specific treatment language, improves communication between providers during interdisciplinary team interactions (eg, rounds and huddles), and enhances patients' understanding of their symptoms and individualized interdisciplinary care plan. Examples of patient care will be presented, demonstrating how providers can begin to conceptualize applying these concepts within their own interdisciplinary team.

Shared vocabulary, in our experience, can improve interdisciplinary team collaboration in a rehabilitation setting dedicated to mTBI. The use of such language can augment patient understanding of often-complicated health concepts and principles, as they relate to individualized treatment goals and recovery. The concepts embodied in shared language can help providers in outpatient treatment settings conceptualize the complexity of their patients' problems, collaborate more effectively with providers from other disciplines, and facilitate patient understanding of multifactorial breakdowns in function and participation.

## 0054

### **Behavioral Blends: A Neurobehavioral Approach to ABI Rehabilitation**

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Rehabilitation hospitals that facilitate the care of patients with traumatic brain injuries are faced with a number of challenges. Hospital staff must ensure patient safety, educate family members, and promote environments that aid patient progress. Patients who engage in high rates of problem behavior pose a unique challenge for hospital staff. Often, these patients require high levels of supervision and staffing ratios as low as 1-to-1. Craig Hospital-Rocky Mountain Regional Brain Injury System, located in Englewood Colorado, has embarked in reshaping their neurobehavioral program to include the principles of applied behavior analysis. This quality improvement initiative is being built off of the 30-year foundation laid by expert brain injury medical physicians, neuropsychologists, rehabilitation and restorative nurses, and the interdisciplinary team. This new structure seeks to establish a consistent and appropriate behavioral approach for patients with ABI. Part of this new structure is the addition of a Board Certified Behavior Analyst (BCBA) and Registered Behavior Technicians (RBT). The overall goal of this initiative is to enhance neurobehavioral care and outcomes for patients and families served. This presentation will cover the challenges endured by a categorical inpatient brain injury rehabilitation program and the pragmatic steps being taken to enhance this program.

## 0055

### **"Will the DNA Do the Talking": A Review of Pharmacogenomics Testing in Traumatic Brain Injury**

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Pharmacogenomics (PGx) testing has become increasingly popular in the last decade to optimize medication therapy. A traumatic brain injury (TBI) patient with severe spasticity requiring lower extremity fixators and baclofen intrathecal pump was in significant pain despite multiple high-dose pain medications. When PGx results were received highlighting the OPRM1 genotype, opioids were changed from oxycodone to morphine. Within days pain was significantly reduced. This case highlights the positive impact PGx testing can have on patient outcomes. In addition to pain, patients with a TBI can be at an elevated risk for seizures and depression. It is well documented that HLA alleles put certain patients at a higher risk for severe rashes with carbamazepine and phenytoin (Depondt, 2011). Carbamazepine has a packaging black box warning for patients with the variant HLA-B\*1502 allele for an increased risk of dermatologic toxicity. In addition, many antidepressant medications are metabolized through cytochrome P450 enzymes. By targeting metabolizer status (eg, intermediate, ultra-rapid), dose adjustments can be made to optimize effectiveness and minimize side effects (Hicks, 2015). Genotypes associated with receptors can also aid in predicting response, toxicities, and the likelihood of particular adverse effects (Bousman, 2018). This presentation will review the basics behind pharmacogenomics testing, how the Food and Drug Administration is involved, its potential use for seizures and depression in addition to the potential future of testing in traumatic brain injury.

**0056****Player Position-Specific Neurometabolic Changes in High School American Football Athletes: Linemen Vs Non-linemen**

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Currently, 1.6 million to 3.8 million sports-related concussions occur annually. Of these, 30% appear in males aged 15 to 19 years, and the highest incidence among all sports (51%) has been reported in football athletes. Due to the high incidence of concussions in collision sports, and concerns surrounding youth athlete participation, it is critical to further understand how collision sports affect brain physiology and health.

Fifty-five male high school athletes (ages 14-18 years) from 3 high schools were imaged using magnetic resonance imaging (MRI) at 4 timepoints: once before contact practice (Pre), twice during the season (In1, In2), and once after the season (Post). Specifically, magnetic resonance spectroscopy (MRS) was used to investigate the neurometabolic profiles of these individuals. MRS was accomplished using a standard sequence (TE/TR = 30/1500 ms, FOV = 30 mm<sup>3</sup>) and spectra were collected from 2 regions of interest: dorsolateral prefrontal cortex (DLPFC) and primary motor cortex (M1). Metabolites of interest included myo-inositol (Ins), N-acetyl-aspartate (tNAA), choline (tCho), creatine (tCr), and glutamate/glutamine (Glx). In addition, head acceleration events (HAEs) were monitored at each practice and game using the X2 Patch sensor. Collision event was recorded and reported as peak linear accelerations (PLAs); hits exceeding 20g were used in further analyses. Players were coded as linemen or nonlinemen. Multiple statistical tests were conducted using metabolite and HAE data; these data were analyzed by session and by position. Any *P* value less than .05 was deemed significant.

Analysis of HAEs revealed that linemen accrued more hits compared with nonlinemen, but nonlinemen had a higher average PLA. Second, neurometabolic analysis revealed statistically significant changes in metabolites by session and position. By session, Ins was significantly lower at In1, In2, and Post compared to Pre in the DLPFC. More strikingly, Ins, tCho, and tCr were significantly lower at In1, In2, and Post compared to Pre in M1 and Glx was significantly lower at In1 and In2. By position, nonlinemen dominated the significant decrease in Ins. Additionally, Ins and tNAA levels were lower in nonlinemen compared to linemen at Post. In M1, nonlinemen dominated the significant decrease in metabolites. However, linemen also exhibited significantly lower levels of Ins and tCho.

Decreased levels of these neurometabolites could be indicative of significant changes in brain homeostasis including localized swelling, tissue damage, energy crises, impaired ATP buffering, and impaired neurotransmission. Nonlinemen appeared to dominate the observed trends in these neurometabolites, suggesting that a small number of high-magnitude hits may impact brain homeostasis more-so than a large number of low-magnitude hits.

Taken together, high school football athletes exhibited significant alterations in neurometabolites, which should remain stable over time. Interestingly, nonlinemen appeared to dominate the significant trends that were observed, suggesting that fewer, high-magnitude hits may more severely impact brain homeostasis.

**0057****Assessment of Neurometabolic Changes in Middle School American Football Athletes**

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Currently, 1.6 million to 3.8 million sports-related concussions occur annually. Of all sports, the highest incidence has been reported in football athletes (51%). In addition, there had been a 143% increase in concussions between 2007 and 2014 in those aged 10 to 14 years. Due to the high incidence of concussions in collision sports, and concerns surrounding youth athlete participation, it is critical to further understand how collision sports affect brain physiology and health.

Twelve male middle school football athletes (aged 12-14 years) were imaged twice using magnetic resonance imaging—once before contact practice (Pre) and once after season commencement (Post). Specifically, magnetic resonance spectroscopy was used to investigate neurometabolic profiles of these individuals. MRS was accomplished using a standard sequence (TE/TR = 30/1500 ms, FOV = 30 mm<sup>3</sup>) and spectra were collected from 2 regions of interest: dorsolateral prefrontal cortex (DLPFC) and primary motor cortex (M1). Metabolites of interest included myo-inositol (Ins), N-acetyl-aspartate (tNAA), choline (tCho), creatine (tCr), and glutamate/glutamine. Metabolite data were compared with previously analyzed high school data. Statistical tests were performed to analyze data by session, position, and by level of play (middle school vs high school). *P* values less than .05 were deemed significant.

In the DLPFC, Ins and tCr were significantly lower at Post and position-wise analyses revealed that only linemen exhibited significantly lower levels. In M1, tNAA and tCho were significantly lower at Post in nonlinemen only. When comparing middle school and high school athletes, significant differences in neurometabolic concentrations were observed at Pre and Post. tNAA and tCr were significantly higher in high school athletes at Pre and Post compared to middle school athletes. In addition, tCho was also higher in high school athletes at Pre. In M1, Ins and tCr were higher in high school athletes compared to middle school athletes. tCho was also higher in high school athletes at Pre. It should be noted that comparisons were also made with noncollision high school control athletes. Metabolic levels in controls subjects were not significantly different from middle school athletes but were significantly lower than collision-sport-athlete levels.

Decreased levels of these neurometabolites could be indicative of significant changes in brain homeostasis including localized swelling, tissue damage, energy crises, and impaired neurotransmission. Both linemen and nonlinemen were observed to dominate the observed trends. Interestingly, high school athletes exhibited significantly higher levels of neurometabolites when compared to middle school football athletes and high school controls. This observation could be indicative of neurocompensatory mechanisms developed from cumulated damage in players with more years of experience.

In summary, middle school football athletes exhibited significant decreases in neurometabolites at postseason. In addition, high school athletes had comparatively higher levels of neurometabolites than middle schoolers and controls, which could be indicative of long-term neurocompensatory mechanisms.

**0058****Status of Trauma Care Facilities and Services in an Indian District: Need for Integrated and Coordinated Approaches**

Gopalkrishna G, Sukumar G, Ghosh S

*National Institute of Mental Health and Neurosciences, Bangalore, India***Introduction**

Neurotrauma is a leading public health problem accounting for an estimated 500 000 deaths and significant loss of DALY's every year in India. The incidence of injury deaths is estimated to be 32 and 42/100 000 population in India and in state of Karnataka. Well-organized trauma care systems are known to reduce trauma deaths by 25 to 30%.

**Objectives**

The present study was undertaken to assess trauma care systems and facilities in public and private healthcare facilities in a rural district of India (population–1.7 million) to identify current status of trauma care and to identify existing gaps in delivery of care.

**Methods**

A semistructured questionnaire was developed and validated to assess trauma care systems based on a mixed-methodology approach using both quantitative and qualitative methods. All 79 healthcare facilities in the district were covered and detailed information was collected by a trained professional using a specially developed mobile-based application for a handheld device. The assessment based on WHO Essential Trauma Care Guidelines focused on both macro- and microareas. A scoring system for each hospital (based on level of care and administrative procedures) was developed to identify the standards of care at each level. Ethical approval was obtained from the Institute Ethics Review Board.

**Results**

The results indicated that both public and private healthcare facilities were engaged in trauma care at the district level. Well-defined trauma care policy, guidelines, and protocols for management of neurotrauma patients were not available. Safe transport of injured through an ambulance service was restricted to the district center and rural areas experienced difficulties. Defined triage facilities were present in only select facilities of level 4 and level 3 hospitals. Physical infrastructure was available in many facilities; however, inpatient facilities for admission of neurotrauma patients were unavailable due to lack of trained human resources. Only 40% of doctors and 28% of nurses were trained in trauma care. CT scan facility was available in only 3 facilities and referral of brain-injured persons to the city was a common feature. Advanced care of brain-injured persons was present in the only medical college hospital (level 3) in the district. Our key informant interviews with managerial teams revealed governance and funding to be major factors for deficient trauma care services.

**Conclusions**

Trauma care systems and services are an urgent and unmet need in India and many less-resourced countries. Trauma care

in urban India is slightly better developed and rural areas lack the much required services. Comprehensive strengthening of trauma care systems at district levels along with systematic prevention programs is required to reduce deaths and disabilities.

**0060****Safety and Clinical Outcomes in Chronic Traumatic Brain Injury Patients: Pre-specified Interim Analysis of the STEMTRA Trial**Weintraub A<sup>1</sup>, Semenov I<sup>2</sup>, McAllister P<sup>3–6</sup>, Ikeda S<sup>7</sup>, Frishberg B<sup>8</sup>, Lai A<sup>9</sup>, Shinoda Y<sup>10</sup>, Cramer S<sup>11,12</sup>, Munin M<sup>13</sup>, Schwartz N<sup>14</sup>, Bates D<sup>15</sup>

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**Background**

Traumatic brain injury (TBI) is a major cause of permanent motor and cognitive impairment for which no effective treatments are available.

**Methods**

This 6-month prespecified interim analysis of the 1-year double-blind, randomized, surgical sham-controlled, phase 2 STEMTRA trial (NCT02416492) evaluated safety and efficacy of the stereotactic intracranial implantation of allogeneic modified bone marrow-derived mesenchymal stem cells (SB623) in patients with stable chronic motor deficits secondary to TBI. This international multicenter trial enrolled 61 subjects (mean age 34 years) from 27 sites in the United States, Japan, and Ukraine. Subjects underwent stratified randomization using baseline GOS-E score to assign in a 1:1:1:1 ratio to either  $2.5 \times 10^6$ ,  $5.0 \times 10^6$ ,  $10 \times 10^6$  SB623 cells or surgical sham procedure. Safety was assessed in all enrolled subjects. Efficacy analyses were conducted on the modified intent-to-treat population of randomized subjects completing surgery ( $n = 61$ ; SB623 = 46, sham controls = 15). Primary efficacy outcome was mean change from baseline in the Fugl-Meyer Motor Scale score (FMMS) of SB623-treated subjects compared to controls at 24 weeks.

**Results**

Significant improvement (LS mean [SE]) from baseline motor function was observed in FMMS at week 24 (8.3 [1.4]

SB623-treated patients vs 2.3 [2.5] control patients;  $P = .04$ ). Significantly more SB623-treated patients than control patients achieved the FMMS clinically meaningful threshold change of  $\geq 10$  points at week 24 (39.1% vs 6.7%,  $P = .04$ ), a threshold that was achieved by 53.3% of patients in the  $5.0 \times 10^6$  SB623 group; 100% of SB623-treated patients experienced treatment-emergent adverse events (TEAEs) compared with 93.3% of patients in the control group ( $P = .25$ ). At the time of this analysis, there were no dose-limiting toxicities or deaths. In both SB623-treated and control patients, 92.3% of TEAEs were unrelated or unlikely to be related to cell treatment, whereas 39.5% of SB623-treated and 36.9% of control patients experienced TEAEs that were possibly, probably, or definitely related to surgical procedure. Six treatment emergent serious adverse events (TESAEs) occurred in 4 (8.7%) SB623-treated patients, compared with 3 TESAEs in 3 (20%) control patients. All TESAEs recovered or resolved without sequelae except for a single SB623-treated patient who experienced worsening of balance, which was ongoing at the time of this analysis.

### Conclusion

SB623 cell implantation was safe and well tolerated, with no significant difference in adverse events between SB623 treatment and surgical sham controls. SB623 treatment was associated with improvement in motor function at 6 months.

## 0061

### Bridging the Gap: Facilitating Transition of Adolescents With Acquired Brain Injury to Adult Services

Xavier J

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### Introduction

The transition between pediatric and adult care for adolescents with disability is challenging, and often poorly managed. People who have sustained an acquired brain injury in childhood have similar aspirations as those without disabilities, but they have more difficulty accessing services that "limits opportunities for full participation in adult life." In 2014, only 3 clients transitioned to the adult team from the pediatric service. Poor success with transition of clients discharged from the pediatric service was evident. Transition clinics had been developed, but no formal process was in place. Consultations with carers and clinicians found that clients who did not engage in a transition process succumbed to poorer outcomes such as unemployment or limited employment choices and access to vocational training, poor self-esteem and self-confidence, lacking in self-care abilities, financial issues, drug, alcohol and gambling addictions, crime involvement, and mental health issues. Anecdotal experience was supported by general transition literature, but very little was found specific to brain injury. Attempt to obtain local data was difficult with no significant findings revealed.

### Objective

For all pediatric clients with moderate-to-severe brain injury requiring transition to adult services to have a transition plan in place within 9 months.

### Methods

To achieve this aim previous transition, clinics were evaluated using telephone surveys with clients and carers. Consultations were undertaken with past families. A project team was established to examine this data and current practice to identify the barriers to achieving successful transition for the young person. From the information gathered, the project team developed strategies to overcome these barriers and the transition process was amended to better facilitate this transition. The meeting format was more flexible to accommodate individual needs, a resource pack was developed, and the HEEADSSS assessment tool was used to assist with identifying rehabilitation goals and implement strategies. These changes were incorporated into formalized guidelines. Staff were provided with training to work effectively with adolescents.

### Results

Following the development of the formalized guidelines in the form of a flow chart, all eligible clients commenced the transition process. Clients attended at least one meeting, which included receiving explanation of the transition process and an information pack, and HEEADSSS assessment was undertaken. Goals were identified and an individual transition plan was developed. Clients were observed to exhibit greater confidence and develop increased responsibility for their rehabilitation. Adult team members developed more awareness of issues associated with adolescence that differ from working with adults, and increased collaboration between pediatric and adult teams has occurred.

### Conclusion

The development of a formalized transition process that incorporates the unique needs of adolescents with brain injury has increased retention of pediatric clients as they transition to adult services, and successful transitions have occurred.

## 0062

### Eye Tracking as a Biomarker for Concussion

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### Aim

Eye tracking tests to measure horizontal and vertical saccades as a proxy for neural deficits associated with traumatic brain injury (TBI) were evaluated in the present study.

### Methodology

A total of 287 participants reporting either no TBI, mild, moderate, or severe TBI participated in a suite of eye tracking tests to measure horizontal and vertical saccadic performance.

### Results

The horizontal saccades test offered a sensitivity of 0.77 and a specificity of 0.78, similarly the vertical saccades tests offered a sensitivity of 0.64 and a specificity of 0.65.

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## Conclusion

The results indicated that using eye-tracking technology to measure these metrics offers an objective, reliable, and quantifiable way of differentiating between individuals with different severities of TBI, and those without a TBI.

## 0063

### Elovanoids Are Neuroprotective in an Experimental Model of Traumatic Brain Injury

Bazan N<sup>1</sup>, Obenaus A<sup>2</sup>, Khoutorova L<sup>1</sup>, Mukherjee P<sup>1</sup>, Jun B<sup>1</sup>, Petasis N<sup>3</sup>, Belayev L<sup>1</sup>

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## Introduction

Traumatic brain injury (TBI) often leads to substantial cognitive impairments and permanent disability. Recently, we reported the discovery and characterization of a novel class of homeostatic lipid mediators termed elovanoids (ELV), which are derivatives from very long-chain polyunsaturated fatty acids (VLC-PUFAs,n-3) (Bazan NG, Mol. Asp. Med, 2018). ELVs display neuroprotective bioactivities both in vitro neuronal injury models and in vivo experimental ischemic stroke (Bhattacharjee et al, Science Advances, 2017). The purpose of this study was to determine whether treatment with ELV (ELV-34:6) would be beneficial in a rat model of TBI.

## Methods

Male SD rats (450-400 g) were anesthetized with 3% isoflurane, mechanically ventilated, physiologically regulated, and subjected to moderate right parieto-occipital parasagittal fluid-percussion injury. ELV (300 µg/per rat) or saline treatment was administered intravenously at 1 hour after TBI ( $n = 5-6$  per group). Behavior was evaluated on days 1, 2, 3, 7, and 14 after TBI; a grading scale of 0 to 12 was employed (normal score = 0, maximal deficit = 12). Ex vivo MRI using 11.7T MRI on day 14 was performed and regional brain volumes were obtained including CA1, CA3, dentate gyrus (DG). White matter connectivity (diffusion tensor imaging, DTI) was also analyzed.

## Results

The physiological variables were comparable between the 4 groups. There were no adverse side effects after ELV administration. Treatment with ELV improved behavioral scores on days 2, 3, 7, and 14 by 20%, 23%, 31%, and 34% compared to saline treatment, respectively. ELV treatment preserved hippocampal volume loss in the CA3 by 4% and DG by 10%. Whole brain tractography (brain and cerebellum) revealed that, in ELV, treatment resulted in increased numbers of cortical fibers at the injury site. We also observed increased tracts (streamlines) from the contralateral hemisphere to the ipsilateral corpus callosum (CC) (injured hemisphere) in the ELV-treated compared to the saline groups. Directionally encoded fractional anisotropy (FA) maps demonstrated preservation of the cortex and improved CC integrity.

## Conclusion

Thus, ELVs protect the integrity of the cerebral gray and white matter with accompanying improved behavioral

outcomes demonstrating promising its potential for clinical applications.

## 0064

### Intranasal Delivery of Elovanoids, Novel Class of Homeostatic Lipid Mediators, Improves Neurobehavioral Functions and Confers Neuroprotection on Rats With Traumatic Brain Injury

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## Introduction

Recently, we discovered and characterized of a novel class of homeostatic lipid mediators, termed elovanoids (ELV), which are derivatives from very long-chain polyunsaturated fatty acids (VLC-PUFAs,n-3). ELVs display neuroprotective bioactivities both in vitro and in vivo experimental ischemic strokes. We also found that intravenous administration of ELV is neuroprotective in experimental traumatic brain injury (TBI). The aim of this study was to examine whether intranasal ELV is an equally effective as intravenous ELV in a rat model of TBI. In addition, we examined whether ELVs can be detected in brain tissue after intranasal delivery.

## Methods

Male SD rats (309-482 g) were anesthetized with 3% isoflurane, mechanically ventilated, physiologically regulated, and subjected to moderate right parieto-occipital parasagittal fluid-percussion injury. ElovMix (32:2, 34:6 and acetyl form of ELVs) and saline were administered intranasal (10 µg in 10 µL per nostril; total 20 µg per rat) at 1 and 24 hours after TBI ( $n = 6-7$  per group). Behavior was evaluated on days 1, 2, 3, 7, and 14 after TBI; a grading scale of 0 to 12 was employed (normal score = 0, maximal deficit = 12). Ex vivo imaging of the brains was conducted on 11.7T MRI on day 14 for lesion volumes and edema (T2WI) and white matter connectivity (diffusion tensor imaging, DTI). In addition, 2 separate groups of rats were subjected to the same TBI model, treatments, behavioral evaluation and were sacrificed on day 3 and LC-MS/MS was used to detect the ELVs in the different areas of the brain.

## Results

The physiological variables were not different among the 4 groups. Body weight was increased by ELV treatment by 13% to 14% on days 3, 7, and 14. Total neurological score was improved by ELV by 37%, 45%, 41%, 41% compared to saline treatment on days 2, 3, 7, and 14. T2WI abnormalities, including cortical thinning and enlarged ventricles, were smaller in ELV-treated rats compared to the saline group. DTI metrics (fractional anisotropy, axial, radial and mean diffusivity) were extracted from 80 brain regions, including the hippocampus. ELVs were detected in the ipsilateral cortex of ELV-treated rats on day 3.

## Conclusion

We have shown that the intranasal administration of ELVs provides high-grade neuroprotection and can be selectively delivered to the brain. Our study opens avenues of exploration of ELVs as a possible therapeutic approach for TBI.

## 0066

### Maternal Mindfulness Training During Pregnancy Has Positive Effect on Executive Abilities in Preschool Children

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## Background

It is known that maternal anxiety during pregnancy can affect child outcomes. We have shown that maternal mindfulness training during pregnancy has positive effect on the development of executive, language, and memory abilities in 6- to 7-year-old children (Kiselev, Volik, 2017). The goal of this study was to evaluate the effect of the maternal mindfulness training during pregnancy on executive abilities in 5-year-old children.

## Methods

In the current study, we included 22 women who participated in the maternal mindfulness training during pregnancy. The control group included 22 women who did not participate in this training during pregnancy. When the offspring of the target pregnancies were 5 years of age, their executive abilities were assessed by 4 subtests from NEPSY (Auditory Attention and Response Set, Visual Attention, Design Fluency, Statue).

## Results

One-way ANOVA was used to reveal group differences in performing executive subtests. We have revealed the significant differences ( $P < .05$ ) between groups in 3 subtests from NEPSY (Visual Attention, Design Fluency, Statue). Children from the experimental group had better performance in these subtests.

## Conclusion

The obtained results suggest that maternal mindfulness training during pregnancy may have positive effect on the development of executive abilities in 5-year-old children.

## Funding

The research was supported by Act 211 Government of the Russian Federation, agreement 02.A03.21.0006.

## 0067

### Evaluation of the Effectiveness of Early Education Provided to Concussion Patients at the Hull-Ellis Concussion and Research Clinic

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## Background

Concussions affect more than 150 000 Ontario residents per year. Early education and guidance are critical components of care for concussion patients. Therefore, a standard approach to postconcussion education is necessary to improve symptom management in patients. Most research has focused on athletes and youth with a concussion; however, very little has focused on the education provided to the general adult population.

## Objectives

The purpose of this study was to evaluate the effectiveness of the concussion education provided by the Hull Ellis Concussion and Research Clinic to patients of the general population and to identify areas for improvement.

## Methods

Patients (18-85 years) were recruited at a rapid access clinic at the Toronto Rehab Institute within 1 week of concussion diagnosis made in a referring emergency department. Demographic and injury characteristics were collected. The patients were administered a questionnaire to survey general knowledge of concussion at weeks 1 and 8 after injury. All participants provided written informed consent.

## Results

At week 1, 334 participants completed the education questionnaire and 196 participants completed the questionnaire at week 8. There was a significant increase in average total score on the questionnaires across time (week 1 72% vs week 8 74% correct;  $P = .03$ ). People with higher education level ( $P = .03$ ), and preexisting anxiety ( $P = .02$ ) and depression ( $P = .0009$ ) had higher scores on the concussion knowledge questionnaire administered at week 1. However, participants with correct beliefs about no typical permanent brain damage following a concussion had on average lower anxiety scores ( $P = .008$ ) on psychological measures and lower symptom scores ( $P = .017$ ) on the Sport Concussion Assessment Tool 5, administered at week 2. No significant relationship was found between recovery/return to patients' preinjury baseline as deemed by a clinic physician by week 8 and total scores on the education questionnaire at either time of administration.

## Conclusions

The education provided to patients at the clinic did improve patients' knowledge of concussion though standardization of the education provided may further increase patients' knowledge of concussion. Prior knowledge of concussion does not affect recovery in the general adult population. Education may be further targeted toward patients with preexisting anxiety and depression to help this patient population better understand concussion recovery.

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**0068****Mindfulness Training Reduces Prenatal Maternal Stress**

Kiselev S

*Ural Federal University, Ekaterinburg, Russian Federation***Background**

Prenatal maternal stress is an important phenomenon. Evidence on this topic suggests that women who experience high stress during pregnancy are more likely to deliver preterm infants. The goal of this study was to evaluate the influence of mindfulness training on stress reduction during pregnancy.

**Methods**

In the current study, we included 23 women who participated in the mindfulness training during pregnancy. The control group included 23 women who were in the reading control condition during pregnancy. Women were eligible to participate if they were experiencing elevated levels of perceived stress or pregnancy-specific anxiety (PSA), as indicated by responses to the Perceived Stress Scale and the PSA scale on a screening questionnaire. Women enrolled between 12 and 26 weeks' gestation were randomly assigned to either the mindfulness training or to the reading control condition. Effects of training were analyzed by means of an ANOVA with repeated measurements.

**Results**

ANOVA has revealed ( $P < .05$ ) that women in the mindfulness intervention experienced larger decreases from pre- to postintervention in pregnancy-specific anxiety and pregnancy-related anxiety than participants in the reading control condition.

**Conclusion**

This pilot study suggests that mindfulness training during pregnancy may effectively reduce pregnancy-related anxiety. However, it is necessary to do further research on the impact of mindfulness training on stress reduction during pregnancy.

**Funding**

The research was supported by Act 211 Government of the Russian Federation, agreement 02.A03.21.0006.

**0069****Positive Effect of Body-Oriented Therapy on Executive Abilities in Children With ADHD**

Kiselev S

*Ural Federal University, Ekaterinburg, Russian Federation***Objectives**

It is known that children with attention-deficit hyperactivity disorder (ADHD) have deficit of executive abilities. The

goal of this study was to reveal effect of body-oriented therapy on executive abilities in ADHD children. Particularly we compared the efficacy of 2 methods of treatment (body-oriented therapy for children vs conventional motor exercises) in a randomized controlled pilot study.

**Methods and Participants**

Fourteen children with ADHD between 5 and 6 years of age were included and randomly assigned to treatment conditions according to a  $2 \times 2$  cross-over design. The body-oriented therapy included the exercises from yoga and breathing techniques. To assess the executive functions and attention in children, we used 5 subtests from NEPSY (Tower, Auditory Attention and Response Set, Visual Attention, Statue, Design Fluency). Effects of treatment were analyzed by means of an ANOVA for repeated measurements.

**Results**

The ANOVA has revealed ( $P < .05$ ) that for all 5 subtests on executive functions and attention the body-oriented therapy were superior to the conventional motor training, with effect sizes in the medium-to-high range (0.49-0.89).

**Conclusions**

The findings from this pilot study suggest that body-oriented therapy can effectively influence the executive abilities in preschool children with ADHD. However, it is necessary to do further research into the impact of body-oriented therapies on the prevention and treatment of ADHD in children.

The research was supported by Act 211 Government of the Russian Federation, agreement No 02.A03.21.0006

**0070****Positive Effect of Visuospatial Training on Language Abilities in Children With SLI**

Kiselev S

*Ural Federal University, Ekaterinburg, Russian Federation***Background**

It was shown that children with specific language impairments (SLI) have deficits not only in producing and understanding language but also in visuospatial abilities (Kiselev et al, 2016). We assume that training programs that are aimed to develop the visuospatial abilities can help children with SLI. The goal of this study was to assess the impact of visuospatial training on the language abilities in children with SLI.

**Participants and Methods**

The participants were 25 children aged 7 to 8 years (mean age = 7.8) with SLI. Children were randomly assigned to the intervention and comparison groups. Children from the intervention group participated in 36 weeks of visuospatial training. This program trains the child to do different visuospatial exercises both on motor and cognitive levels. This program is built on the conceptual framework derived from the work of Luria's theory of restoration of neurocognitive functions

(Luria, 1963, 1974). We used the subtests from Luria's child neuropsychological assessment battery to assess language abilities in children before and after the intervention period.

## Results

Analysis of covariance tested the effect of visuospatial training program on 5 language subtests from Luria's child neuropsychological assessment battery. Group differences ( $P < .05$ ) were found for subtests that assess understanding prepositions that describe the spatial relations between objects. Posttest mean for the intervention group was significantly ( $P < .05$ ) greater than the control group.

## Conclusion

It can be assumed that visuospatial training in children with SLI benefits specific language abilities for understanding sentences with spatial prepositions.

## Funding

The research was supported by Act 211 Government of the Russian Federation, agreement no. 02.A03.21.0006.

## 0071

### Impact of Motor Sequencing Training on Motor Abilities in Children With Hyperactivity Disorder

Kiselev S

*Ural Federal University, Ekaterinburg, Russian Federation*

## Background

It is known that children with hyperactivity disorder have deficit in motor abilities. It is of great significance to receive the evidence for efficiency of different training programs that are aimed to help children with this disorder. The goal of this study was to assess the impact of 12 weeks of motor sequencing training on motor abilities in children with hyperactivity disorder.

## Participants and Methods

The participants were 20 children aged 6 to 7 years (mean age = 6.2 years) with hyperactivity disorder. Children were randomly assigned to the intervention and comparison groups. Children from the intervention group participated in 12 weeks of motor sequencing training. This program trains the child to plan, sequence, and process information more effectively through repetition of goal-directed movements. This program is built on the conceptual framework derived from the work of Luria's theory of restoration of neurocognitive functions (Luria, 1963, 1974). The Luria's child neuropsychological assessment battery was administered before and after the intervention period.

## Results

Analysis of covariance tested the effect of motor training program on 4 scales of the Luria's child neuropsychological assessment battery: Executive scale; Motor scale; Visuospatial

scale; Memory scale. Group differences ( $P < .05$ ) were found for the Motor scale. Posttest mean for the intervention group was significantly ( $P < .05$ ) greater than the control group.

## Conclusion

It can be assumed that motor sequencing training in children with hyperactivity disorder benefits motor abilities.

## Funding

The research was supported by Act 211 Government of the Russian Federation, agreement no. 02.A03.21.0006.

## 0072

### Baseline Characteristics of Participants After Stroke Enrolled in an Intensive Lifestyle Intervention to Promote Weight Loss

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## Objective

To describe the (1) weight and medical history and (2) physical activity and eating behaviors/habits of a sample of people after stroke enrolled in a 12-month intensive lifestyle intervention. Weight gain after stroke significantly restricts functioning and independence and greatly increases the risk of chronic diseases such as diabetes, metabolic syndrome, pulmonary disease, heart disease, and recurrent stroke. It is important to understand the weight loss history of people after stroke if intensive lifestyle interventions are to effectively meet individuals' needs.

## Methods

Participants included people enrolled in a 12-month weight loss program who were  $\geq 12$  months poststroke, had a body mass index (BMI)  $\geq 25$ , were between 18 and 85 years old, had any type of stroke, and had physician's clearance to participate. Baseline assessments included quantitative questions about participants' weight, medical history, and physical activity, and eating behaviors/habits.

## Results

The sample included 42 participants (mean age =  $57.4 \pm 12.8$  years), who were  $4.2 \pm 4$  years since injury, primarily male (54.8%), reported having a slight to moderate disability (64.3%), and mild cognitive impairment (mean score =  $23.6 \pm 5.3$  on Montreal Cognitive Assessment). Mean weight was  $210.8 \pm 41.4$  lb, average BMI was 34.0 (considered obese), waist circumference  $42.8 \pm 4.6$  inches, 20% had a maternal/paternal history of diabetes, and participants had a 54.8% higher risk of metabolic syndrome than the general population. Individuals' mean weight at the time of stroke was  $190 \pm 50.9$  lb, indicating an average weight gain of 36 lb since the initial stroke. Hypertension (64.3%) and high cholesterol (61.9%) were the most frequently reported health conditions and resting metabolic rate was  $1349 \pm 381.9$  calories. Participants were in the "preparation" stage of behavior change, as they reported

having “definite plans” to improve eating and physical activity behaviors and reported completing  $183.5 \pm 198.7$  minutes of total physical activity per week. Finally, participants “slightly agreed” that they had already established positive eating and physical activity habits.

## Conclusion

Weight gain after stroke further increases an individual’s risk of morbidity and mortality. Our data indicate that on average participants gained 19% weight after their stroke and, not surprisingly, were at greater risk of metabolic syndrome than the general population. Our next step is to examine the efficacy of an evidence-based weight loss intervention, the Group Lifestyle Balance program, on weight, biomarkers, functional, and patient-reported outcomes. The intervention was previously modified by our team to meet the unique needs of people after stroke. The randomized controlled trial study design will be discussed.

## 0073

### Marcus Institute for Brain Health: Two Years of Clinical Experience

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The Marcus Institute for Brain Health (MIBH) was inaugurated in 2017 as an interdisciplinary treatment program for military Veterans and other adults who experience persistent postconcussion symptoms and related behavioral health concerns. At the heart of this rehabilitation program are the many clinical modalities that each uniquely contributes to healing, and patients present with a wide array of symptoms that require a comprehensive approach. In order to best treat these patients, the MIBH is founded on the concept of an Integrated Practice Unit (IPU) with a highly integrated and co-located team of providers. Most care is provided by one modality at a time, but in some cases transdisciplinary care is preferred, in which 2 modalities engage with a patient in the same treatment session.

MIBH disciplines include behavioral neurology, physical therapy, speech-language pathology, neuropsychology, behavioral health, integrative therapies, healing arts, case management social work, clinical pharmacy, animal assisted therapy, and Veterans relations. In all modalities, we have found that knowledge of and sensitivity to military culture are crucial for effective treatment.

In the IPU model, patients come to the MIBH for a 3-day evaluation, beginning with an interdisciplinary meeting with the patient called the “Fishbowl,” during which patients can “tell their story” once to the entire team. Many patients then return for treatment, the 3-week Intensive Outpatient Program (IOP). During the IOP, patients are engaged in 8 hours of treatment (individual and group) each weekday, and Equine therapy on Saturdays. Providers spend time each day discussing patients’ treatment, their progress, and barriers to improvement. These meetings occur either in 15-minute huddles

(3 mornings per week) or 1-hour rounds (twice weekly). Family members participate in specific family programming during the last 3 days of the IOP. At the conclusion of the IOP, all staff, patients, and involved family members participate in a commencement ceremony.

To date, the MIBH has evaluated 135 patients, 69 of whom have completed the 3-week IOP. Within our patient population, 93% are male and 93% are military veterans. Average age is 41 years (min = 24 and max = 72). All patients (100%) reported multiple mTBIs with either alteration of consciousness and/or loss of consciousness. Outcome data are collected at time of application, at the beginning of evaluation, at the beginning and the end of IOP, and at 1-, 6-, and 12-month follow-up intervals. Preliminary data will be available for discussion at the time of the poster presentation.

## 0074

### An Interdisciplinary Approach to Assessment of Readiness for a Behind the Wheel Driving Evaluation Following Brain Injury

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Driving is a complex activity integrating cognitive, physical, and emotional demands. The behind-the-wheel evaluation is the gold standard for determining whether a person can be medically cleared to return to driving after a brain injury; however, this can be a costly and high stakes endeavor if a patient is not set up for success. An interdisciplinary predrive screen may be helpful to determine readiness for a behind-the-wheel evaluation as well as help mitigate cost and safety risks associated with the evaluation for individuals with BI. This poster aims to present retrospective data that utilizes subjective and objective measures from physical, occupational, and speech therapies obtained in a predrive screen to determine readiness for participation in a behind-the-wheel evaluation. This information can be used by the interdisciplinary team to provide education and recommendations to the patient that may set them up for success when completing the behind-the-wheel evaluation. The predrive screen may additionally predict the time required to pass the behind-the-wheel evaluation, which may decrease the financial burden to the patient as well as optimize staff resource utilization. Retrospective data including visuomotor coordination, attention, visual processing speed, and self-awareness will be presented from interdisciplinary predrive screens completed at Craig Hospital during the years 2018-2019.

## 0075

### Establishment of a Patient-Centered Outcomes Research Network for Individuals With TBI and Neuropsychiatric Symptoms

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## Background

There is scant literature on patient-centered outcomes research (PCOR) in the area of neuropsychiatric symptoms following traumatic brain injury (TBI). While very few studies have utilized person-centered outcome methods and practices, there are even fewer studies determining how individuals and families dealing with both neuropsychiatric symptoms and traumatic brain injuries can improve overall care and recovery.

## Aims

The overarching goal of this project was to establish a group comprised of a variety of TBI stakeholders to: (1) determine facilitators and barriers in the management of neuropsychiatric symptoms after TBI; (2) identify strategies for maintaining a TBI PCOR network (ie, a network of TBI stakeholders that conducts patient-centered research to address questions important to TBI stakeholders and the community); (3) enumerate important research topics related to TBI neuropsychiatry; and (4) highlight needed policy changes related to neuropsychiatric symptoms after TBI.

## Methods

Twenty-nine TBI stakeholders participated in 5 focus group discussions. Qualitative analyses were conducted both manually and using Dedoose software by identifying and coding general themes on the data obtained from focus group discussions.

## Results

Participant-identified barriers included stigma associated with experiencing neuropsychiatric symptoms and poor insurance coverage for management of neuropsychiatric symptoms. Identified facilitators included treatment focused on education of neuropsychiatric symptoms during the acute trauma period and having a comprehensive caregiver plan. Best strategies for maintaining the TBI PCOR network included having a well-defined project, continued regular meetings, and on-going education of network members. The 3 major research topics included relationship between TBI and aging, factors influencing positive outcomes after TBI, and addiction before and after TBI. Needed policy changes included making TBI mental health education accessible to all stakeholders and improving affordability and accessibility of TBI neuropsychiatric care.

## Conclusion

TBI stakeholders identified several important facilitators of care for neuropsychiatric symptoms after TBI and suggested research topics and best practices for conducting PCOR in TBI populations.

## 0077

### Estimating the Probability of Pediatric Abusive Head Trauma Pre- and Post-abuse Evaluation

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## Introduction

The PediBIRN (Pediatric Brain Injury Research Network) 4- and 7-variable clinical prediction rules facilitate patient-specific estimation of abusive head trauma (AHT) probability pre- and postabuse evaluation, respectively. We sought to measure the correlation between their serial estimates of AHT probability, and to identify patients with disparate pre- and postevaluation estimates of AHT probability. We hypothesized that PediBIRN pre- and postevaluation estimates of AHT probability would correlate positively and strongly.

## Methods

Retrospective analysis of an existing, de-identified dataset containing prospective, historical, clinical, and radiological data regarding 322 young, acutely head-injured children who underwent skeletal survey and retinal examination while hospitalized for intensive care across 18 sites between 2010 and 2013. Patients had previously been sorted as AHT vs non-AHT based on definitional criteria. Outcome measures included the correlation (Pearson's *R*) between PediBIRN pre- and postevaluation estimates of AHT probability, and the percentage of patients with preevaluation estimates of AHT probability < .50 whose postevaluation estimates of AHT probability were > .50.

## Results

PediBIRN pre- and postevaluation estimates of AHT probability were positively and strongly correlated (Pearson's *R* = 0.89). Fifteen (13%) of 115 patients with preevaluation estimates of AHT probability < .50 had postevaluation estimates > .50. Applied as a directive clinical decision rule instead of a prediction tool, the PediBIRN-4 would have recommended thorough abuse evaluations in 14 of these 15 patients.

## Conclusion

PediBIRN pre- and postevaluation estimates of AHT probability were positively and strongly correlated in this patient population. Application of the PediBIRN-4 as a directive decision rule—rather than a prediction tool—could reduce missed cases of AHT.

## 0078

### Applying Cluster Analysis to Explore Physicians' Diagnostic Reasoning Regarding Pediatric Abusive Head Trauma

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## Objective

To sort 500 young, acutely head-injured patients into 2 groups based solely on their clinical and radiological findings, excluding consideration of historical data and physicians' final diagnoses of abusive (AHT) versus non-abusive head trauma (non-AHT). We hypothesized that sorting would mirror physicians' final diagnoses.

## Methods

Unsupervised cluster analysis via K-means clustering of an existing, de-identified, cross-sectional, multicenter dataset;

[www.headtraumarehab.com](http://www.headtraumarehab.com)

sorting 500 young, acutely head-injured patients hospitalized for intensive care into 2 clusters; based solely on 32 reliable ( $\kappa > 0.6$ ), dichotomous, clinical, and radiological variables; using probability ( $P$ ) values and odds ratios (OR) to identify variables most predictive of sorting into each cluster.

## Results

Variables most predictive ( $P < .0001$  and  $OR > 10$ ) of sorting into cluster 1 ( $n = 203$ ) included acute respiratory compromise, seizures, and encephalopathy; encephalopathy lasting  $> 24$  hours; bilateral and/or interhemispheric subdural hemorrhage, brain hypoxia/ischemia/swelling, and an abnormal retinal examination. Variables most predictive ( $P < .0001$  and  $OR > 10$ ) of sorting into cluster 2 ( $n = 297$ ) included simple linear parietal skull fracture and epidural hematoma. Physicians had previously diagnosed 186 (92%) of cluster 1 patients with AHT and 215 (72%) of cluster 2 patients with non-AHT ( $P < .001$  based on  $\chi^2$  test).

## Conclusion

Cluster analysis separated the study population into cohorts that mirrored physicians' final diagnoses of AHT versus non-AHT. These results support a conclusion that physicians are identifying a latent explanation for their patients' clinical and radiological findings. While not proving that this latent explanation is abuse, these results validate physicians' current diagnostic approach for sorting victims of AHT versus non-AHT.

## 0079

### Variations in Amantadine Prescribing Practices for the Native Alaskan Population

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## Background

Research into traumatic brain injury (TBI) has increased significantly. Amantadine is a dopaminergic agonist and weak antagonist of the NMDA-type glutamate receptor that is consistently prescribed to promote neurorecovery, regulate wakefulness, and treat common symptoms of mild to severe acquired and traumatic brain injury. In 2014, a brain injury clinic was established in Alaska with a goal of creating a brain injury network and treatment model for the state. It was soon noted that, when given amantadine, patients with Alaska Native heritage were unable to tolerate standard dosing and timing recommendations. They would gain the expected cognitive benefits from usage but experienced an atypical response: amantadine caused significant drowsiness and had to be taken prior to sleep with a reduced dosing for TBI recovery. Once dosing and timing was changed, the associated side effects were reduced while maintaining cognitive improvements generally seen with amantadine administration after TBI. This effect was also seen, to a lesser extent, with patients of Native heritage from other areas of the United States.

## Methods

A comprehensive literature review of PubMed was conducted, searching for keywords including "Native Alaskan"

with amantadine, bromocriptine, modafinil, memantine, ketamine, and MDMA, respectively. The searches yielded zero results. When expanding the search to include Native Americans, none were related to TBI, and only one publication discussed prescribing variances for dementia medications with a decreased rate for Native Americans. Some studies showed links between NMDA receptors with alcohol and depression, as well as genetic variances among Native tribes, but nothing specific to TBI, amantadine, or other medications listed above.

## Results

Patients with Alaska Native heritage, and to a lesser extent, those with Native American heritage, present significantly different responses to amantadine treatment after TBI compared to treatment responses of non-Native populations. This led to clinical- and system-wide changes within the state of Alaska regarding prescribing practices for amantadine to the native population. After an extensive review of the literature, it was concluded that the response of Native Alaskans to amantadine has not been previously documented, nor are there studies linking any medications that would allow parallel correlation.

## Conclusions

Amantadine has benefits for patients in the Native American populations; however, the timing and dosing of this medication needs to be adjusted, given side effect profiles evident in the Alaska Native population. Clinical experience has led to changes within the brain injury network and in provider education in the state of Alaska. Those changes may benefit other locations that provide treatment to local Native populations affected by this phenomenon. More research is needed to determine the effects of NMDA and dopaminergic medications in Native populations.

## Reference

[https://docs.google.com/document/d/1rU3jxf4QH6luGjAUcPw6tawLktNjUY6Z\\_gLrLvzz8EE/edit?usp=sharing](https://docs.google.com/document/d/1rU3jxf4QH6luGjAUcPw6tawLktNjUY6Z_gLrLvzz8EE/edit?usp=sharing)

## 0082

### Brain-Derived Neurotrophic Factor Preserves the Functional Activity of Neural Networks in the $\beta$ -Amyloidopathy Model in Vitro

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Alzheimer's disease (AD) studies are becoming more relevant year by year. The reason of such importance associated with an increase in life expectancy of the population and accumulation of information about AD polyethiology. Alzheimer's disease (AD) is a widespread chronic neurodegenerative pathology characterized by synaptic dysfunction, partial death of neurons, cognitive and memory impairments, etc. It is currently considered that the major hallmarks of AD are the presence of extracellular senile amyloid plaques formed by various types of amyloid proteins ( $A\beta$ ), and the formation and accumulation of intracellular neurofibrillary tangles. However, there is still no effective therapeutic method for AD correction

and relevant experimental models for studying the changes in neural network activity, the features of intercellular signaling, and drugs effects on the functional activity of nervous cells during AD development.

In this work, we have created an experimental model of amyloidopathy using primary hippocampal cultures. The model is based on chronic application of amyloid beta 1-42 (A $\beta$ 1-42). Chronic application of A $\beta$ 1-42 allows quickly simulation of significant neurodegenerative changes in the primary hippocampal cultures, leading to sharp impairments in neural network calcium activity and increased cell death. Using this model and multielectrode arrays, we studied the influence of amyloidopathy on spontaneous bioelectrical neural network activity. We showed that the formation of amyloid conglomerates decreased the number of network bursts and spikes in a burst and disrupted the spatial network structure manifested in a decrease of the number of key network elements (hubs) and the number of connections between the network elements. Our study also revealed that application of BDNF in the form of recombinant protein and in a case of its hyperexpression by an adeno-associated virus vector partially prevents amyloidopathy-induced neurodegenerative phenomena. The use of BDNF maintains cell viability and spontaneous bioelectrical and calcium network activity in primary hippocampal cultures. The internal functional structure of neural networks, the number of hubs, and connections between active elements in the network were partially preserved.

### Funding

This research was funded by a grant from Russian Science Foundation (RSF), project no. 18-75-10071 in BDNF effects studying and by Grant of the President of the Russian Federation (MK-1485.2019.4) in the development of the model of amyloidopathy.

## 0085

### Progress on Implementing Provincial Concussion Clinical Practice Guideline Recommendations

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In 2018, the Ontario Neurotrauma Foundation (ONF) released the third edition of the Guideline for Adults with Concussion/Mild Traumatic Brain Injury and Persistent Symptoms. Versions of these materials have been developed for healthcare providers, patients, and families, in both English and French. This Clinical Practice Guideline (CPG) includes 102 evidence-based recommendations covering areas ranging from diagnosis and management to addressing persistent symptoms and return-to-activity considerations. Twenty-eight of these have been identified as key recommendations to prioritize for implementation.

A preimplementation survey was conducted to assess the degree of implementation of CPG recommendations deemed to be "key" by the guideline development team. Levels of priority and feasibility, along with main obstacles and gaps, were

identified. Across the province, only 4 of these recommendations were reported as fully implemented; the remaining recommendations ranged from 49% to 97% implemented. Of the 10 least implemented key recommendations, on average only 57% were deemed to be a high priority.

Dedicated funding and support for implementation have been shown to be critical factors in facilitating practice change. Given the broad setting of concussion management in Ontario, the ONF initiated a call for catalyst grant applications to be awarded to concussion service providers across Ontario for projects moving CPG recommendations into everyday practice. The catalyst funding supported service providers to allow for engagement in the planning and initial implementation of evidence-based practice change consistent with the CPG. The proposed practice changes were required to be sustainable without reliance on continued outside funding. The projects involved improving capacity building in a range of disciplines in both the fee-for-service and public healthcare sectors.

Projects included integrating a physician assistant model into current clinical practice, piloting group self-management education sessions, customizing symptom management resources, mobilizing and implementing practical skill-based clinical interventions, and building capacity among clinicians and local interdisciplinary health networks. The ONF's Concussion Guideline team gave grant recipients the autonomy to pursue their project goals, while offering support through expertise in implementation science strategies to ensure these projects became sustainable and generalizable.

Implementation processes and outcomes, along with clinical evaluation data from these projects, will be discussed. Following the release of the ONF's Concussion Guideline, the Foundation has also been working with professional organizations to build capacity among their members, with local health teams to develop interdisciplinary care networks, and with individual clinicians to build implementable tools and resources. These additional knowledge mobilization activities will also be addressed.

## 0086

### Improving Outcomes for Students With Acquired Brain Injury: A Systematic Search of Available Educator Resources

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### Background

Although acquired brain injury (ABI) is recognized as the leading cause of disability in children and impacts a significant number of Canadian students, it is not an area of exceptionality within Ontario schools and educators are not provided formal ABI training at the preservice or practicing levels. As such, students with ABI are typically poorly identified within the school system, leading to insufficient educational supports and programming. A recent needs assessment confirmed that Ontario educators have low to minimal knowledge of ABI but are interested in increasing their capacity and knowledge of this topic. They also expressed the need for a short, engaging eLearning module to improve educator knowledge and awareness of ABI.

## Objective

To complete a rigorous environmental scan of gray literature to inform the development of an educator eLearning intervention module and to determine what free, online resources exist for educators regarding supporting children with ABI in the classroom.

## Design

Key websites were identified and reviewed for resources focused on supporting students with ABI in schools. An internet-based search supplemented the review of websites to identify resources pertaining to ABIs other than concussion. The iterative online search process mimicked the steps an educator may take to locate information regarding ABI. Identified resources were evaluated based on expert-informed inclusion/exclusion criteria.

## Results

After greater than 100 hours of searching, 84 resources met inclusion criteria. Resources predominantly focused on traumatic brain injury (57/84), compared to nontraumatic brain injury (2/84) and general ABI (25/84). Only 27% of the resources were created in the context of the Canadian education system ( $n = 23$ ). A review of Canadian resources revealed that no resources exist regarding nontraumatic ABI or moderate/severe traumatic brain injury (TBI).

## Conclusions

The environmental scan revealed a lack of resources for Canadian educators regarding pediatric ABI, especially in the areas of nontraumatic ABI and moderate/severe TBI. Resources must be developed for Canadian educators to support students with nontraumatic ABI and moderate/severe TBI. Future resources for Ontario educators should also focus on how to provide support for students with ABI without the recognition of ABI as a category of exceptionality. The lack of user-driven, accessible resources relevant to the Canadian education system demonstrates a need for the development of an eLearning intervention to raise knowledge and awareness of ABI and support the movement of evidence-based knowledge into the hands of educators.

## 0087

### Relations of Social Inferencing Skills After Brain Injury and Attributions of Intent, Hostility, and Blame

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## Objective

People with traumatic brain injury (TBI) are at risk for negative attribution bias, which is the tendency to ascribe disproportionate or extreme judgments of intent, hostility, and blame to others' actions. Recent research found negative attributions to be related with social inferencing. However, social inferencing is a complex construct and it is unknown which

aspects are most relevant to negative attributions. Thus, the main study objective was to examine specific components of social inferencing in relation to judgments made regarding the degree of intent, hostility, and blame persons with TBI assigned to others' actions. Specific aims were to examine relations of negative attributions with (1) misinterpreting neutral expressions on an emotion perception test, (2) accuracy of inferences made about what others are doing, saying, thinking, and feeling, and (3) accuracy in making inferences from exchanges that are sincere, sarcastic, or a lie.

## Design

Prospective cross-sectional study.

## Setting

Two rehabilitation hospitals that treat TBI.

## Participants

One-hundred and five adults with complicated mild to severe TBI and 105 healthy controls (HC), frequency matched for age and sex.

## Interventions

Not applicable.

## Main Outcome Measures

Epps' scenarios describing characters' hypothetical behaviors were used to rate the degree of perceived intent, hostility, and blame attributions using a 9-point scale. The Awareness of Social Inference Test (TASIT) is a video-based assessment that measures emotion perception (part 1) and social inferences (what a character is doing, thinking, saying, and feeling) from characters' interpersonal exchanges that were sincere, sarcastic, or lies (parts 2 and 3).

## Results

Participants with TBI had significantly lower scores on the TASIT and more intense attribution ratings on the Epps than HCs. Weak but significant correlations were found between interpreting neutral expressions (TASIT part 1) and the degree of perceived intent and hostility to Epps' scenarios ( $P < .01$ ). Most Do, Say, Think, and Feel inferences (TASIT Part 3) were significantly, moderately to weakly correlated with attributions to Epps' scenarios ( $P < .05$ ), except Blame and Think. Accurate Do, Say, Think, and Feel inferences from sincere exchanges were associated with hostility and blame ratings to Epps scenarios; inferences from sarcasm were associated with Epps attributions of intent and hostility; and inferences from lies were associated with intent, hostility, and blame attributions. Social inferences (TASIT part 3) were associated with emotion perception (TASIT part 1) ( $P < .001$ ).

## Conclusion(s)

In general, the ability to accurately interpret neutral expressions and infer what others are doing, saying, thinking, and feeling is related to how intentional, hostile, and blameworthy participants with TBI perceived others' behavior. Targeting these types of social inferences may be relevant to changing negative attribution perceptions in the TBI population.

**0088****Teaching Educators About Acquired Brain Injury: Building a User-Driven eLearning Technology**

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**Background**

Although acquired brain injury (ABI) is the leading cause of disability among children, it is not an area of exceptionality within Ontario schools and educators are not provided formal ABI training at the preservice or practicing levels. As such, students with ABI are typically poorly identified within the school system, leading to insufficient educational supports and programming. The present study aims to use integrated knowledge translation principles to close the educator knowledge gap by creating an ABI eLearning intervention tool for Ontario educators.

**Objective**

To use Kern's 6-Step Model for Curriculum Development to create an innovative, user-driven eLearning intervention technology for educators about ABI that respects and includes the voices of interdisciplinary stakeholders (youth, families, clinicians, and educators). The present stage of research sought to evaluate the usability of the eLearning module prior to pilot testing.

**Design**

The eLearning intervention curriculum build consisted of 2 steps: (1) expert consultation to develop curriculum goals and objectives using the results from the educator needs assessment and the systematic search of available educator resources and (2) expert cocreation of the eLearning intervention content and method of presentation. The usability testing will be completed through conducting cognitive interviews based on the "think-aloud" method and exit interviews. Data gathered through the interviews will be analyzed using thematic content analysis. The purpose of these interviews will be to gather information from intended users to improve the module prior to pilot testing. Educator participants will be recruited until data saturation is reached (approximately 10-12 participants).

**Results**

Interdisciplinary expert consultation revealed the desire for a nontraditional, context-driven eLearning intervention. Experts elected a case-based approach to the eLearning curriculum, whereby the module is structured around a case example of a student with an ABI and the process an educator takes to support the student. The initial module content build is complete and results from the usability testing, which will inform the first phase of revisions, will be available in December 2019.

**Conclusions**

The present study contributes to the development and implementation of an eLearning intervention technology that is the first of its kind. Testing the usability of the technology is a crucial step in ensuring that the technology is cocreated with educators, the end users, to promote the uptake of the information. The long-term impact of the eLearning technology has the potential to significantly enhance educators' knowledge and awareness of ABI and promote positive outcomes and experiences for children with ABI in the Ontario education system and beyond. The eLearning technology development framework may be applied nationally and internationally to create additional eLearning interventions to close this well-documented educator knowledge gap.

**0090****Single Cell Sequencing of Microglia Following Mild Traumatic Brain Injury and Novel Targets of Neuroinflammation**

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With increased public interest in short- and long-term effects of traumatic brain injury (TBI) and the current pharmacological void in effective therapies, investigation of targets for candidate drugs has become a public health priority. The Nogo-like signaling system, comprising Nogo receptors (NgR1, NgR2, and NgR3) and various ligands (including Nogo-A), is an important negative regulator of neuronal plasticity. Recent evidence shows that overexpression of NgR1 impairs recovery from mild TBI in mice (Lai et al, *J Neurotrauma* 36:1054-59, 2019). To add to this knowledge, our group has recently investigated a novel mechanism of neuroinflammation involving Nogo-like signaling. Application of functional NgR1 agonists to primary microglia cultures induces an inflammatory response, specifically increased cytokine release. Additionally, we have performed single cell sequencing of microglia from mice subjected to a mild TBI, revealing the presence of Nogo-involved genes in subpopulations of these cells 1, 3, and 7 days following injury. Nogo-signaling in microglia has not previously been a focus of research although it may be an important target for treatment of neuroinflammation. Incretin-mimetic therapies, including single or combinatory use of glucagon-like peptide 1 (GLP-1), glucagon insulinotropic peptide (GIP), and glucagon (Gcg), are rational therapeutics to fill the pharmacological void in TBI treatments. In their synthetic long-acting forms, these peptides can act on the CNS and show great promise in chronic and acute neurodegenerative conditions (Glotfelty et al, *ACS Pharmacol Transl Sci*. 2:66-91, 2019). Modulating inflammation, including the Nogo-signaling system, with incretin mimetics may also be a fruitful avenue for the treatment of TBI.

**Funding**

This research was supported in part by the Intramural Research Program of the NIH, National Institute on Aging.

**0091****Lifetime Blast Exposure's Impact on Recovery From Traumatic Brain Injury**

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**Background**

Subconcussive injuries have emerged as an important factor in long-term brain health of athletes and military personnel. In the military, career exposures to blast has been associated with complaints such as poor memory and attention. There is concern that heavy career blast exposure may negatively impact neurological functioning. The objective of this study was to explore the relationship between service member's lifetime blast exposure and recovery from a traumatic brain injury (TBI).

**Methods**

A total of 354 service members or veterans (SMVs) with a history of TBI prospectively enrolled from the Walter Reed National Military Medical Center (Bethesda, Maryland) as part of the Defense and Veterans Brain Injury Center 15-year Longitudinal TBI Study (Sec721 NDAA FY2007). SMVs were examined at 0 to 3 months, 4 to 8 months, 9 to 15 months, 33 to 39 months, 57 to 63 months, and/or 114 to 126 months following injury. Some participants completed multiple assessments; 22.7% completed  $\geq 2$  assessments, 11.8%  $\geq 3$  assessments, 3.5%  $\geq 4$  assessments, and 0.9% 5 assessments. Participants were on average 34.1 (SD = 9.8) years of age. TBI severity was 71.5% uncomplicated mild TBI, 12.7% complicated mild TBI, 8.8% moderate, and 7.1% severe TBI. Lifetime blast exposure (LBE) was based on self-report (mean = 61.8, SD = 170.8) categorized into 3 groups: No-LBE ( $n = 93$ ), moderate-LBE ( $n = 155$ ; LBE mean = 3.9; SD = 2.8, range 1-11), heavy-LBE ( $n = 106$ ; LBE mean = 200.7; SD = 265.0, range 12-736). Dependent variables were the total Neurobehavioral Symptom Inventory (NSI) and Post-Traumatic Stress Disorder Checklist (PCL). Participants were excluded if the Validity-10 indicated an invalid score.

**Results**

The no-LBE group (NSI mean = 19.5, SD = 16.6) had significantly lower NSI scores than the moderate-LBE group (NSI mean = 25.5, SD = 16.9) and the heavy-LBE group (NSI mean = 30.2, SD = 16.0) at initial evaluation; moderate-LBE had lower scores than heavy-LBE,  $F = 10.1$ ,  $P < .001$ . No-LBE had lower NSI compared to high-LBE at 0 to 3 months ( $P = .006$ ) and 9 to 15 months ( $P = .021$ ) but no other time points. No-LBE had lower scores than moderate-LBE only at 9 to 12 months ( $P = .011$ ). No-LBE had lower PCL scores than moderate-LBE ( $P = .003$ ) and heavy-LBE ( $P < .001$ ) and moderate-LBE less than heavy-LBE ( $P = .007$ ). When controlling for PCL, the effect of LBE on NSI was no longer significant ( $P = .806$ ).

**Conclusion**

Heavy and moderate levels of blast exposure over an SMV's career was associated with increased neurobehavioral and post-traumatic stress symptoms following a TBI. Higher LBE resulted in more neurobehavioral symptoms in early recovery (0-3 months) and at 1 year, but not at later stages. The influence of psychological trauma associated with blasts may be an important factor influencing symptoms as well as the accuracy of self-reported estimates of LBE.

**0092****Preclinical Evidence That Prior Stress Exposure Modulates Outcomes From Traumatic Brain Injury**

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Traumatic brain injury (TBI) leads to persistent neurological and neurobehavioral dysfunction. TBI frequently occurs following traumatic stressful events, like military combat, vehicular accidents, or domestic violence. Stress is associated with pathophysiological and behavioral changes that overlap with those produced by TBI. However, whether prior stress worsens TBI-related outcomes is not understood. This study tested the hypothesis that pre-TBI exposure to predator odor stress exacerbates TBI-induced neurobiological and neurobehavioral outcomes. Adult male Wistar rats all received a 5-mm craniotomy above the left sensorimotor cortex. After 3 to 7 days' recovery from surgery, rats received a 15-min bobcat odor exposure (stress) or no odor control treatment. Twenty-four hours later, animals were randomized to receive moderate TBI (~2 atm) via fluid percussion or sham (anesthesia only) procedures. Neurological severity and neurobehavioral scores, anxiety-like behavior (elevated plus-maze), and neuroinflammation (GFAP, Iba-1, and ED-1 immunohistochemistry) were measured during the first week post-TBI. Stress+TBI animals exhibited increased neurological severity and neurobehavioral scores compared to stress or TBI alone 1 day post-injury. At 7 days post-TBI, stress+TBI animals exhibited elevated neurobehavioral scores and trends toward increased anxiety-like behavior relative to sham controls. Neuroinflammation at the site of injury 7 days post-TBI was not exacerbated in stress+TBI animals. These results suggest that preinjury stress exposure enhances and/or prolongs post-TBI neurobehavioral impairments, without further altering neuroinflammation. The differential effects on behavioral and not neuroinflammatory outcomes warrants further investigation of the neurobiological mechanisms underlying worsened TBI outcomes that could help identify clinically relevant treatments for comorbid TBI and stress-related pathology.

**Funding**

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**0093****Decreasing the Burden of Persistent Concussion Symptoms on the Healthcare System: Timely and Coordinated Pathways to Appropriate Care for High-Risk Children and Youth**

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*Holland Bloorview Kids Rehabilitation Hospital, Toronto, Canada***Background**

In Ontario, concussion-related emergency department (ED) and physician office visit rates for children quadrupled during 2003-2013 (Zemek et al, 2016). Current best-practice and legislation in concussion states all youth who have sustained a concussion should, at minimum, receive (1) proper diagnosis and (2) final clearance by a physician (McCrorry et al, 2016). It is estimated 70% of children/youth will recover before 4 weeks of their injury; however, 30% will have ongoing symptoms. In addition, for youth at risk of a delayed recovery, it is necessary that they have access to appropriate, timely, coordinated, multidisciplinary evidence-based care (ONF, 2017). However, this is a challenge in the current healthcare climate in Ontario because concussion care is disjointed, challenging to navigate, with long wait times. Therefore, the lack of timely and appropriate specialized services may be contributing to persistent symptoms in youth.

**Solution**

The goal of the early concussion care program at Holland Bloorview is to facilitate the right care, at the right time, by the right providers for children. This is the only hospital-based specialized program for youth concussion within the first 4 weeks of injury in Ontario. It has filled a gap in the system through the following approach:

1. Feasible and efficient model: Early education and gradual active progression of activities are some of the strongest areas of evidence in concussion management (McCrorry et al, 2016). Prolonged rest may place youth at risk for secondary issues and contribute to the chronicity of concussion symptoms (ONF, 2017). In addition, appropriate education can ensure that unnecessary anxiety and vulnerability do not occur. We provide an assessment and consultation model providing physician (initial assessment and clearance) and occupational therapy touch points focused on holistic and individualized education and fast-acting accommodations to support recovery.
2. Innovative referral pathways through system partnership: Recent research has informed the development of a new tool for ED physicians to better identify which youth at risk for having persistent symptoms (Zemek et al, 2016). Holland Bloorview has created pathways for youth identified as high risk at the ED to be referred for care. In addition, we have strategic partnerships with community sports and school organizations to ensure seamless education pathways for high-risk youth with concussions.

**Outcomes**

- Improved processes and coordination of concussion care pathways from EDs and the community for high-risk youth
- Shorter wait times to access care through a feasible and sustainable model

- Lower rates of persistent symptoms (<10%) in youth and children who access this model

**Conclusion**

Further development multidisciplinary concussion programs across Ontario to provide timely and evidence-based care to children and youth in order to lessen the burden of persistent concussion symptoms on the healthcare system.

**0094****Intrinsic Functional Connectivity Associated With Mental Flexibility and Decision Duration in Athletes With and Without a History of Concussion**de Souza N<sup>1</sup>, Gonzalez C<sup>1</sup>, Viagas N<sup>1</sup>, Buckman J<sup>2</sup>, Esopenko C<sup>1</sup><sup>1</sup>Rutgers University, Newark, United States, <sup>2</sup>Rutgers University, New Brunswick, United States**Background**

Cognitive impairments, including deficits in mental flexibility and processing speed, are detected acutely after sport-related concussion (Makdissi et al, 2010; Broglio et al, 2007), but resolve in a few weeks in most cases (Covassin et al, 2010; McCrorry et al, 2017). However, concussion history is associated with later-life cognitive and psychological problems in retired athletes (Guskiewicz et al, 2005; Esopenko et al, 2017). This may suggest unresolved physiological damage, such as altered brain function, that cannot be detected by cognitive testing alone. To better understand the relationship of brain function with cognitive performance, we examined the relationship between resting-state functional connectivity (rsFC) with mental flexibility and decision duration in collegiate athletes with and without a history of concussion.

**Methods**

Forty-eight collegiate athletes (56% female, mean age = 19.3 years; 11 with self-reported concussion history) performed Trail Making Test B (TMT-B) and simple and choice reaction time (RT). Decision duration was calculated as the difference between choice and simple reaction time. Athletes also completed resting-state functional magnetic resonance imaging (rsfMRI). We then compared: (1) RsFC in the salience, default mode (DM), and left and right frontoparietal (LFP, RFP) networks, and (2) the relationship of rsFC to mental flexibility and decision duration between athletes with and without a history of concussion. A general linear model was used to examine group differences and correlations of rsFC with cognitive data.

**Results**

Collegiate athletes with a history of concussion showed greater inter- and intranetwork connectivity of the salience network compared to athletes without a history of concussion. Greater rsFC from the right caudate nucleus to the left middle frontal gyrus and left medial frontal gyrus, and from the left caudate to the right insula were shown in athletes with a history of concussion. There were no behavioral differences in TMT-B completion time, simple RT, choice RT, or decision

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duration dependent on concussion history. However, slower TMT-B completion time and decision duration were related to increased rsFC in athletes with a history of concussion. Specifically, athletes with concussion history demonstrated a positive relationship (1) between TMT-B completion time and rsFC between regions in the DM network and regions in the LFP and salience networks, and (2) between decision duration and regions of the salience network with bilateral FP and DMN, and between the right and left frontoparietal networks. There were no relationships between rsFC and connectivity in athletes without a history of concussion.

## Conclusion

Our results demonstrate that altered rsFC may support recovery of mental flexibility and decision-making after concussion. Future longitudinal, prospective studies are needed to determine how chronic alterations in brain function affect long-term recovery. Further, the effects of multiple concussions on rsFC and cognitive performance in young athletes should be explored.

## 0095

### Call to Action—Exertion Testing in Deconditioned Patients: The Problem and a Possible Solution

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The Buffalo Concussion Treadmill Test (BCTT) and the Buffalo Concussion Bike Test (BCBT) are the current gold standard measures of autonomic function following sport-related concussion with its ability to differentiate physiological dysfunction from other diagnoses and quantify clinical severity (Leddy, Hinds, Sirica, Willer, 2016). However, the primary BCTT/BCBT research is focused exclusively on the highly conditioned athlete population.

In applying this valuable measure to the greater concussion population, such as those who have been injured in motor vehicle accidents (MVAs) or falls, which naturally includes the elderly and deconditioned individuals, the assessing clinician will confront symptoms that occur earlier in the test preventing its completion. These symptoms differ markedly from the symptoms which can occur during the BCTT/BCBT, at near exhaustion or immediately following intense exercise, with the latter indicating physiologic dysfunction, and the former associated with deconditioning or other system degradation.

Advance Concussion Clinic (ACC), a Vancouver-based interdisciplinary concussion clinic, treating a broad range of sport, MVA, fall, and other induced mTBI since 2013, manages a large number of patients with preinjury deconditioning, as well as many with an increased risk of cardiopulmonary disease (as defined by the American College of Sports Medicine, ACSM). Cardiovascular and cardiopulmonary risk factors are contraindications for administration of the BCTT/BCBT, further underscoring the need for an appropriate alternative for these patients as well as the deconditioned or elderly. In these patients and others who are unable to tolerate the BCTT/BCBT, their peak exertion and exhaustion fails to differentiate between autonomic dysfunction, age-related system degradation, or general deconditioning.

There is a clear need for further research trials of an alternative or preemptive measure for the BCTT/BCBT. This is

critical for the BCTT/BCBT-contraindicated concussion patient in order to differentiate and potentially facilitate the autonomic function assessment, which is a foundational component of the concussion evaluation toward informing the treatment planning for the concussed patient. One suggestion, as a focus and stepping point for moderate -and high-risk patients, is the 6-minute walk test (6MWT). The 6MWT assesses global conditions of the cardiopulmonary system to inform a walking program that the clinician can implement as a preliminary step toward decreasing sedentary lifestyle, thus allowing for a safe and valid BCTT/BCBT to be administered to test autonomic function at the appropriate time. Administration of the BCTT/BCBT will remain a goal and target in context of a comprehensive concussion assessment and rehabilitation program to differentiate physiological dysfunction from other diagnoses.

## 0096

### Assessing the Representativeness of a Probabilistically Linked Sample of Traumatic Brain Injury Model Systems Cases With National Trauma Data Bank Acute Care Records

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There exist rich research infrastructures in trauma and rehabilitation that can be used to characterize patients with traumatic brain injury (TBI) across the continuum of care. The Traumatic Brain Injury Model Systems National Database (TBIMS NDB) is the largest longitudinal, prospective cohort studies of TBI with over 17 000 participants. The TBIMS NDB contains detailed preinjury, rehabilitation, and outcome data collected at 1, 2, and 5 years postinjury, and every 5 years thereafter. These data are used extensively to inform research, treatment, and policy. Prior work demonstrated the TBIMS NDB is largely representative of adults admitted for rehabilitation in the United States with a primary diagnosis of TBI. However, information on patients during acute care is limited. The National Trauma Data Bank (NTDB) is the largest aggregation of US trauma registry data containing a broad collection of acute hospitalization data. It is instrumental in developing performance improvement tools for trauma care and practice; however, it lacks detailed postacute information. Previous work used probabilistic matching algorithms to link TBIMS cases with acute records in the NTDB by leveraging common data elements between the 2 databases to produce

a single dataset. Since only a subset of the TBIMS NDB was successfully linked to NTDB records, a key consideration of the utility of this linked dataset is its representativeness relative to the larger TBIMS NDB sample and more broadly to the US population of adults receiving inpatient rehabilitation for TBI. We used national data acquired from the Uniform Data System for Medical Rehabilitation and eRehabData on 227 187 persons admitted for rehabilitation in the United States between 2002 and 2013 to assess the representativeness of the NTDB-TBIMS-linked dataset relative to the larger US TBI population. A total of 9689 cases from the TBIMS NDB 16 years or older at rehabilitation admission and discharged alive between 2002 and 2013 were selected, of which 3538 (37%) were successfully linked to NTDB records. Key variables for comparison include age, sex, race/ethnicity, marital status, living situation, occupational status, rehabilitation insurance provider, FIM motor and cognitive scores at rehabilitation admission, and rehabilitation length of stay (LOS). Variables specific to the TBIMS NDB include Glasgow Coma Scale, acute length of stay, days in posttraumatic amnesia, disability rating scale, body mass index, and urbanicity. We found linked and nonlinked TBIMS cases were similar on all characteristics with the exception that linked cases were more likely to be from rural and suburban areas. Relative to the larger TBI population, the linked sample was more likely to be younger, male, black, never married, living with others, employed, have private insurance or Medicaid, lower FIM scores, and shorter LOS. This merged trauma-rehabilitation dataset has promising utility for the study of long-term outcomes following TBI.

## 0097

### Neuropsychological Management of an Infant With Severe Head Injury

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An 18-month-old nursing infant was injured in a motor vehicle accident, ejected out of a motor vehicle while carried in the arms of her mother. Emergency room examination and investigations revealed that the infant's initial Glasgow Coma Scale (GCS) score on admission noted as 9/12. A CT brain scan revealed a left parietal fracture, a left parietal brain contusion with edema, and subarachnoid hemorrhage. The patient developed hypoglycemia. The patient was managed medically and progress CT brain scans revealed bilateral hypodense subdural collection in the frontotemporal regions representing chronic subdural hematoma or subdural hygromas. Following discharge at 2 years of age, developmental neuropsychological assessment revealed severe hand-psychomotor reduction with significant right hand slowing and lack of coordination, severe restlessness and loss of mental focusing during play assessment, emotional dysregulation with disinhibited responses, and loss of mental direction to test material. The patient underwent systematic play therapy aimed at promoting hand coordination for skilled writing and self-care activities, cognitive activities to promote attention and to improve executive functioning. The impact of the head injury on the family resulted in the parents succumbing to depression, thus requiring psychological and psychiatric interventions. The impact of the TBI on the individual and family systems is discussed with proposals for multilevel interventions suggested.

## 0098

### Gait Kinematics Altered After Single Session of Robotic Gait Training in People With Stroke

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#### Background

Robotic Exoskeletons (EKSO) are a dynamic device used to retrain standing and gait in people with unilateral or bilateral lower extremity weakness. Common deficits after stroke include mobility impairment such as gait asymmetries. The acute effects of EKSO on gait kinematics in people with stroke are unknown. The purpose of this study was to compare limb symmetry in kinematic and temporospatial gait parameters before and after a single EKSO session in people with chronic stroke.

#### Methods

Each participant walked under 2 conditions: pre-EKSO, and immediately post-EKSO. A 10-camera motion capture system synchronized with 6 force plates was used to capture kinematic and temporospatial gait parameters. Ten good-quality walking trials (20 ft) were collected for each condition, of which best 5 for each condition were included for data analysis. Wilcoxon signed rank tests were used to analyze differences between involved and uninvolved lower extremities in kinematic and temporospatial gait parameters for the pre- and post-EKSO conditions, respectively. EKSO session lasted  $22.3 \pm 6.8$  minutes total "Up" time and comprised of  $7.2 \pm 1.5$  minutes "Walk" time with  $250.7 \pm 40.0$  steps.

#### Results

Six adults (3 female and 3 male) aged  $44.7 \pm 14.6$  years with chronic stroke (mean years since stroke =  $4.5 \pm 1.9$ ) participated in this study. Participants walked without physical assistance (Functional Ambulation Category, range = 4-5). In the stance phase, significant differences between joint range of motion of unaffected and affected limbs were found in the pre-EKSO condition, but not in the post-EKSO condition, including knee flexion (pre-EKSO,  $7.7^\circ$ ,  $P = .03$ ; post-EKSO,  $7.4^\circ$ ,  $P = .22$ ), knee extension (pre-EKSO,  $6.7^\circ$ ,  $P = .03$ ; post-EKSO,  $6.4^\circ$ ,  $P = .22$ ), and hip flexion (pre-EKSO,  $5.2^\circ$ ,  $P = .03$ ; post-EKSO,  $4.5^\circ$ ,  $P = .22$ ). In swing phase, significant differences between joint range of motion of unaffected and affected limbs were found in pre-EKSO with decreased variance in post-EKSO hip flexion (pre-EKSO,  $4.7^\circ$ ,  $P = .03$ ; post-EKSO,  $3.2^\circ$ ,  $P = .69$ ). No significant differences in range-of-motion asymmetry were seen in the ankle in stance and swing phases or the knee in the swing phase. In addition, there was no significant difference in gait speed (pre-EKSO,  $0.74$  m/s; post-EKSO,  $0.72$  m/s) although trends were observed for increased stance time on the involved limb (pre-EKSO,  $0.83$  seconds; post-EKSO,  $1.09$  seconds;  $P = .08$ ) and increased double-limb support time (pre-EKSO,  $0.43$  seconds; post-EKSO,  $0.56$  seconds;  $P = .08$ ) after a single EKSO session.

#### Conclusion

Results suggest improved limb symmetry in kinematics in both the stance and swing phases of gait immediately after a

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single EKSO session in individuals with chronic stroke. However, these kinematic changes were insufficient to alter temporospatial parameters. Future studies should assess whether robotic gait training can demonstrate long-term benefit on gait patterns after stroke.

## 0099

### Muscle Activity Altered After Single Session of Robotic Gait Training in People With Stroke

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#### Background

Robotic exoskeletons (EKSO) have been used as a gait training tool for persons experiencing unilateral or bilateral lower extremity weakness. EKSO has been shown to be safe and feasible for rehabilitation, but limited evidence exists for the impact of EKSO on lower extremity muscle activity in patients after stroke. The purpose of this study was to compare lower extremity muscle activity before and after a single EKSO session in people with chronic stroke.

#### Methods

Each participant with stroke walked under 2 conditions: pre-EKSO, and immediately post-EKSO. At least 5 walking trials of 20 ft at a self-selected speed were performed for each condition. A 10-camera motion capture system synchronized with 6 force plates and to obtain the temporospatial gait parameters. Surface EMG activity was obtained from the bilateral gluteus medius (GM), rectus femoris (RF), medial hamstrings (MH), tibialis anterior (TA), and soleus (S) muscles. Wilcoxon signed rank tests were used to analyze differences between the affected and unaffected lower extremities in muscle activity and temporospatial gait parameters pre- and post-EKSO conditions. EKSO session consisted of 22.3 ± 6.8 minutes total time (walk time = 7.2 ± 1.5 minutes) with 250 ± 40 steps.

#### Results

Six adults (3 female and 3 male) aged 44.7 ± 14.6 years with chronic stroke (mean years since stroke = 4.5 ± 1.9) participated in this study. All participants were able to walk without physical assistance (Functional Ambulation Category, range = 4-5). During the stance phase, significant differences were observed in EMG for GM ( $P = .046$ ; pre-EKSO = 0.0400; post-EKSO = -0.0726), RF ( $P = .028$ ; pre-EKSO = 0.1042; post-EKSO = -0.0777), and TA ( $P = .046$ ; pre-EKSO = 0.0152, post-EKSO = -0.1808), indicating increased muscle activity of the affected limb after a single session compared to the unaffected limb. No significant differences were observed in lower extremity muscle activity during the swing phase of gait after the intervention. In addition, there was no significant difference in gait speed (pre-EKSO, 0.74 m/s; post-EKSO, 0.72 m/s) although trends were observed for increased stance time on the affected limb (pre-EKSO, 0.83 seconds; post-EKSO 1.09 seconds;  $P = .08$ ) and increased double-limb support time (pre-EKSO, 0.43 seconds; post-EKSO, 0.56 seconds;  $P = .08$ ) after a single EKSO session.

## Conclusion

Lower extremity muscle activity of the affected limb increased during the stance phase of gait immediately after a single session of EKSO in our participants with chronic stroke. EKSO training appears to be able to alter gait in people with chronic stroke and may be a viable intervention to reduce gait dysfunction after stroke. Further research is required to determine long-term effects on muscle activity patterns after gait training with EKSO.

## 0100

### An Interdisciplinary Approach to the Treatment of Mild Traumatic Brain Injury in Veterans With Co-morbid Post-traumatic Stress Disorder Utilizing Service Dogs in Training as a Therapeutic Tool

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In the post 9/11 era, Veterans are experiencing increasing rates of mild traumatic brain injury (mTBI) and posttraumatic stress disorder (PTSD) diagnoses. Evidence indicates the risk for PTSD increases after mTBI and the significant overlap between mTBI and PTSD symptomology increases the complexity of care and differential diagnosis. mTBI and PTSD profiles share common impairments within physical, emotional, and cognitive domains, but distinctions emerge in mTBI's neurologic and vestibular-ocular dysfunction and PTSD's flashbacks, cognitive effects, and survivor's guilt. Treatment within a single provider can rarely address the dynamic range of impairments typical to this population; therefore, the Marcus Institute for Brain Health (MIBH) was founded as an interdisciplinary intensive outpatient program. Within the MIBH, Warrior Canine Connection (WCC) provides a unique and nuanced therapeutic model providing Veterans a sense of purpose and the opportunity to engage in a critical support mission while receiving treatment for their own symptoms of mTBI and PTSD. The Warrior Ethos is an aspect of military culture that is the cornerstone of WCC; which compels Veterans to make extreme sacrifices for a fellow Veteran. Service dog training (SDT) creates a unique opportunity for interdisciplinary care with Speech Language Pathology, Integrative Therapy and Physical Therapy due to significant similarities between clinical care and SDT. These disciplines collaborate to create and enhance patient care by integrating clinical concepts, training, and language into SDT sessions. Clinical opportunity for functional intervention through cotreatments and carryover within sessions resulting in canine facilitated positive physiological (ie, lowers cortisol, blood pressure, heart rate, pain; increases dopamine, oxytocin), emotional (improved mood, regulation, heart rate variability, sleep, confidence; reduces anxiety), and cognitive (improved memory, communication) outcomes are also provided.

Treatment objectives addressed within SDT sessions span across multiple discipline objectives. Key activities implemented within SDT sessions are vestibular stimulation, visual motion habituation, emotional regulation, synchronization,

awareness, grounding, memory, communication, learning, and socialization. Specific examples of intervention and collaborative strategies will be presented to providers to deliver samples and application of principles.

WCC Service Dog Trainers implement dog training concepts based on positive reinforcement methods that align with traditional clinical interventions in a cotreatment model with individual providers, or apply concepts discussed in weekly interdisciplinary rounds into individual WCC sessions that are specifically designed to address symptoms of PTSD and mTBI in Veterans. WCC training sessions also integrate into Implementation Group, a community-based group intervention targeting the application of interdisciplinary intervention strategies into everyday environments associated with increased symptom occurrence (airports, shopping centers) under the guidance of clinical staff.

WCC provides a meaningful, motivating, and mission-based opportunity that augments other treatments in unique ways that allow for a treatment resistant population to be more receptive to traditional therapeutic services.

## 0101

### Neuropsychological Evidence for Cortical Reorganization Following Traumatic Brain Injury in Adults: A Case Series

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Following motor vehicle accident leading to loss of consciousness, an adult male patient was admitted to hospital with a Glasgow Coma Scale (GCS) score of 15/15. Additional injuries included a traumatic left lower facial nerve palsy and bilateral mastoid longitudinal fractures. The patient sustained a left upper limb (dominant) brachial plexus injury with dislocation of the left shoulder. Following discharge from hospital, the patient lost complete use of the left upper limb, essentially functioning as a 1-armed man. Neuropsychological assessment conducted 30 months postaccident revealed significant visuospatial and visuoconstructional functions with relative preservation of language functions as well as disorganized skilled motor responses such as drawings and writing using the right (nondominant) hand. The reciprocal responses of the right motor areas that theoretically and anatomically are involved in response to loss of left arm use suggested relative progressive changes suggestive of mild atrophy in the right cortical areas subserving motor functions. The role of motor pathways in the organization of higher cortical functions is discussed and reference to case studies with similar outcomes is made.

## 0102

### A Policy Analysis of Access to Post-acute Rehabilitation Services for People With Acquired Brain Injury

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Acquired brain injuries (ABI)—from trauma, stroke, infectious diseases, and brain tumors—are a serious public health issue affecting individuals, families, and communities. Ad-

vances in emergency medicine have increased the likelihood of surviving a severe brain injury. However, the US healthcare system comes up short on providing appropriate access to postacute rehabilitation that benefits physical, cognitive, and emotional/behavioral function, return to work, independence, and community participation. We conducted an analysis of studies published in the last 20 years exploring outcomes and cost-effectiveness from access to rehabilitation services after a serious acquired brain injury requiring hospitalization. Our analysis of 8 studies from 5 countries shows that on average the cost of rehabilitation is offset (recouped) in between 1 and 5 years. Savings identified in the 6 studies that examined cost-savings from access to postacute, intensive, multidisciplinary rehabilitation after a severe brain injury ranged from \$1.28 million to \$2.27 million per patient, with an average of \$1.67 million per person over their lifetime. These savings do not include a decrease in social costs, for example from easing of family caregiving and economic burdens. Policy recommendations include: Increase access to postacute rehabilitation, especially after a severe brain injury, where the greatest cost-savings are observed. Ensure access within 12 months of injury, when capacity for improvement is greatest, and provide access in a continuous chain, without interruptions. One approach to increasing access to postacute rehabilitation is to mandate coverage through state legislation, as has been done in Texas since 1995. Another is to provide these services universally through federally funded insurance programs: Medicaid and Medicare.

## 0103

### Precision-Tinted Spectral Filters Reduce TBI-Related Migraines and Visual Cortical Sensitivity

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#### Background

The lingering effects of TBI can continue for months or years, especially with regard to headaches and migraines. These issues can be frustrating and debilitating, especially when they are unresponsive to standard courses of treatment. This can make a return to functionality at work and at home impossible. Increasing evidence suggests light wavelength regulates brain activity in ways extending beyond color perception. Here, we investigated the use of precision-tinted spectral filters on brain activity and their application to persistent headaches and migraines as a result of brain or head trauma that have not been successfully remediated through standard medical and alternative treatment, including medications.

#### Methods

Study 1. A total of 184 participants diagnosed with medically resistant headaches and migraines as a result of brain or head trauma completed the Headache Impact Test (HIT-6) before and after treatment with precision-tinted spectral filters, worn as glasses for 4 to 12 weeks. The HIT-6 is designed to capture the impact of headache and its treatment on an individual's functional health and well-being and is considered useful both for screening and monitoring change in headache impact. Participants also reported on migraine frequency. Study 2. In a

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pilot study ( $n = 7$ ), individuals with abnormal light sensitivity and a history of headaches were administered retinotopic mapping fMRI scans with spectral filters or blank lenses to examine regulation of neural hypersensitivity to visual stimulation.

## Results

Pre- versus postcomparison of migraine frequency, medication usage, and scores on the HIT-6TM showed that there was significant reduction in migraine frequency (mean = 18.8, SD = 22.0 vs mean = 2.0, SD = 6.0);  $t(181) = 10.6$ ,  $P = .000$ . There was also significant improvement (mean = 66.0, SD = 8.0 vs mean = 41.6, SD = 9.9) in terms of impact of headaches on functional health and well-being,  $t(183) = 32.9$ ,  $P = .000$ . Precision-tinted spectral versus blank filters reduced within primary and secondary visual regions as well as frontoparietal attentional networks, consistent with reduced hyperactivity to visual stimulation and reduced recruitment of neural networks outside the visual system proper. These results suggest that precision-tinted spectral filters can reduce migraine frequency with headaches reduced from having a significant negative impact to having little or no impact on subjects' health and well-being. Preliminary evidence supports a potential mechanism of action is reduced uncontrolled cortical excitability to patterned light stimulation.

## Conclusions

For individuals who have suffered head trauma resulting in light sensitivity and chronic headaches and migraines that fail to respond to standard interventions, precision-tinted spectral filters may provide relief that translates to improved functional health and well-being by regulating neural responses to light.

## 0104

### Region Based T1-Weighted MRI Volumetric Changes in High School Contact Sport Athletes

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Brain volume quantification is of potential clinical value in the study of individuals at risk of longitudinal exposure to neurotrauma. Precomputed atlases of gray matter (GM), white matter (WM), and cerebrospinal fluid (CSF) were used to characterize longitudinal volumetric changes at a regional level in a population of high school-aged collision sport athletes. The resulting metric exhibits a high degree of sensitivity in detecting changes in athletes who experience repetitive subconcussive trauma and produces good consistency with existing automated tools (eg, SIENA-FSL). Additionally, the new methodology readily allows group-level comparisons for (normalized) region-specific tissue volumes, complementing the visualization of brain volume changes on a standard template/atlas.

A pooled dataset of 81 high school (ages 14-18 years, mean = 16.4) collision sport athletes (CSA: 19 female soccer; 62 male football), and 29 age-matched non-collision sport athletes (NCA: 15 male; 14 female), was used to assess the novel approach. CSA (soccer and football) underwent 5 MRI sessions around the onset of collision-related activities (Pre = before collision activity onset; In1 = 1-7 weeks after onset; In2 = 4-12 weeks after onset; Post1 = 15-24 weeks after onset; Post2 = 26-36 weeks after onset. Note that the average inter-session gap from In1 to In2 was ~4 weeks, from In2 to Post1 ~8

weeks, and from Post1 to Post2 ~12 weeks). NCA was imaged twice, 4 to 9 weeks apart, once before (Test) and once after (ReTest) training and competition activity onset, maintaining comparable levels of physical activity at both sessions. For CSA, peak translational acceleration (PTA) of on-field head acceleration events (HAEs) was recorded in all practices and games via sensors placed in the helmet or behind the right ear.

All imaging was conducted using a 3T General Electric Signa HDx with a 16-channel brain array. A high-resolution T1 scan was acquired at each session to quantify anatomical volumes. Each T1 scan underwent bias field correction, brain extraction, and then registered via affine, high-dimensional nonlinear transformations to the MNI152 standard space template. The template was segmented into 3 tissue classes: GM, WM, and CSF. GM and WM volumes were subdivided at each subject-session using parcellations of 278 and 20 regions-of-interest (ROIs), respectively. The CSF tissue class was further segmented into whole brain CSF and deep brain (dCSF; third and lateral ventricles).

For both genders of CSA, volumes of GM and dCSF exhibited significant deviations during the season that largely recovered to preparticipation levels at Post 2; 4 to 5 months after the end of HAE exposure. Volumetric changes in brain tissues indicated a decrease in GM, with an increase in dCSF. These changes varied longitudinally over the course of the continued participation in collision-based activities and were correlated strongly ( $P < .05$ ) with the number of HAEs with high PTA (dCSF: >50 g; GM: >85 g).

## 0105

### Changes in Blood-Based Biomarkers in Chronic Moderate to Severe Traumatic Brain Injury: Preliminary Findings

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## Objectives

In the past few years, blood-based biomarkers have shown their potential as diagnostic and prognostic markers in patients with acute traumatic brain injury (TBI). However, very little is actually known about the changes in such biomarkers and their relation to outcome, years after TBI. Therefore, this study aimed at gathering preliminary data on changes in blood-based biomarkers more than a year after a moderate to severe TBI and relating these changes to changes in behavioral outcome measures but also to changes in cerebral structure and activity.

## Methods

In this prospective longitudinal study, 8 patients with moderate to severe TBI were recruited (7 males,  $35 \pm 7.6$  years old, 5 severe TBI,  $17.52 \pm 3.84$  months postinjury). The following data were collected, at monthly intervals across 6 time-points: (a) Blood samples were collected and blood-based biomarkers (ie, GFAP, NSE, S100A12, SDBP145, UCH-L1, T-tau, P-tau, and P-tau/T-tau ratio) were determined in serum using ELISA. (b) Magnetic resonance imaging (MRI) recordings were performed on a Siemens Magnetom Verio 3T and MRI data were

analyzed using FMRIB Software Library (FSL). (c) Resting-state electroencephalograms (EEG) were performed, using a B-Alert wireless system, and data were analyzed using EEGLAB. (d) Behavioral outcome measures were administered by trained clinicians to assess cognition and functional recovery (ie, MOCA, RBANS, BDI-II, and DRS).

## Results

P-tau was positively related to functional and cognitive outcome, and negatively related to the severity of depression more than 6 month later. P-tau and P-tau/T-tau ratio were also positively related to a change of shape in subcortical areas such as brainstem and putamen.

## Conclusion

Our study provides preliminary findings that suggest a positive role of P-tau in the recovery of patients with chronic TBI. Further investigation in larger cohorts is warranted to better understand the mechanism of neural recovery in chronic patients. Indeed, a better understanding of the biological processes underlying TBI will also allow more effective therapeutic options for this challenging population.

## 0106

### Knowledge of Concussion Guidelines and Patterns of Communication Between School-Based Staff in Wisconsin Public High Schools

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## Background

The Centers for Disease Control and Prevention (CDC) estimate that approximately 1.6 million to 3.8 million sport-related concussions occur each year in the United States. It is understood that high school students who suffer this injury can experience short- and long-term effects that disrupt various aspects of their lives, including learning. Current concussion guidelines emphasize the importance of a multidisciplinary team approach with efficient and effective communication between medical providers, teachers, school nurses, athletic trainers, students, and families. However, recent studies reveal school-based communication specific to concussion to be unorganized, disjointed, or absent. Further research investigating knowledge of concussion guidelines and communication patterns is needed.

## Objective

The purpose of this study was to characterize the knowledge of concussion guidelines and patterns of concussion-specific communication between administrators, teachers, school nurses, and athletic trainers within Wisconsin public high schools.

## Methods

The National Association of School Nurses (NASN) framework for 21st Century School Nursing Practice guided this

study. This model stresses multidisciplinary collaboration for optimal student health and learning. A cross-sectional survey design using UW-based Qualtrics was electronically delivered to administrators, teachers, school nurses, and athletic trainers within Wisconsin public high schools using an adapted version of the BAK-PAC (Beliefs Attitude and Knowledge of Pediatric Athletes with Concussion) survey in the spring of 2018. Descriptive statistics were used to characterize the sample and examine variables related to knowledge of concussion guidelines and communication patterns.

## Results

Overall, 242 Wisconsin high school staff responded to this survey. The majority of respondents were school nurses ( $n = 99$ , 40.1%), teachers ( $n = 63$ , 25.5%), principals ( $n = 25$ , 10.1%), and athletic trainers ( $n = 24$ , 9.7%). Respondents were primarily female ( $n = 171$ , 70.7%), white ( $n = 238$ , 96.4%), of non-Hispanic ethnicity ( $n = 234$ , 96.8%), and from the age group 35 and 64 years ( $n = 193$ , 79.6%). They primarily represented public schools ( $n = 235$ , 95.1%) located in rural areas ( $n = 172$ , 69.6%), with school enrollment of 250 to 999 ( $n = 145$ , 60.9%). Overall, 64.4% reported they had received formal concussion education and 55.5% reported being aware that the state of Wisconsin has a concussion law. Communication in their high school was ranked as excellent by 20.2% and adequate by 45.5%, with 34.0% reporting that communication needs improvement or is nonexistent. Examination of communication patterns revealed that 52.7% reported they regularly discuss the care of concussed students with teachers, 52.8% with the school nurse, 46.3% with the athletic trainer, and 50.6% with the school counselor—most commonly in person and by e-mail.

## Conclusions

Data from this statewide study of key high school multidisciplinary team members offer new insights into current concussion knowledge, patterns of interactions, strengths, and areas of improvement for Wisconsin high schools. A greater focus on concussion education in addition to strategies to improve communication may better support high school students who sustain a concussion.

## 0107

### Relating Blast-Induced Traumatic Injury to Observable Blast Injuries by Analyzing Shock Wave Physics

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With the increased use of explosive devices in combat, blast-induced traumatic brain injury (bTBI) has become one of the signature wounds in the Iraq and Afghanistan Wars. Currently, bTBI severities are determined by peak pressure and time duration, which is often displayed on a pressure versus time (P-T) graph. Impulse and dynamic pressure of a shock wave have been neglected with this type of classification. Impulse is the pressure loading over the duration of the shock wave. Dynamic pressure is the amount of drag placed on the item that the shock wave is passing over. Both impulse and dynamic pressure have a role in the severity of the bTBI acquired.

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Open-field and shock tube testing are the commonly used methods to cause bTBIs. However, the differences between the 2 test setups have not been accounted for in the P-T graph. A pressure versus impulse (P-I) graph accounts for the loading on the item and has been found useful in presenting lung lethality regions and building damage thresholds. This research proposes a new method of presenting bTBI data by using a P-I graph. To present the animal bTBI data on a P-I graph for humans, the reported peak pressures needed to be scaled to humans, impulse values calculated, and impulse values scaled. Peak pressures were scaled using Jean et al's method, which accounts for the soft tissue, brain, and skull of the head. Impulse values were estimated in 2 methods: Friedlander's impulse equation and the Rutter-Johnson equation. The Rutter-Johnson equation accounts for the sustained pressures outside the end of a shock tube, which does not have a steady decay. Mass scaling was used to scale the reported duration in the impulse calculation.

This work discusses a P-I graph displaying scaled peak pressure and impulse values. The severity of bTBI was assigned to studies that stated the severity of the bTBI, determined based on histological or behavioral analysis. Each severity had its own region on the P-I graph, as the 3 severities did not overlap. The severity regions were overlaid with human lung damage and eardrum rupture P-I curves and correlations were made. bTBIs are not a new phenomenon, but in the past other primary injuries were more prominent and diagnosed first, advances in body armor have contributed to the change toward increased brain injury diagnosis.

## 0108

### Influence of Concussion History on Objective and Subjective Measures of Memory and Executive Function in Collegiate Student-Athletes

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While disturbances in cognitive function (eg, memory and executive function) are often reported immediately following a concussion, these disturbances may last longer. The Immediate Postconcussion Assessment and Cognitive Test (ImPACT; ImPACT Applications, Inc, Pittsburgh, Pennsylvania) is a commonly used tool in concussion management to measure neurocognitive function in athletes. While objective measures of cognitive function, such as those from the ImPACT, are commonly assessed as part of concussion management protocols, subjective measures of cognitive function are not commonly used, but could be useful. The Behavior Rating Inventory of Executive Function (BRIEF) survey is one measure to assess an individual's perception of their own cognitive abilities and working memory and may be useful in concussion management and help medical professionals determine the proper support needed to help recovery. The objective of this study was to examine both subjective and objective measures of memory and executive function in collegiate student-athletes to see whether concussion history has any influence. The participants in this study included 58 (42 males and 16 females) Division I student-athletes from a mid-size private university in the Southeastern part of the United States. These student-athletes participated in football ( $n = 22$ ), soccer ( $n = 19$ ), baseball ( $n =$

12), and volleyball ( $n = 5$ ). The battery of tests included in this study all took place as part of baseline measurement related to the concussion management protocol at the host institution. All participants completed both the ImPACT (an objective measure of neurocognitive function) and the BRIEF (a subjective measure of working memory and executive functioning). Preliminary data analyses found that there were no significant differences in objective measures of neurocognitive functioning as obtained from the ImPACT or subjective measures of memory and executive function as obtained from the BRIEF by concussion history or sex (all  $P$ 's  $> .05$ ). Additionally, no significant correlations were found between neurocognitive measures from the ImPACT and subjective measures from the BRIEF (all  $P$ 's  $> .05$ ). The preliminary findings of this study suggest that concussion history and sex do not have a significant influence on either objective or subjective measures of memory and cognitive function. Despite the findings from the present study, these measures could still be useful in examination as part of acute recovery from a concussion as opposed to examination of potential long-term deficits in memory and executive function.

## 0109

### Use of Robotic Exoskeleton for Therapeutic Management of Individual With Disorder of Consciousness

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#### Background and Purpose

Brain injury is a serious public health issue due to high incidence (2.8 million Americans/year), cost of care ( $\geq$  \$60 billion/year), and resulting disability. Moderately intense exercise is known to improve cardiovascular function, promote neuroplasticity, and increase health outcomes. However, for individuals with the most severe brain injuries, termed "disorders of consciousness," typical rehabilitation interventions include low-intensity activities such as positioning, spasticity management, and standing frame. Robotic exoskeleton gait training (RGT) allows for early mobilization, decreased physical demand on therapists, and may be a moderately intense activity. The purpose of this case study was to describe a novel use of RGT to address impairments with severe brain injury.

#### Case Description

A 21-year old African American man (GD) with severe anoxic brain injury in February 2017 from sudden cardiac arrest resulting in dysphasia, hypertonia, and upper and lower extremity contractures, requiring tracheostomy and PEG placement and total care. GD admitted to inpatient rehabilitation in July 2019 for multidisciplinary intervention with goals to improve ROM, standing frame program, and possible tracheotomy decannulation. During his 23-day stay, therapy interventions included usual standard of care. RGT was utilized for 5 sessions to address reduced ROM, poor postural control, and overall cardiovascular health.

#### Outcomes

Number of steps, up time, "swing assist," and "min assist" were recorded during RGT sessions. GD walked between 225

and 405 steps/RGT session, tolerated 8:40 to 14:29 minutes up time/RGT session, and initiated/assisted up to 30% of the gait cycle based on “min assist” and “swing assist” exoskeleton device values. Intensity level during RGT sessions was determined by heart rate via Polar Flow Tracking wristwatch. GD attained moderate intensity (70%-80% heart rate max) for 22% of one RGT session and 58% of a second RGT session. During the remaining RGT sessions GD attained light intensity (60%-70% heart rate max). Coma Recovery Scale-Revised (CRS-R) scores indicating minimally conscious to emergent from minimally conscious state remained consistent throughout length of stay. However, therapists and family observed increased head movement and visual tracking during RGT sessions, more frequent vocalizations, and increased trunk and limb movements. Modified Ashworth Scale (MAS) scores decreased 1 point for each lower extremity major muscle group from pre- to post-RGT session and overall MAS decreased 1 point by end of stay. No adverse events occurred during RGT sessions.

## Discussion

Patients with disorders of consciousness experience challenges due to severity of physical deficits and medical complexity. While traditional therapy interventions did promote range of motion for GD, RGT appeared to improve tone, increase alertness, and be a moderately intense upright intervention. This case study suggests RGT should be considered as an adjunct therapy intervention allowing for benefits of early upright mobilization and moderately intense activity.

## 0110

### Examining the Neural Substrates of Language and Cognitive Processing in Young Adults With Acquired Brain Injury Using Functional Near-Infrared Spectroscopy

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## Introduction/Rationale

The Intensive Cognitive and Communication Rehabilitation (ICCR) program has led to gains in cognitive-linguistic function, classroom performance, participation, and quality of life for young college-bound adults with acquired brain injury (ABI). Yet, the neuroplasticity underpinning these gains remains unknown. Functional near-infrared spectroscopy (fNIRS) uses near-infrared light to quantify the hemodynamic responses associated with neural activity by measuring concentration changes in oxy-hemoglobin (HbO), deoxyhemoglobin (HbR), and total hemoglobin (HbT). While fNIRS is well-suited to study neuroplasticity in ABI, it has had limited application to this population. A first step in understanding the brain reorganization associated with ICCR involves assessing language and cognitive processing in young, healthy adults via fNIRS as conducted in this study.

## Method/Approach

Twenty young, healthy individuals (male = 12; age mean [SD] = 25 [5]) were recruited from the Boston area. Partici-

pants completed 3 tasks taxing language and cognitive processing (ie, semantic feature verification [ $n = 20$  subjects]; picture naming [ $n = 10$  subjects]; arithmetic [ $n = 10$  subjects]) while undergoing fNIRS measurement. All fNIRS data were acquired using a TechEn continuous-wave NIRS device. The fNIRS probe, consisting of 56 channels, covered the following regions of interest (ROIs) bilaterally: superior frontal gyrus (SFG), middle frontal gyrus (MFG), inferior frontal gyrus (IFG), middle temporal gyrus (MTG), supramarginal gyrus (SMG), and angular gyrus (AG). fNIRS raw signal was processed and converted to concentration changes in HbO and HbR via HOMER2, then, subsequently visualized via AtlasViewer using landmarks obtained with a 3-D digitizer. HbO concentration changes from all channels within 1 ROI were averaged across participants and runs for each task. Paired  $t$  tests were conducted for each ROI across each timepoint to assess for statistically significant differences in the HbO concentration changes in the experimental compared to the control condition.

## Results/Effects

While judging features of real versus scrambled pictures during the semantic feature verification task, participants demonstrated significantly increased HbO concentration changes in LMFG, LIFG, and bilateral MTG and AG accompanied by significantly decreased HbO concentration changes in RMFG. For the picture-naming task, participants showed significantly increased HbO concentration changes when naming real versus scrambled pictures in RIFG and RMTG. During the arithmetic task, participants exhibited significantly increased HbO concentration changes when solving hard versus easy math problems in bilateral SFG and MFG.

## Conclusions/Limitations

These results align with findings from fMRI studies using these tasks, supporting the use of fNIRS to study therapy-induced neuroplasticity in young adults with ABI enrolled in an intensive, academically focused cognitive rehabilitation program. Furthermore, they serve as a basis for understanding the brain reorganization associated with language and cognitive recovery in young adults with ABI.

## 0111

### Pre- and Post-exercise Heart Rate Variability in Adolescents Who Have Been Cleared for Return-to-Play From Sport-Related Concussion

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## Introduction

Sport-related concussion (SRC) is associated with autonomic nervous system (ANS) dysfunction, which may persist even after clinical recovery. Heart rate variability (HRV)

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is a measure of ANS function. The root mean square of the standard deviation of R-R intervals (RMSSD) and the low-frequency/high-frequency ratio (LF/HF) are measures of parasympathetic (PNS) and sympathetic (SNS) nervous system tone, respectively. We measured HRV before and after a graded cycle ergometer protocol to exhaustion in adolescents who had been cleared for return-to-play (RTP) after SRC and compared it to healthy controls.

## Methods

Concussed adolescents (CA,  $n = 9$ ,  $15.0 \pm 0.9$  years, 56% male) were enrolled within 10 days of SRC and followed up with their physician on a weekly basis until they were declared recovered and cleared for RTP. After clearance, CA returned to the clinic for assessment within 7 days. Resting HRV was recorded using EKG during a 2-minute period after 10 minutes of supine rest. CA then performed a graded cycle ergometer test to exhaustion (defined as reporting at least 18/20 on the Borg Rating of Perceived Exertion [RPE] scale) and then rested for 30 minutes. Postexercise 2-minute HRV was recorded in the supine position. Age- and sex-matched healthy controls (HC,  $n = 13$ ,  $16.1 \pm 1.4$  years, 62% male) performed the same assessment. HRV was analyzed using Kubios HRV software.

## Results

CA and HC did not significantly differ in age, sex, height, or weight. Preexercise resting heart rate ( $66.4 \pm 13$  bpm in CA vs  $69.5 \pm 10$  bpm in HC,  $P = .90$ ), RMSSD ( $80.1 \pm 50$  ms in CA vs  $85.3 \pm 45$  ms in HC,  $P = .65$ ) and LF/HF ( $1.01 \pm 0.8$  in CA vs  $1.03 \pm 0.9$  in HC,  $P = .97$ ) did not differ between groups. CA exercised for  $19.1 \pm 4$  minutes versus HC for  $25.4 \pm 6$  minutes ( $P = .01$ ). Postexercise LF/HF was not significantly different ( $1.10 \pm 0.7$  in CA vs  $1.05 \pm 0.9$  in HC,  $P = .90$ ); however, postexercise heart rate was significantly lower ( $65.9 \pm 11$  bpm in CA vs  $75.8 \pm 10$  bpm in HC,  $P = .05$ ) and RMSSD was significant greater ( $93.6 \pm 47$  ms in CA vs  $56.8 \pm 29$  ms in HC,  $P = .05$ ) in CA versus HC. The ratio of post-to preexercise RMSSD was significantly greater in CA than in HC ( $1.6 \pm 1.5$  in CA vs  $0.7 \pm 0.3$  in HC,  $P < .01$ ) but not for LF/HF ( $P = .56$ ). Exercise duration did not correlate with changes in RMSSD ( $P = .64$ ) or LF/HF ( $P = .31$ ).

## Conclusion

This pilot investigation suggests that adolescents who are declared clinically recovered from SRC continue to demonstrate abnormal ANS function after exercise when compared with nonconcussed controls. These data suggest that physiological recovery may not coincide with clinical recovery in some concussed patients. Further research is warranted.

## 0112

### Annexin A2 Deficiency Exacerbates Neuroinflammation and Long-Term Neurologic Outcome After Traumatic Brain Injury

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## Background and Purpose

Traumatic brain injury (TBI) causes mortality and disability worldwide. Previously we showed that Annexin A2 knockout (AnxA2<sup>-/-</sup>) mice displayed impaired blood-brain barrier (BBB) function and recombinant Annexin A2 (rA2) protected against hypoxia plus IL-1 $\beta$ -induced cerebral trans-endothelial permeability in vitro, implying that AnxA2 may be a key endogenous regulator for maintaining homeostasis of neurovascular unit against brain injury. To understand the role and mechanisms of endogenous Annexin A2 in TBI pathophysiology, this study aimed to investigate the effect of Annexin deficiency on neuroinflammation and long-term neurologic outcome after TBI.

## Methods

Adult wild-type (WT, C57BL/6J) and AnxA2<sup>-/-</sup> mice were subjected to controlled cortical impact (CCI) injury. Neurobehavioral assessments including neurological severity score, Rota-Rod test, Morris water maze, Y-maze, and Grid walk were performed to analyze long-term neurologic outcome. Lesion volume was measured by MAP2 staining at 28 days after CCI. Apoptotic brain cells were measured by TUNEL staining at 3 days after CCI. Ipsilateral brain cortical tissues were collected at 1, 2, and 3 days after TBI. Western blotting and immunostaining were performed to detect CD45 and Ly6G expression after TBI. Protein array was used to determine inflammatory cytokines in the brain of WT and AnxA2<sup>-/-</sup> mice after CCI. RT-qPCR was used to determine inflammatory cytokines including TNF $\alpha$  and IL-1 $\beta$  and adhesion molecules such as ICAM1, VCAM1, and E-selectin in the brain microvessel of WT and AnxA2<sup>-/-</sup> mice after CCI. Western blotting analysis was used to determine NF $\kappa$ B signaling protein expression in primary cultured mouse mixed glia cells isolated from WT and AnxA2<sup>-/-</sup> mice.

## Results

AnxA2 expression was significantly upregulated in response to TBI from post-TBI day 3 up to day 14 with peak time at day 7, and the increased AnxA2 expression can be observed in endothelial cells, neuron, microglia, and astrocytes. Compared with WT mice, AnxA2<sup>-/-</sup> mice displayed worse neurobehavioral outcome after TBI. Moreover, AnxA2<sup>-/-</sup> mice showed a significantly increased lesion volume and TUNEL-positive cell number after TBI. Furthermore, we found that there are more induction of proinflammatory cytokine and adhesion molecules in the ipsilateral brain and isolated microvessels of AnxA2<sup>-/-</sup> mice, respectively, compared with WT mice after TBI. Importantly, we also found AnxA2<sup>-/-</sup> mice showed significant increases of leukocyte brain infiltration and microglia activation. Lastly, we observed that isolated microglia from AnxA2<sup>-/-</sup> mice showed increased NF $\kappa$ B signaling in response to cytokine exposure stimulation, compared to the mixed glia cells from WT mice.

## Conclusion

AnxA2 deficiency results in exacerbated neuroinflammation, which might be detrimental to long-term neurologic outcome after TBI. Further investigating and targeting AnxA2-associated neuroinflammation modulation may lead to a promising therapeutic strategy for TBI treatment.

**0113****Recombinant Annexin A2 Improves Neurological Outcomes by Inhibition of BBB Leakage and Leukocytes Brain Infiltration**Liu N<sup>1</sup>, Jiang Y<sup>1</sup>, Chen C<sup>2</sup>, Yu Z<sup>2</sup>, Li Y<sup>1</sup>, Wang X<sup>1,2</sup>

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**Background and Purpose**

Maintenance of inhibition of lymphocyte and neutrophil transmigration had been reported protective against deleterious neuroinflammation and improve long-term outcome after brain injury. We previously reported that Annexin A2-knockout mice displayed impaired blood-brain barrier (BBB) and recombinant Annexin A2 (rA2) protected against hypoxia plus IL-1 $\beta$ -induced cerebral trans-endothelial permeability, indicating a potential protective role of rA2 in the pathology following TBI. This study aimed to investigate the effect of rA2 in BBB leakage, lymphocyte and neutrophil infiltration, neuroinflammation, and long-term neurologic outcome after TBI.

**Methods**

Controlled cortical impact (CCI) injury model was conducted in C57BL/6/J mice. Human rA2 protein (1 mg/kg) or saline was administered intraperitoneally at 2 hours after TBI. Neurobehavioral experiments including neurological severity score, Rota-Rod test, Grid walk, Grip test, Morris water maze, and Y-maze were performed to analyze long-term neurologic outcome up to 28 days after TBI. Brain lesion volume was also examined at 28 days after TBI. The effect of rA2 on blood-brain barrier function was assessed by Evan's blue dye extravasation, and brain edema was examined by brain water content at 24 hours after CCI. Immunostaining was performed to analyze infiltration of lymphocyte and neutrophil, and microglia/macrophage activation at 2 day after CCI. RT-qPCR was used to determine gene mRNA expression of inflammatory cytokines of brain tissue and adhesion molecules of isolated brain microvessels, respectively. Lastly, we also tested the effects of rA2 in leukocyte transmigration across monolayer of cultured human brain microvascular endothelial cells under TNF $\alpha$  exposure condition.

**Results**

Compared to saline, rA2-treated mice exhibited improved neurobehavioral outcomes including motor function and working memory. Moreover, rA2 treatment significantly reduced BBB disruption, edema, and lesion volume after CCI. Furthermore, rA2-treated mice had a significantly decreased brain infiltration of lymphocyte and neutrophil, activated microglia/macrophage after CCI. Additionally, rA2 treatment significantly inhibited inflammatory cytokines expression including TNF $\alpha$  and IL-1 $\beta$  in the brain tissue, and adhesion molecules including ICAM1, VCAM1, and E-selectin in the brain microvessels. Furthermore, rA2 treatment significantly attenuates TNF $\alpha$ -induced leukocyte transmigration across a

monolayer of cultured human brain microvascular endothelial cells.

**Conclusion**

Post-TBI treatment of rA2 improves long-term neurobehavioral outcome and reduces brain lesion volume. Its underlying mechanisms are at least in part by reduction of BBB permeability, edema, brain infiltration of lymphocyte and neutrophils, and proinflammatory microglia/macrophage activation. Taken together, rA2 might be developed as a novel and effective vascular targeting approach for treating TBI.

**0114****Resting Cerebral Blood Flow and Cerebral Blood Flow Velocity After Sport-Related Concussion in Adolescents**Haider M<sup>1-3</sup>, Wilber C<sup>1</sup>, Horn E<sup>1</sup>, Couch S<sup>4</sup>, Mazur B<sup>1</sup>, Leddy J<sup>1</sup>

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**Introduction**

Sport-related concussion (SRC), a type of mild traumatic brain injury (mTBI), is associated with altered cerebral blood flow (CBF) and CBF velocity (CBFv), which may be due to injury to the autonomic nervous system (ANS). We did a controlled study of resting CBF and CBFv in concussed adolescents within 10 days of injury and again after being cleared for return-to-play (RTP).

**Methods**

Concussed adolescents (CA,  $n = 17$ ,  $15.4 \pm 0.9$  years, 47% male,  $7.3 \pm 2$  days since injury) were diagnosed with SRC by a sports medicine physician. Whole brain weighted mean CBF was measured by ASL MRI. CBFv at the middle cerebral artery (MCA) was measured through the temporal acoustic window using transcranial Doppler (TCD) for 10 minutes in the supine position in a dark, quiet room. CA followed up with their physician until cleared for RTP. They returned for CBF and CBFv assessment within a week of RTP (mean 33.5 days since initial visit). Healthy controls (HC,  $n = 9$ ,  $16.1 \pm 1.5$  years, 56% male) performed the same assessment at 2 visits (mean 40.8 days apart).

**Results**

CA and HC were matched on age ( $P = .13$ ), sex ( $P = .56$ ), height ( $P = .59$ ), and weight ( $P = .32$ ). At visit 1, whole brain CBF ( $51.90 \pm 2.6$  mL/100g/min in CA vs  $51.87 \pm 2.7$  mL/100g/min in HC,  $P = .98$ ) and MCA CBFv ( $61.9 \pm 10$  cm/s, mean depth 49.6 mm in CA vs  $61.7 \pm 4$  cm/s, mean depth 52.4 mm,  $P = .95$ ) were not significantly different between groups. At visit 2 (after RTP), whole brain CBF was not significantly different between groups ( $53.50 \pm 3.7$  mL/100g/min in CA vs  $52.11 \pm 3.0$  mL/100g/min in HC,

$P = .38$ ) whereas CBFv was significantly greater in CA ( $71.4 \pm 14$  cm/s, mean depth 50.0 mm in CA vs  $62.3 \pm 6$  cm/s, mean depth 50.8 mm in HC,  $P = .02$ ). There continued to be no difference in whole brain CBF at visit 2.

## Conclusion

This pilot investigation suggests that CBFv is significantly higher in concussed adolescents at the time of clinical recovery (ie, no symptoms or exercise intolerance) despite no significant increase in whole brain CBF. Increased CBFv may be a compensatory response to differences in cerebral vascular resistance or compliance after SRC. Thus, physiological recovery may not coincide with clinical recovery in some concussed patients. Further research is warranted.

## 0115

### Elovanoids (ELV) Protect Telomere Length Shortening and Restore of Telomerase Activity Upon Exposure to Uncompensated Oxidative Stress (UOS) or Oligomeric Amyloid $\beta$ (Oa $\beta$ ) Recapitulating Brain Injury

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## Purpose

Elovanoids (ELVs) are a novel lipid mediator class derived from 32:6n3 and 34:6n3. We established stereochemistry that ELVs mediate cell death protection by counteracting uncompensated oxidative stress (UOS) in human retinal cells and brain and have the potent ability to inactivate pro-apoptotic and pro-inflammatory signaling (Jun B et al, *Sci Rep* 2017; Bhattacharjee S et al, *Sci Adv.* 2017; Bazan NG. *Mol Aspects Med.* 2018). The present study investigates the role of ELV on telomerase activity and telomere-independent function under UOS or oligomeric amyloid  $\beta$  (Oa $\beta$ ). The toxic A $\beta$ 42 is aggregated in drusen and senile plaques, in age-related macular degeneration (AMD) and Alzheimer's disease, respectively. Telomerase is involved in senescence, DNA damage repair (DDR), and age-related pathologies and acts as "mitotic clocks" in neurodegeneration fueled by inflammation, and nontelomeric functions for the telomerase proteins TERT (telomerase reverse transcriptase), TTI1 (TELO2-interacting protein 1 homolog), and RAP1 (repressor/activator protein1) influence key cellular processes in oxidative stress resistance and neuroprotection. These telomere-independent functions and signaling pathways are critical for cell survival. Thus, we investigated ELV in modulating telomerase activity.

## Methods

Serum-starved primary RPE cultures were UOS-H<sub>2</sub>O<sub>2</sub> (1200  $\mu$ M) + TNF $\alpha$  (10 ng/mL) or Oa $\beta$  (10  $\mu$ M) stressed and treated with ELV or other lipid mediators (200 nM). Protein abundance was checked by Western blots, RNA transcripts, and absolute telomere length (ATL) analyzed by RT-PCR, and global DNA and histone H3K9 methylation and H3K9 acetylation assayed by ELISA.

## Results

Induction of TTI1 & RAP1 protein abundance upon UOS was attenuated by ELV-32:6 and 34:6, respectively. ELVs rescue TERT transcription upon UOS or Oa $\beta$ , and compensate UOS and Oa $\beta$ -upregulated global DNA methylation (5 mC). UOS or Oa $\beta$  upregulates H3K9 methylation in presence of ELV. ELVs restore ATL in UOS and Oa $\beta$ -stressed RPE.

## Conclusions

Our data suggest that ELV reduction of UOS or Oa $\beta$ -induced TTI1 & RAP1, and upregulation of TERT, neuroprotection, restoration of ATL, and 5-mC involve key targets of telomerase. The telomerase complex is involved in DDR; we know DNA repair enzymes are activated in photoreceptors by photo-oxidative stress. We are currently defining ELV-specific mechanisms; this novel signaling may be fundamental for photoreceptor integrity. ELVs, the molecular guardians, may act as epigenetic regulators contributing to responses to brain injury.

## Funding

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## 0116

### ISG15 Is Developmentally Upregulated Following TBI

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## Introduction

Recently, we have shown that ISG15, a ubiquitin-like protein, is upregulated prior to breakdown of the BBB following TBI and colocalizes with MLCK and claudin5, which plays a pivotal role in development of cerebral edema. Here, we show that free ISG15 and ISGylation are greater in older mice PND35 compared to PND24 or PND21 mice. ISG15 is increased following focal ischemia and has been shown to be neuroprotective. The significance of ISG15 in the disruption of the BBB following TBI is still unclear.

## Methods

PND21, PND24, and PND35 mice were anesthetized with avertin, mechanically ventilated, physiologically regulated, and subjected to lateral closed-skull injury model with impact depth of 2 or 2.25 mm (bregma level -0.10 mm) for PND21 and PND24 mice and 3 or 3.25 in PND35 mice. Mice were sacrificed at T0, T1 hour, and T4 hour. ISG15 and ISGylation were analyzed by Western blot, immunohistochemistry; BBB disruption was evaluated with a triple dye of fluorescein sodium salt and 4Kda dextran and Evans blue bound to albumin.

## Results

- Protein expression
- ISG15

- Free ISG15 is downregulated normalized to actin immediately following TBI in PND21 mice. ISGylation does not change significantly in the 4 hours following TBI. Free ISG15 upregulates normalized to actin immediately following TBI in PND24 mice and ISGylation shows and increases at 4 hours following TBI. In PND35, free ISG15 upregulates immediately following TBI and ISGylation shows upregulation at 1 hour following TBI and continues through the 4-hour timepoint.
- Claudin 5
- PND21 expresses decreased levels of Claudin 5 compared to PND24 and PND35 and shows no significant change in expression between PND 24 and PND35. PND21 shows decreased expression of Claudin 5 following TBI PND24 and PND35 shows an increased level of Claudin 5 following TBI.

### Blood-Brain Barrier Disruption

Fluorescein extravasated into the parenchyma of the brain PND 21 TBI mice more readily than in both PND24 and PND35 beginning at impact through 4 hours. Evans blue bound to albumin showed no real significant difference in the early timepoints of T0 through 4 hours in any of the age grounds.

Texas Red-dextran extravasation was decreased in PND21 mice compared to PND24 or PND35 mice. PND24 mice and PND35 mice showed increased extravasation following TBI, with PND24 being greater than PND35. PND21 mice showed decreased extravasation following TBI.

### Conclusion

Delay in upregulation of ISG15 in PND21 mice compared to PND24 mice and PND35 mice may play a role in the dysregulation that occurs in young brains compared to older brains following TBI. There remains much to be learned about ISG15 and TBI.

## 0117

### The Impact of an Interdisciplinary Team-Based Assessment for Youth With Concussion and Their Families

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### Background

Persistent concussion symptoms (PCS) can include physical, cognitive, and mental health complications. It is essential for individuals with PCS to have access to appropriate and timely, coordinated, interdisciplinary, and evidence-based services. However, there are currently no guidelines regarding how these interdisciplinary services should be organized. The

Persistent Concussion Clinic at Holland Bloorview Kids Rehabilitation Hospital (Toronto, Canada) has developed a novel interdisciplinary team-based assessment that includes 4 professionals (occupational therapy, physiotherapy, social work, and neuropsychology), the youth experiencing symptoms, and their family.

### Objective

The objective of this study was to describe the key elements of the interdisciplinary team-based assessment process within the Persistent Concussion Clinic at Holland Bloorview, from the perspective of youth clients and their families.

### Methods

A qualitative descriptive study using semistructured interviews was conducted with youth ( $n = 8$ ) and their caregivers ( $n = 7$ ). Youth participants ranged in age from 8 to 17 years, with PCS lasting 6 to 49 months. Analytic devices typical of interpretive qualitative research were used (eg, multiple readings of the data, coding to complicate data, and conceptualize findings).

### Results

A conceptual model was developed to capture the experiences of youth and their families with the interdisciplinary team-based assessment. Three key elements were identified: (1) initiate, (2) dialogue, and (3) cocreate. Participants described evolving expectations throughout the assessment process; they were nervous at the outset but were quickly made to feel comfortable by the team. Central to this shift was a back-and-forth dialogue in which youth felt they were taken seriously, enabling the cocreation of a personalized treatment plan. Of primary importance is the notion that this process was a welcomed change from how youth and their families had previously experienced care, leaving families optimistic about treatment to follow.

### Conclusions

This novel interdisciplinary team-based assessment appears to be an acceptable model for concussion assessment in youth with complex clinical presentations. This study demonstrates the importance of involving youth and their families as active participants within interdisciplinary concussion care.

## 0118

### Agreement in Perceptions of Relationship Quality Among Patients With Acquired Brain Injury and Their Uninjured Partners

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### Objective

Research indicates that at least one-third of brain injury caregivers are spouses, and there is little doubt of their important long-term role in facilitating recovery and adaptation. Unfortunately, the impact of brain injury on coupled relationships

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has been a consistently neglected area of focus. Research has typically focused on the perceptions of uninjured partners, and there are relatively few studies comparing partners' and patients' perceptions. The objective for the present investigation was to characterize marital quality after acquired brain injury (ABI) considering the perspectives of the patient and the uninjured partner.

## Methods

The sample consisted of 74 couples with ABI participating in an intervention to promote couples' adjustment and coping. Marital quality was measured using the Revised Dyadic Adjustment Scale (RDAS), with higher scores indicating greater marital satisfaction. A score of less than or equal to 48 indicates a distressed relationship. The RDAS was administered to both the patients and their partner prior to initiating the intervention.

## Results

Fifty-nine percent of patients viewed their relationship as distressed on the RDAS, as did 65% of partners. For most couples (72%), there was a consensus on the quality of their marital relationship. Thirty-four couples (46%) agreed that their marriage was in distress, while 19 couples (26%) agreed that their marriage was not. An exact McNemar's test comparing patient and partner RDAS ratings did not indicate disproportionate perceptions of quality.

## Conclusions

The RDAS may serve as a useful tool in understanding relationships after ABI. Results suggest a substantial number of couples view their relationship as distressed. Given the importance of marriages and the role changes that commonly follow injury, clinicians are encouraged to consider the quality of relationships, particularly when formulating treatment plans.

## 0119

### Elovanoids Reduce Microtubule-Associated Protein Tau (MAPT) Missorting

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## Purpose

Microtubule-associated protein tau (MAPT) provides microtubule stability and neuronal axoplasmic transport integrity. Hyperphosphorylated MAPT is the principal constituents of neurofibrillary tangles, a histopathological hallmark of traumatic brain injury (TBI) and of Alzheimer's disease (AD). MAPT is key to understanding the onset and progression of neurodegeneration. The hyperphosphorylated forms of MAPT migrate from the axon to the somatodendritic compartment after additional phosphorylation and likely other posttranslational modifications. The regulation of missorting and of specific phosphorylation profiles that promote migration of MAPT from the axon to the somatodendritic compartment is

not clearly known. In this project, antibodies for MAPT and its phosphorylated forms (Tyr18, Ser202/Thr205, Ser199, and Thr231) are used in neurons exposed to oligomeric amyloid-beta ( $Oa\beta$ )  $\pm$  elovanoids (ELVs), neuroprotective and neurorestorative lipid mediators. ELVs are derived from 32:6n3 and 34:6n3.

## Methods

Rat primary embryonic hippocampal cultures were established and exposed to  $Oa\beta$  (10  $\mu$ M) and treated with ELVs or other lipid mediators at different concentrations. Tau missorting was assessed by confocal microscopy (immunocytochemistry) in both standard 12-well culture plates and microfluidic chambers. Antibodies for MAPT and its phosphorylated forms (Tyr18, Ser202/Thr205, Ser199, and Thr231) were used for immunocytochemistry to document the subcellular location of MAPT in neurons exposed to  $Oa\beta$  and to study the effects of ELVs. Protein abundance was checked by WB and capillary electrophoresis.

## Results

Confocal imaging demonstrates a significant ( $P < .0001$ ) difference in signal intensity from wells exposed to  $Oa\beta$  in comparison to wells exposed to  $Oa\beta$  plus ELVs. Antibodies that show differences include AT8, Tyr18, and Thr231.

## Conclusions

Our results show that ELVs restore  $Oa\beta$ -induced MAPT somatodendritic missorting and reduce hyperphosphorylation, making the ELVs a potential avenue of therapeutic exploration for TBI pathology and AD.

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## 0120

### The Relationship Between Gender, Sport Level, Concussion History, Academic Confidence, and Academic Performance in Collegiate Student-Athletes

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The benefits of sport for health and well-being are well known, but sport participation also comes with a risk of injury. Many college students participate in sport at the club and varsity levels as part of their collegiate experience. Concussions are a significant public health concern and universities are implementing concussion management protocols across all levels of sport participation. While research has addressed the relationship between concussive injury and neurocognitive performance, less is known about the influence on academic performance in collegiate student-athletes. Thus, the main purpose of this study was to retrospectively investigate how academic performance may be altered by a history of concussion(s) and academic confidence. Additionally, a supplementary objective of this study was to examine whether gender and sport level (varsity or club) were related to academic performance and academic confidence. Measures included in this study were ImpACT composite subscores (verbal memory, visual memory, reaction time, visuomotor processing speed); self-reported demographics from ImpACT (gender, age, concussion history, sport level, quality of student); GPA from academic records; and academic confidence scale (ACS). A total of 622 Southeastern Private University collegiate student-athletes (club,  $n = 281$ , varsity,  $n = 341$ ; female,  $n = 317$ , concussed,  $n = 166$ , above average student quality,  $n = 392$ ) participated in this study via online questionnaires, GPA, and ImpACT across 1 academic year. Multivariate analysis of variance resulted in significant concussion group differences in verbal memory, visual memory, visuomotor processing speed (no concussion > concussed;  $P < .05$ ), quality of student differences in GPA (above average > average;  $P < .05$ ), and sport-level differences in academic confidence (varsity > club;  $P < .05$ ). A multivariate linear regression was tested to predict GPA. Variables included in the model that were not significant were concussion history and sport level ( $P > .05$ ). Significant variables included gender ( $P < .001$ ), quality of student ( $P < .001$ ), and visuomotor processing speed ( $P < .05$ ). Together, these accounted for 8% of the variance in GPA. Similar analysis was conducted for academic confidence with sport level ( $P < .001$ ); quality of student ( $P < .001$ ); and visuomotor processing speed ( $P < .01$ ) accounting for 8% of variance. Gender and concussion history did not contribute significantly to the model ( $P > .05$ ). Overall, these findings suggest a meaningful relationship between neurocognitive baseline measures and academic performance, which may be influenced by concussion history, gender, and sport level. This has implications in concussion management and education for collegiate student-athletes at all sport levels.

## 0121

### Predicting Intentions to Report Concussions: A Latent Profile Analysis of Collegiate Student-Athletes

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Of the nearly 9 million student-athletes who engage in varsity or club sports at the collegiate level, approximately 1.6 million to 3.8 million sports-related concussions (SRCs) occur each year. This estimate is likely skewed, as research has theorized that as many as 80% of SRCs go unreported. Interventions for collegiate student-athletes typically address concussion education, leaving much to be desired about under-

standing the athlete as a whole. Focusing on education may not necessarily explain why concussions are going unreported and may be better attributed to other factors like the fear of losing time on the field, loss of athletic scholarship, loss of athletic identity postconcussion, or not being seen as "tough enough."

Secondary data analysis consisted of data from 506 student-athletes who completed baseline physical functioning assessments, measures of psychosocial functioning, and demographic information. Student-athletes ranged in age from 17 to 25 years (mean = 18.80, SD = 1.17). There were 257 males and 249 females; the majority of students were white ( $n = 430$ ) and in their first year of college ( $n = 308$ ). Student-athletes were also designated into NCAA tiers, playing limited contact sports ( $n = 115$ ), contact sports ( $n = 90$ ), and contact and collision sports ( $n = 278$ ).

A latent profile analysis was used to examine profile membership of student-athletes based on the following constructs: athletic identity, academic identity, motivation to engage in their sport, and goal orientation. MPlus fit index analyses yielded a 3-cluster model that was used to predict intentions to report concussion symptoms. Demographic moderators (age, gender, year, race, tier of sport) were also used to predict profile membership and to examine interactions with profiles to predict intent.

It is important to engage in higher-level statistical modeling in order to better understand the profiles of student-athletes who may experience concussion symptoms. As a result, practitioners and intervention scientists must consider multiple variables simultaneously (rather than individually) to predict concussion reporting and other significant health outcomes. Understanding that student-athletes are multidimensional individuals will likely impact future efforts to tailor concussion education interventions that consider these differences across multiple variables among profiles of students.

## 0122

### Blood Serum Lipid Mediators and Pathological MicroRNAs Linked to Concussion in Football Players: Novel Biomarkers of Brain Injury

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## Introduction

Sports-related concussion, a common and serious type of mild traumatic brain injury (mild-TBI), is a growing concern because such injuries can have devastating long-term neurological and behavioral consequences. Repeated concussions can lead to long-term brain damage including chronic traumatic encephalopathy (CTE) and progressive, age-related, neurodegenerative change. This study aimed to understand the mechanisms of concussion-triggered brain damage via blood-serum analysis.

## Materials and Methods

A cohort of 54 football players were sampled both throughout the season and immediately following on-field concussion. Physical examinations and questionnaires were used to collect data on immediate mental, physical, or physiological change. Helmet accelerometer data were retrospectively assessed and correlated with clinical and laboratory data. Serum was analyzed for known TBI biomarkers (t-tau, S100B, GFAP), arachidonic acid (AA) derivatives (12-HETE), novel docosanoids (NPD1), and serum microRNA.

## Results

Linemen and nonlinemen players revealed different AA and docosanoid changes after concussion; postconcussion, nonlinemen players showed decreases in the docosanoid NPD1. Linemen had significant increases in the AA derivatives 12-HETE, alterations in DHA and EPA levels, and decreases in NPD1 after concussion. Of considerable interest was the observation of a selective increase of a neurodegeneration-associated Let-7c-5p miRNA.

## Conclusions

These data suggest that the number and magnitude of concussive impacts correlate with several lipid mediators including significant increases in the AA derivatives 12-HETE, temporal alterations in free DHA, free EPA, decreases in the docosanoid NPD1, and upregulation of Let-7c-5p. Let-7c-5p is a 22-nucleotide, single-stranded chromosome-21q21-encoded-microRNA also known to be increased in Down syndrome (DS), Alzheimer's disease (AD) and multiple system atrophy (MSA). A miRNA signature was discovered that distinguished with good specificity and sensitivity players with concussions from nonconcussed players. This is the first investigation: (i) showing parallel increases in the inflammation-supporting 12-HETE; (ii) a downregulation in the neuroprotective docosanoid NPD1; and (iii) an upregulation of the pathogenic and neurodevelopment-associated biomarker Let-7c-5p microRNA after concussive brain injury. Postinjury increases in 14-HDHA, a precursor to maresin indicated a possible de novo stimulation of neuroprotective activities. Large-scale, prospective studies should be undertaken to elucidate the potential mechanistic and predictive significance of these lipid and epigenetic biomarkers.

## Funding

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## 0123

### Augmenting Rehabilitation Services at a Level 1 Pediatric Trauma Center for Children With Moderate to Severe Traumatic Brain Injury

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## Objective

The purpose of this study was to determine whether length of stay (LOS), consultation referrals, and time to consultation to various rehabilitation services would be impacted following an advanced quality improvement program, which included an educational intervention aimed at care providers of children with moderate to severe traumatic brain injury (TBI) admitted to a pediatric level 1 trauma service.

## Methods

Sixty-one patients diagnosed with moderate to severe TBI were included in the study. The educational intervention was divided into preeducational (5 months), posteducational (2 months), and follow-up (12 months) periods. The trauma, rehabilitation, and other associated service lines were analyzed and key staff were identified for additional education on how to identify and refer patients who may benefit from rehabilitation services. Data were gathered from the institution's trauma and rehabilitation patient databases. The number of consultations by service line, ICU and total length of stay, and time to consultation by service line were analyzed. The outcome data were analyzed descriptively, and comparatively using *t* tests, independent ANOVAs, and  $\chi^2$  with an  $\alpha$  level set at .05.

## Results

The average age of the participants was 5.96 years (SD: 5.66). Twenty-four of the participants had a GCS score in the moderate range and 37 in the severe range with an average GCS of 6.89 (SD: 3.47). The average ICU LOS was 8.37 days, with a total LOS of 15.59 days. The AIS severity varied with 94% of the participants categorized as serious, severe, or critical with an overall average score for the group of 3.69 (SD: 1.10). The average injury severity scale (ISS) was 20.24 (SD: 10.68). For participants who received a rehabilitation consult (which included PM&R, PT, OT, and/or SLP), the average ICU LOS decreased pre/post by 8.68 days (total LOS decreased by 1.49 days). In addition, the number of referrals increased by 18.6% for any type of rehabilitation consultation with the largest increase found for PT by 25.7% and PM&R by 37.1% with significant  $\chi^2$  values found for PT ( $P = .016$ ), SLP ( $P = .008$ ), and PM&R ( $P = .021$ ). The time to consultation was reduced for all disciplines with the average time to PM&R consult decreasing from 3.83 days to 0.88 day. Similarly, time to PT consult decreased from 6.22 days to 2.50 days.

## Conclusions

This study found that an educational intervention targeting appropriate and timely referral of patients to rehabilitation services can decrease both the overall and ICU LOS despite an increase in the utilization of inpatient services. Furthermore,

targeted intervention can decrease the time to rehabilitation consultation. Since a delay in the initiation of comprehensive rehabilitation services has been correlated with lower functional outcomes, institutions may wish to consider similar interventions to improve the consistency and timeliness of rehabilitation services.

## 0124

### Feasibility of the Overt Behavior Scale in the Inpatient Rehabilitation Setting

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Persons with acquired brain injury exhibit a range of problematic behaviors in the acute period including aggression, impulsivity, perseveration, hypersexuality, and disinhibition. These behaviors pose particular challenges in the inpatient rehabilitation (IPR) setting and for community reintegration. Accurate measurement of these complex behaviors facilitates appropriate treatment planning. Conversely, poor understanding of ABI behavior may lead to inefficient or even unsafe interventions. Available scales often collapse unsafe behaviors into broad behavioral domains (eg, aggression). There are limited tools that fully capture the broad range of behaviors resulting from ABI (Kelly et al, 2008). One outcome measure that captures the range and severity of behaviors seen in the acute phase is the Overt Behavior Scale (OBS). The OBS includes 3 indices: (1) Cluster (0-9) score denotes the number of total categories of behavior (eg, physical aggression toward others) observed during the rating period, (2) Total Levels (0-34) captures the sum of the number of individual behavioral descriptors observed (eg, "strikes, kicks, pushes"), and (3) Clinical Weighted Severity (0-84) represents a numerical rating of overall severity of behaviors demonstrated across all behavioral categories. This tool was developed for community use via clinical interview and direct observation. The OBS asks raters to indicate the presence and severity of a behavior rather than the underlying meaning or intent of the behavior, thereby resulting in high interrater reliability ( $r_s = 0.99, P < .001$ ; Kelly et al, 2006). Specific measurement needs in the IPR setting include ease of use and administration time, as raters possess variable knowledge bases to accurately measure or describe the complexities of ABI behavior. Finally, speed of administration and repeatability are crucial in the inherent constraints of the IPR setting. As a result of these unique needs and challenges, accurate measurement of behavior poses barriers to adequate treatment planning and safe discharge. The goal of this study is to understand the feasibility of administration via direct observation within a clinical treatment session with the intent to decrease clinician burden and maximize productivity. The following outcomes will be assessed: (1) administration time (more or less than 5 minutes), (2) completion rate, and (3) clinician rating of ease of administration. Administration of the OBS is performed during each 30- or 60-minute treatment encounter by a licensed rehabilitation therapist (ie, speech, occupational, and physical therapies). Prior to administration, licensed therapists underwent competency training for administration guidelines. The results of this feasibility study will aid in determining whether the OBS is a valid and reliable tool in predicting supervision level at time of discharge and in predicting functional outcomes.

## 0125

### Experimental TBI Induces Long-Term Cognitive Deficits and Vascular Pathology

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Traumatic brain injury (TBI) is a worldwide health concern with approximately 5.3 million Americans currently living with TBI-induced disability. For many, long-term TBI-associated disabilities impair cognition, provoke seizure, and elevate risk for neurodegenerative disease. Oxidative stress, nitrate stress, and derangement of cerebrovascular physiology have been implicated in acute acquired neurological injury and aging-related dementia disorders. Experimental models of TBI provide a unique opportunity to investigate the relationship between vascular disturbances and impaired cognitive performance. In this study, diffuse brain-injured (midline fluid percussion) adult male rats were assessed for long-term molecular, vascular, and cognitive pathologies. At 90- and 180-days postinjury, brain-injured and uninjured sham rats performed 3 cognitive tasks: a novel object recognition task (NOR) assessing short-term memory, a novel location recognition task (NOL) assessing long-term memory, and a temporal order recognition task (TOR) assessing working memory. Rat brains were imaged at 182 to 187 days postinjury via dynamic susceptibility contrast monocrySTALLINE iron oxide particle (MION) magnetic resonance imaging (MRI) to assess in vivo cerebrovascular blood flow and vasoreactivity in response to hypercapnic challenge. At 189 to 193 days postinjury, brains were collected for histology and arteries (circle of Willis, ventral circuit) were collected ex vivo vasoreactivity and markers of oxidative and nitrate stress, respectively. Brain-injured rats performed significantly worse than shams on the NOR and TOR tasks at 90 days postinjury. At 180 days postinjury, brain-injured rats performed significantly worse than sham on all 3 cognitive tasks. By MRI, brain-injured rats showed significantly less cerebrovascular blood volume compared to sham rats. Ex vivo vasoreactivity was not significantly different in baseline cerebrovascular myogenic tone or endothelial reactivity between groups. Cerebral arteries of brain-injured rats exhibited significantly greater levels of superoxide and peroxynitrite in the presence of amyloid-beta-42 (A $\beta$ 42) compared to cerebral arteries of sham rats, indicating significantly higher response to oxidative and nitrate stress. Thus, experimental TBI induced long-term cognitive and vascular pathologies, which supports the potential for injury-induced vascular dementia. Further analysis will integrate the relationship between brain injury parameters, cognitive performance, and vascular function in order to elucidate the mechanistic role of vascular dysfunction in TBI-mediated cognitive dysfunction.

## 0126

### Envisioning a Path Toward Healing: An Interdisciplinary Approach to Clinical Care for Mild Traumatic Brain Injury in Veteran Populations

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Veterans of the ongoing conflict in the Middle East experience the consequences of a wide range of injuries when seeking treatment for mild traumatic brain injury (mTBI) and posttraumatic stress (PTS). Veterans with mTBI and co-occurring psychological health issues present a wider range of symptoms than other populations due to the nature of their injuries while in military service. These complex issues may require special considerations not typically addressed in mTBI care. Wide-ranging symptoms must be treated for the individual to successfully reengage with their lives. Emotional, psychological, cognitive, spiritual/existential, creative, relational, and physical functioning often changes because of the impact of trauma to the brain and to the veteran's psychological and spiritual health.

A veteran's complex injuries can be extremely difficult and/or frustrating for individual providers to treat successfully. This presentation describes how multidimensional injuries are addressed by a team of professionals in behavior health, mind/body medicine, speech-language pathology, physical therapy, and art therapy.

The poster will utilize de-identified case examples to describe both the expression of these multifactorial issues and the treatment provided in an interdisciplinary team approach to address challenges such as moral injury, self-forgiveness, and existential meaning/purpose in addition to the physical, cognitive, and emotional sequelae of mTBI and PTS. The collaborative treatment team addresses the complex and comorbid psychological impairments, laryngeal dysfunction, postural deviation, and manifestations of unprocessed grief and trauma in the physical body. Visual art (photographed for this poster) produced by veterans in art therapy sessions served as a catalyst for the veterans' and the team's recognition of the consistent and collective clinical themes. Within the integrated practice unit of the Marcus Institute for Brain Health, an interdisciplinary approach of targeted, individualized, multimodal, and cohesive methods supported the veterans' understanding of the interconnected nature of symptoms and daily challenges.

This poster illustrates the rehabilitative value of caring for veterans with complex health needs through interdisciplinary methods. Clinical providers' personal and professional awareness of the integrated mind-body-spirit element of care is crucial to best support comprehensive healing. The aim of this presentation is to highlight the importance of addressing injuries from a holistic perspective so that clinicians from any discipline, in any setting, treating veterans with mTBI and PTS, can expand the therapeutic lens and address overlapping symptomatology. This trauma-informed, holistic understanding can help clinicians identify, assess, and treat veterans who suffer from the unique complexities of their military service-related injuries.

## 0128

### Clinical Presentation of Concussion in Age- and Sex-Matched Work Related and Non-work-Related Patients

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#### Objective

To explore differences in initial presentation between Worker's Compensation (WC) and nonlitigating, non-WC (NNWC) concussion patients.

#### Design

Retrospective cohort of age- and sex-matched patients with a diagnosed concussion.

#### Setting

Regional concussion center.

#### Participants

Six NNWC participants were age- and sex-matched with 6 WC, diagnosed with a concussion, and tested on their first visit.

#### Main Measures

*Primary:* referral utilization and number of clinical visits. *Secondary:* neurocognitive testing (ImPACT) and symptom reporting (PCSS).

#### Results

The matched groups consisted of 50% males, mean age of  $25.3 \pm 2.9$  years, and time to first visit was  $18.2 \pm 11.6$  days—ImPACT composites ( $P = .067-.204$ ), total symptom severity ( $P = .182$ ), and number of symptoms ( $P = .185$ ). The number of referrals utilized ( $1.8 \pm 1.1$  vs  $0.7 \pm 0.5$ ) ( $P = .093$ ) and the number of office visits ( $4.3 \pm 2.4$  vs  $2.2 \pm 0.7$ ) ( $P = .082$ ) were slightly increased in the WC group but not significantly different.

#### Conclusions

In this preliminary age- and sex-matched study of young adults, we found no significant differences between WC and nonlitigating, non-WC patients on resource utilization, neurocognitive test performance, and symptom reporting at initial visit. With continued recruitment, an expanded sample should determine whether preliminary findings are confirmed. Future research will focus on patterns of recovery and clinical outcomes.

## 0129

### Healthcare Costs and Utilization Associated With the Assessment and Treatment of Persistent Post-concussive Symptoms in a Pediatric Sample in Ontario, Canada

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#### Background

For the majority of youth who sustain a mild traumatic brain injury, or concussion, symptom recovery typically occurs within a few weeks following injury. However, up to 30% will experience postconcussion syndrome (PCS) symptoms that persist for a longer period and can interfere with daily activities. In Ontario, Canada, the Brain Injury Rehab Team (BIRT), Outpatient Services Concussion Clinic at Holland Bloorview Kids Rehab Hospital is a service that focuses exclusively on

youth with persistent PCS and consists of an interdisciplinary clinic team. The goal of this study was to assess the healthcare costs and utilization associated with such an outpatient service in order to evaluate the delivery and quality of a novel model of persistent PCS care.

### Objectives

(1) Determine direct costs associated with services received; and (2) summarize utilization patterns of the clinic based on: (a) comprehensiveness of services provided and referrals made; (b) continuity of care (ie, average wait times); and (c) productivity (ie, percentage of missed appointments).

### Methods

A retrospective chart review of 172 youth (ages 3-18 years) with persistent PCS (>1 month) seen at the clinic from July 2015 to October 2018. Direct healthcare costs for physician and hospital service use were calculated using the Ontario Physician Schedule of Benefits. Costs in relation to all other services were estimated from the salary or hourly wages allotted for these services within the BIRT budget. Data regarding healthcare utilization parameters were descriptively summarized based on information available in client electronic medical records.

### Results

Direct costs associated with services received through the clinic were approximately Can\$1000 per client, with an accumulated total cost of approximately \$83 000. Per client direct costs were greatest for neuropsychological services and lowest for occupational therapy (OT). Total accumulated direct costs were highest for physician services. With respect to comprehensiveness of service utilization, 84% of clients were referred to at least one other service. The highest referral rate was for OT (74%) and half of the sample went on to receive an external service referral. For continuity of care, the average wait time for an initial physician consultation was 2.5 months, and 1 month for interdisciplinary services. For productivity of services, combined no show and cancellation rates ranged from 9% to 22%, with the highest rates being associated with OT.

### Conclusions

A unified approach for persistent PCS care has the potential to provide significant cost savings from both the client and societal perspectives. Identifying factors that underlie cost and utilization differentials among clients will provide valuable insight regarding barriers and facilitators to care. The information gained from the current study may improve future service delivery and ensure that access to care is equitable across all clients in need.

## 0130

### Playing the Game or Gaming the System: Are US High School Student-Athletes Reporting, Hiding, or Faking Concussions?

Snedaker K

*Pink Concussions, Norwalk, United States*

A recent study reported that approximately 19.5% of adolescents have experienced a concussion, also known as a mild traumatic brain injury (TBI), at some point in their lives (Veliz, McCabe, Eckner, and Schulenberg, 2017). Additionally, we know that these injuries might be increasing over time: during the last decade, emergency department visits for sports-related TBIs among children and adolescents in the United States increased by 60% (Faul, Xu, Wald, and Coronado, 2010).

However, most of the surveillance information that we have about concussions has been conducted with samples of public school students (eg, in High School RIO, 85% of participating high schools are public schools with the remainder being private). Data from the US Department of Education demonstrate that there are systematic differences between public and private schools, in terms of resources, socioeconomic, student makeup, and location (Choy, 1997).

Evidence also suggests that the athletic experience in private versus public schools can be different (Allen, 2016). And finally, most of the youth sports traumatic brain injury state laws do not apply to children who attend private schools. Therefore, a crucial gap in knowledge exists regarding the concussion experience of youth attending private schools.

Using data by PINK Concussions under an IRB from Connecticut Children's Medical Center entitled "Playing the Game or Gaming the System: Are Current High School Student-Athletes Reporting, Hiding or Faking Concussions?", a joint program between the CDC and PINK Concussions is currently analyzing data collected from over 1900 male and female high school students enrolled in a private school that is part of the New England Preparatory School Athletic Council (NEPSAC) in order to describe the concussion experience of students attending private high schools in Connecticut, New York, and Rhode Island.

There were a total of 25 questions, including the traditional concussion survey questions:

- How many seasons of sports do you play a year?
- Have you ever had a concussion?
- How old were you when you sustained your first concussion?
- If you got a sport-related concussion today at your team's practice at school, who would be the first person you would tell?

But this study also asked students whether they were taking advantage of the new concussion protocols at their schools—a concern some teachers have expressed to concussion experts:

- Have you ever pretended to have a slower recovery from a concussion to stay out-of-school work longer than you needed to be sidelined?
- Have you ever pretended to have a slower recovery from a concussion to stay out of sports longer than you needed to be sidelined?

The answers to these questions and cross-tabulations of the concussion-specific questions were examined by sex, sport, and number of seasons played.

## 0131

### From Paper to Practice: Developing and Implementing Sports Injury Prevention Interventions That Make a Difference

Snedaker K

*Pink Concussions, Norwalk, United States*

There has been much written in the last 5 years, in science publications and in the press, on the importance of reducing the number of youth sports concussions and finding ways to manage concussion recovery better in children. For all the clamor to create or change school and youth sport concussion policies, there are very few examples of how to take theory laid out in these scientific papers and implement low-cost programs in children's day-to-day lives across an entire city.

This presentation will highlight an ongoing 3-year project in Norwalk, Connecticut, where RE-AIM Sports Setting Matrix (RE-AIM SSM), a health promotion planning and evaluation framework, was used to develop and implement a city-wide concussion education and management policy targeted at the 11 000 children in all schools and all city youth recreation sports programs. In 2014, researchers were concerned the newly updated CT State Concussion Law only applied to 1145 high school students participating in official high school teams. The project launched in the 2014-2015 school year to investigate how many of the 9855 nonchildren not covered by the state law were having concussions and how many student-athletes were having concussions.

For the last 4 years, all concussions reported to the school nurses and athletic trainers in all the Norwalk Public Schools were recorded by age, sex, mechanism of injury, and where the injury occurred. All children, aged kindergarten to 12th grade, could be considered involved in sports if sports are considered in a range from peer-organized games at recess, school gym class, official sports teams, and also solo sports outside of school. Specific data were also captured on the ratio of sports to nonsports injuries, and if concussions happened at school or home.

Researchers then used the RE-AIM Sports Setting Matrix (RE-AIM SSM) to guide the development, implementation, and evaluation of sports injury prevention interventions across this entire city by involving the schools, the city hospital, city government, youth sports organizations, and the city parks and recreation department.

The proposed presentation on this project will discuss how to use RE-AIM SSM to develop interventions and accompanying implementation plans targeted at a multilayered implementation context to maximize the adoption and overall impact of sports injury prevention interventions. The presentation will also provide a unique opportunity for participants to share the challenges they face and explore practical solutions in planning and implementing sports injury prevention interventions in complex settings.

*Note:* While the RE-AIM SSM used in this case was modified to be specific to the community sports setting context, this framework could be used to optimize the impact of future sports safety and other health promotion, interventions in complex real-world settings.

## 0132

### Sex and Gender Differences in mTBI: The Invisible Women and Girls

Snedaker K

*Pink Concussions, Norwalk, United States*

TBI is not the same in women as in men. And yet decades ago, when research began to identify significant sex differences, due to the higher overall male TBI numbers and the effect of reproductive cycles of female laboratory animals, TBI research almost solely focused on males with findings applied to

women. Females of all ages suffer brain injury from sports, domestic violence/assaults, accidents, and military service. And when seeking care, the lack of sex/gendered information seriously inhibits diagnosis and appropriate intervention across the care continuum and affects the development and provision of appropriate healthcare service.

This presentation provides a broad overview of sex and gender differences in brain injury between men and women based on current scientific research. And beyond the research, why these differences are important for patients, families, and clinicians to consider in care plans for women and girls. The lack of education and awareness about these differences can lead to a patient's unrealistic expectations of recovery time and an underestimation of the need for support from family and school/work. In addition, a lack of training in a medical professional in these differences can inhibit diagnosis and appropriate intervention across the care continuum and affects the development and delivery of appropriate healthcare service.

This presentation provides a broad overview of sex and gender differences in brain injury between men and women based on current scientific research and Katherine's experience working with the thousands of women in the PINK Concussions Support Groups. And beyond research data, Katherine has addressed why these differences are important for patients, families, and clinicians to consider in care plans for women and girls.

### Objectives

- Describe 3 ways in which brain injuries (including concussion) in women differ from males.
- Articulate factors that may account for sex and gender differences in TBI incidences, severity, and recovery.
- Understand the urgent need to develop "better" practices in the care and education of women with brain injury to facilitate recovery and positive long-term outcomes.

## 0133

### The PINK Concussions Patient Panel: Women With Brain Injury Share Their Thoughts With Medical Providers and Researchers

Snedaker K

*Pink Concussions, Norwalk, United States*

TBI is not the same in women as in men. And yet decades ago, when research began to identify significant sex differences, due to the higher overall male TBI numbers and the effect of reproductive cycles of female laboratory animals, TBI research almost solely focused on males with findings applied to women. Females of all ages suffer brain injury from sports, domestic violence/assaults, accidents, and military service. And when seeking care, the lack of sex/gendered information seriously inhibits diagnosis and appropriate intervention across the care continuum and affects the development and provision of appropriate healthcare service. This symposium will intersperse scientific findings with women's lived experience to translate research into actionable change in clinical practice.

Even today, most woman and medical providers are unaware of the #pinkTBI—sex and gender differences—in how women and girls experience in brain injury. This lack of sex and gendered information seriously inhibits diagnosis and appropriate intervention across the care continuum and affects

the development and provision of appropriate healthcare service. Women and girls are rarely educated about these #pinkTBI differences, which can lead to unrealistic expectations of their recovery time and an underestimation of the need for family and school/work support.

The PINK Concussions Symposium will be a panel presentation of key #pinkTBI differences in female versus male brain injury interspersed with sound bites from our panel of women patients who will share of their lived experience of brain injury to illustrate these differences. The goal of blending the scientific findings with the patient's perspective is to truly help translate data in research paper into actionable change in the clinical practice of participants.

### Presenter

Katherine Snedaker will summarize female differences (such as recovery time, fatigue, depression, and hormone issues) and the panel of women with brain injury will share their lived experience of brain injury in short responses. The purpose is to make the research come alive via the voices of women to translate the research into everyday experience. Our hope is clinicians to retain and apply the #pinkTBI science in their everyday interactions with their female patients.

### The Panel

The all-female panel will consist of a cross-section of brain injuries from sports, domestic violence, work-related injuries, accidents, and military service. The panel will also represent a range of ages from teens to older women.

## 0134

### Brain Injury Clubhouses and Their Effects on Neurobehavioral Functioning and Participation

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### Background

Acquired Brain Injury (ABI) Clubhouses are innovative community-based rehabilitative programs for adult survivors of brain injury. They are modeled after mental health Clubhouses, which are well established, widely implemented, and evidence-based, including randomized trials. ABI Clubhouses facilitate increased community re-entry, the rebuilding of self-esteem and social relationships, and the skill acquisition required for meaningful and productive lives. Within the Clubhouse, participants (known as members) collaborate as equals with program staff and set person-centered goals related to increasing independence, improving safety, and returning to work. Clubhouses are increasingly used in the United States to fill the void in community-based care. Participation continues indefinitely, at the choice of the Clubhouse member. Currently, no data are published documenting ABI Clubhouse services provided or member outcomes.

### Aims

The ABI Clubhouse model's emphasis on employment, education, empowerment, and social supports has great potential to meet the specific needs of adults with brain injury-related

disability. Our 3-year collaborative research grant's, funded by the Commonwealth of Virginia's Neurotrauma Initiative, primary objectives are to establish foundational evidence for brain injury clubhouse service provision and members' participation and health outcomes.

### Methods

Eight Brain Injury Clubhouse programs participated in this research project, including all 5 Virginia-based clubhouses and 3 clubhouses based in Georgia, Pennsylvania, and Florida. ABI Clubhouse characteristics are measured using the Clubhouse Profile Questionnaire (CPQ). A prospective, pre-/poststudy design was used in which members were evaluated within 2 weeks of service initiation and again 6 to 9 months later. Primary outcome measures were the Mayo-Portland Adaptability Inventory (MPAI-4), the Safety Assessment Measure (SAM), and the CDC Health Related Quality of Life metric.

### Results

ABI Clubhouse characteristics varied widely in number of years providing services, physical capacity, funding sources, membership size and demographics, and supported education and employment services offered. Common member activities included administrative, clerical, food preparation, cleaning, maintenance, recreation, wellness/health promotion, establishing healthcare and entitlement linkages, and outreach. On average, ABI Clubhouse members ( $n = 69$ ) were 13 years postinjury/event, and had 9 chronic medical, mental health and/or functional conditions. At 6-months postbaseline, ABI Clubhouse members showed improvement in self-care, social contact, ability to do household chores and tasks, general health, and number of days per month that physical or mental health negatively impacted usual activities.

### Conclusions

ABI Clubhouses provide a wide variety of community re-entry services that differ based on local needs and payment models. Initial evidence suggests that ABI Clubhouse services improve members' abilities to do everyday activities and health-related life quality. Next steps include evaluating reimbursement models that assure ABI clubhouse sustainability and positive outcomes in order to provide guidance to policy makers, state administrators, practitioners, and other stakeholders.

## 0135

### The Relationship Between Fatigue Using the Patient Outcomes Measurement Information System (PROMIS v2.1) and Near Point of Convergence (NPC) in a Sample of Concussion Patients

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### Introduction

An mTBI is characterized by shearing forces that disrupt axonal connections between the visual and vestibular systems. Consequences include problems with eye coordination and oculomotor function, leading to disruption in saccades, smooth pursuits, gaze stability, and convergence. Near point of

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convergence (NPC) is commonly impaired post-mTBI, and an NPC greater than 5 cm is considered abnormal. This measurement aids in the diagnosis of convergence insufficiency (CI). It has been reported in literature that common complaints of CI include eyestrain, headaches, blurred vision, diplopia, sleepiness, loss of place when reading, difficulty concentrating, and poor comprehension after short periods of reading. The link between fatigue and CI in the concussion population is not well understood and has implications for assessment and treatment planning with this population. It is hypothesized that individuals who self-report elevated levels of fatigue would also suffer from an NPC score of greater than 5 cm.

## Objectives

This analysis explored the relationship between fatigue and NPC on assessment in individuals with mTBI.

## Methods

Data from initial intake assessments of consented patients were collected. The sample included 97 patients (49 males, 48 females; age range 18-77 years with a mean age of 37.2 years, and mechanism of injury; 33 sports-related, 31 motor vehicle accident, 33 other), presenting to Advance Concussion Clinic (ACC), a Vancouver-based interdisciplinary concussion clinic. Raw scores on the Fatigue self-report PROMIS (v2.1) measure were collected and used for analysis once converted to T-scores. Average NPC scores were collected by trained healthcare professionals with expertise in concussion within 1 week of the PROMIS scale administration. A Pearson's correlation and linear regression was calculated using XL Miner Analysis ToolPak.

## Results

A negligible correlation was identified between fatigue and NPC ( $r = 0.255$ ,  $P < .05$ ,  $r^2 = 0.065$ ). The average NPC measurement was 11.1 cm. The average fatigue from the PROMIS-v2.1 was 61.96.

## Conclusions

Based on the results, a definitive link between NPC and fatigue post-mTBI was not supported. Although this direct association was not evident based on our current analysis, it may be that NPC alone may not fully account for the fatigue the authors hypothesize to be associated with oculomotor dysfunction in concussion. Additionally, a greater sample size may improve the strength of the findings and this further exploration into the relationship between NPC and perceived fatigue is considered warranted. A broader analysis of oculomotor dysfunction may better inform the impact of this symptom area on fatigue, given its impact on recovery and symptom resolution in concussion patients.

## 0136

### The Relationships Between Vestibular-Ocular Motor Screening (VOMS) Scores and Near Point of Convergence (NPC) With Sleep Disturbance as Reported on PROMIS v2.1 in a Sample of Concussion Patients

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*Advance Concussion Clinic, Vancouver, Canada*

## Introduction

An mTBI is characterized by shearing forces that disrupt axonal connections between the visual and vestibular systems. Consequences include problems with eye coordination and oculomotor function, leading to disruption in saccades, smooth pursuits, gaze stability, and convergence. Oculomotor dysfunction occurs frequently in concussion and may be accountable for the prolonged recoveries observed in mTBI patients with these deficits. Sleep disturbance, as well, is a more commonly reported symptom in persistent post-concussion symptoms and is typically treated with prescription and over-the-counter medications. Given the presence of both oculomotor and sleep disturbances in protracted concussion recovery, both in the literature and in our clinical experience, a better understanding of the relationship between oculomotor function and sleep disturbance in concussion is warranted.

## Objective

To explore the relationships between Vestibular-Ocular Motor Screening (VOMS) scores and Near Point Convergence (NPC) with Sleep Disturbance as reported on PROMIS v2.1 in a sample of concussion patients.

## Methods

Data from initial intake assessments of consented patients were collected. The sample included 95 patients (47 males, 48 females; age range 18-77 years with a mean age of 37.3 years, and mechanism of injury; 32 sports-related, 31 motor vehicle accident, 32 other), presenting to Advance Concussion Clinic (ACC), a Vancouver-based interdisciplinary concussion clinic. Raw scores on the Sleep Disturbance self-report PROMIS (v2.1) measure were collected and used for analysis once converted to T-scores. Average NPC scores and VOMS scores were collected by trained healthcare professionals with expertise in concussion within 1 week of the PROMIS scale administration. An NPC greater than 5 cm is considered abnormal. A Pearson's correlation and linear regression was calculated using XL Miner Analysis ToolPak.

## Results

A weak positive correlation was observed between VOMS Total scores and sleep disturbance ( $r = 0.324$ ,  $P < .05$ ,  $r^2 = 0.105$ ), and between NPC and sleep disturbance ( $r = 0.310$ ,  $P < .05$ ,  $r^2 = 0.096$ ).

## Conclusion

The results highlight a weak positive relationship between oculomotor function and sleep disturbance in concussion patients. Stronger results could be demonstrated with a greater sample size, which may be a limitation in this analysis. Nevertheless, the findings suggest that clinical assessment of oculomotor function should include consideration of sleep performance in the concussed individual. Proper sleep management needs to be considered in screening, treatment, and recovery trajectories particularly in cases of protracted concussion recovery. A greater understanding of these complex systems and their interplay is needed as well.

**0137****The Relationship Between Anxiety and Dizziness in a Sample of Concussion Patients**

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Concussion/mTBI is associated with a constellation of symptoms spanning somatic, cognitive, emotional, and behavioral domains. Current research indicates up to 30% of individuals can suffer prolonged recoveries. Preexisting psychosocial factors are recognized to be risk factors predisposing individuals to a prolonged recovery process. Anxiety is commonly associated with chronic dizziness, and the combination is understood to be associated with worse outcomes. Dizziness is a common postconcussion symptom, affecting up to 80% of those with mTBI, and persisting up to 5 years in 20% of concussion sufferers. This research looks to better understand the association between dizziness and anxiety with implications for rehabilitation and treatment.

**Objective**

This study investigated the relationship between anxiety on the Patient Reported Outcomes Measurement Information System (PROMIS-57 v. 2.1) and dizziness on the Dizziness Handicap Inventory (DHI) in individuals attending rehabilitation at Advance Concussion Clinic in Vancouver, Canada.

**Methods**

This study implemented a retrospective design consisting of 50 patients (19 male [38%], 30 female [62%], aged 17-75 years, mean age 38.8 years) at Advance Concussion Clinic (ACC), a Vancouver-based interdisciplinary concussion clinic. Anxiety scores were collected from PROMIS-57 v. 2.1, and dizziness scores were obtained from the DHI. Both measures were administered to each patient during their intake assessment. All participants provided consent for their data to be utilized for research purposes. Statistical analysis in the form of linear regression was administered utilizing RStudio, a statistical computing program.

**Results**

A moderate positive correlation was found between anxiety scores on the PROMIS-57 v. 2.1 and dizziness scores on the DHI ( $r = 0.451$ ,  $P < .05$ ,  $r^2 = 0.671$ ). The average anxiety score from the PROMIS-57 v.2.1 was 20.9 out of a maximum of 40, with an average T-score of 58.8. The average score on the DHI was 34.2 out of a maximum of 100.

**Conclusion**

These results provide further support for the hypothesized link between anxiety and dizziness ratings. Limitations include a small sample size. The researchers also acknowledge the possibility of confounding variables such as preexisting anxiety and vestibular dysfunction, as well as the possibility of these findings are an artifact of some individuals reporting heightened symptoms in general. Further longitudinal research is indicated to elucidate whether and how these symptoms may affect each other over time.

**0139****Virtual Reality-Based Cognitive Deficits in Student-Athletes With a Prior History of Concussion: Study Protocol**

Ni M, Hazzard, Jr J, Olivo P

*Institute for Concussion Research & Services, Bloomsburg, United States***Context**

Sport-related concussion (SRC) continues to have a great impact on athletes at all levels of competition. In as much, the incidence rates are currently above 3 million participants annually in the United States alone. Virtual reality has gained prominence in assessing cognitive deficits and continued to advance and develop appropriate rehabilitative tools to capture clinically relevant data in assessment of sport-related concussion. While emerging research has enlightened the medical community, there is still a lack of data regarding the assessment of related long-term effects of concussion, especially in college-aged athletic populations.

**Objective**

To assess the long-term cognitive deficits associated with previous incidence of SRC in a group of college-aged student-athletes.

**Design**

A cross-sectional study.

**Setting**

A laboratory of concussion research and services.

**Participants**

Healthy college student-athletes without a history of concussion ( $n = 15$ ) and college student-athletes with a history of concussion within the last 2 previous competitive seasons ( $n = 15$ ).

**Main Outcomes**

Cognitive functions, including memorization, reflex VR, rod & frame test, and Stroop Test will be assessed by utilizing a virtual reality system (VirtualisVR). In addition, paper-and-pencil cognitive assessments, including trail making and digit symbol, will be used.

**Data Analyses**

The associations between each VR cognitive measure and 2 paper-and-pencil cognitive measure outcomes will be evaluated by Pearson or Spearman correlation and multivariable regression. Group differences in the cognitive outcomes between previously concussed athletes and previously nonconcussed athletes will be evaluated by Student  $t$  tests, along with significant differences in number of previous concussions and gender analysis.

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## Conclusions

Much debate exists in the literature regarding the chronic or lingering effects of sport-related concussion, particularly in the area of cognitive functioning postconcussion. As technological advances yield “real-world” experiences, virtual reality development has emerged as a useful tool to assess human function in these environments. Cognitive function and recovery following sport-related concussion is instrumental to the conversation surrounding long-term effects of head injury to student-athletes.

## 0140

### Resting-State EEG Demonstrates Functional Brain Network Disruption in Athletes Following a Concussion With No Association in Subjective Symptom Reporting

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## Introduction

Children and youth are more affected by sport-related concussion (SRC) (Baillargeon et al, 2012; Moore et al, 2018). Concussion diagnosis and postconcussive care are based mainly on visual signs and subjective symptoms reported by the injured athlete (Noble and Hesdorffer, 2013; Dunn et al, 2019). However, even after clinical concussion is said to be resolved, persistent abnormalities in the brain have been identified using neuroimaging techniques (Johnson et al, 2011; Talavage et al, 2013).

## Objective

1. To evaluate the changes on brain function in groups of healthy adolescents and adolescents with subacute concussion during the resting-state condition EEG.
2. To explore the correlations between subjective symptom reporting and objective brain connectivity measures.

## Methods

Fifty-six participants between the ages of 9 and 18 years were recruited from athletic clubs across Greater Vancouver; 32 participants were controls athletes while 24 were concussed athletes, between 1 and 3 months postconcussion. In order to be eligible, all concussed athletes needed to be symptomatic at time of participation, as determined by the Sports Concussion Assessment Tool (SCAT-3), Child Sports Concussion Assessment Tool (Child SCAT-3) (McRory et al, 2012), or the Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT) tool. Five minutes of resting-state EEG with eyes closed was recorded for each participant. Graph theoretical analyses were used to evaluate the differences between controls and concussed athletes.

## Results

Group-wise differences in both global and regional measures in functional brain networks were analyzed using graph theory measures. Globally, there were statistically significant

differences between the groups. Specifically, modularity was found to be significantly higher in the concussed group ( $P < .001$ ). Density was significantly lower in the concussed group ( $P < .001$ ). Global efficiency was significantly lower in the concussed group ( $P < .001$ ). Regionally, there were significant differences found between the control and concussed groups. Specifically, of the 15 regional source brain regions, the concussed group had significantly higher betweenness centrality values in 7 regions: the midline frontal (FM) ( $P < .027$ ), midline frontopolar cortex (FpM) ( $P < .028$ ), right frontal (FR) ( $P < .010$ ), left parietal (PL) ( $P < .041$ ), right parietal (PR) ( $P < .033$ ), right temporal anterior (TAR) ( $P < .010$ ), and midline occipitopolar cortex (OpM) ( $P < .031$ ). In terms of correlations, there were no significant associations between the total number of symptoms reported and the global and regional graph theoretical metrics.

## Conclusions

Results of this study demonstrated that there are both global and regional brain network alterations in concussed athletes with sports-related concussion. The changes in the resting-state EEG brain networks were unrelated to the subjective symptom reporting from the athletes. Subjective measurement alone is not a comprehensive enough means for diagnosis and recovery trajectories. Objective measurement adds more robust diagnostic and prognostic utility for adolescents with SRC.

## 0141

### Changes in Resting State Brain Networks Post Sports-Related Concussions Following an In-Home Transcranial Direct Current Stimulation (tDCS) Program: A Case Report

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## Introduction

Sports-related concussions affect a high percentage of athletes. There is emerging evidence that starting exercise early may enhance recovery; however, there are no studies that have systematically examined the role of transcranial direct current stimulation (tDCS) in conjunction with physical exercise to facilitate recovery. tDCS is a safe, noninvasive technique of neuromodulation and has shown promise in enhancing motor and cognitive function when combined with task-specific training.

## Objective

The objective of the current study was to evaluate the association between symptoms and EEG metrics at baseline and following 5 days of tDCS in conjunction with exercise in symptomatic, concussed athletes.

## Methods

A 30-year-old man with subacute (3 months) sports-related concussion diagnosed by a physician. The study was divided

into 3 stages: baseline, in-home tDCS+exercise and cognitive assessment, and follow-up. At baseline, resting-state EEG (rsEEG) and concussion symptoms were collected. The participant was trained on his in-home tDCS unit (Soterix, New York) and had his first tDCS session under supervision. Over the next 4 days, the participant completed 4, 20-minute tDCS sessions and began a program of daily aerobic exercise. A week after his first tDCS session, the participant returned for follow-up assessment. The primary outcomes were EEG power spectral density and graph theory analysis as well as symptom changes.

## Results

Pilot data of the concussed, symptomatic individual showed that a 5 consecutive, 20-minute sessions of tDCS can induce localized changes in brain network organization. This participant demonstrated a positive change in average EEG frontal power and overall graph theory metrics. Additionally, this participant demonstrated a significant decrease in concussion symptoms.

## Conclusions

This pilot study shows the potential of tDCS combined with exercise to enhance recovery from symptoms of concussion and effects on brain network organization. A larger sample size is needed to investigate whether tDCS can be an effective rehabilitation tool when combined with exercise. Recruitment is on-going to further support these results.

## 0142

### Bridging the Gap: Supporting Atypical Communicators in the Adult Rehabilitation Setting

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After an acquired injury, various diagnoses may impair a patient's ability to communicate with their healthcare providers, therapy team, family, and loved ones. Importance of communication not only lies in discussing direct medical needs, but also includes endless areas such as asking questions, participating in interactions to maintain social closeness, processing emotions, and providing opinions.

Prognosis of regaining typical communication may vary by diagnosis; however, providing maximum possible communication for all patients at all times improves patient engagement/motivation, amount of burden placed on family members/loved ones, and/or information on cognitive status unable to determine via standard assessment.

Craig Hospitals Augmentative Alternative Communication (AAC) team explores how to best ensure all patients are provided the maximum amount of opportunity to communicate via alternative means to compensate for impaired spoken expression. Alternative communication means often include no technology solutions, low technology solutions, and/or high-level technology.

Primary cases explored include patients with motor speech, voice, brainstem injury, traumatic brain injury, and/or aphasia diagnoses.

## 0143

### A Registry for Adolescent Concussion Patients: An Interdisciplinary Approach to Personalizing Medicine

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## Introduction

In Canada, over 60% of children and youth aged 10 to 18 years visiting the emergency department for sports-related head injuries have diagnosed or suspected concussions. Though recent studies have shown that sleep deprivation, insomnia, and/or daytime sleepiness increase the risk of injury/concussion, sleep is not emphasized or is overlooked in medical assessments. We investigated sleep/wake-behavior-related information in adolescent patients who experienced a concussion.

## Methods

*Sample:* Forty-nine patients (12-18 years) from the Adolescent Complex Concussion Clinic at the GF Strong Rehabilitation Centre (Vancouver, Canada), who experienced a concussion due to sports injury between 2014 and 2019. Their referrals were made because of unresolved complex persistent concussion symptoms that required specialized multidisciplinary care.

## Available Information

- Rivermead Post-Concussion Symptoms Questionnaire (PCSQ), Kutcher Adolescent Depression Scale (KADS), and Patient-Reported Outcomes Measurement Information System (PROMIS) Anxiety Short Form.
- The BEARS sleep screening concept (Owens and Dalzell, 2005) was applied to extract sleep-related information: B: bedtime problems; E: excessive daytime sleepiness; A: awakenings; R: regularities and routines; S: snoring/sleep disordered breathing.
- Medications and blood work results.

## Results

A. At entry sleep disturbances (PCSQ) correlated for males and females with (i) restlessness (PCSQ; Spearman's  $r = 0.554$ ,  $P < .01$ ) and (ii) tiredness (KADS; Spearman's  $r = 0.566$ ,  $P < .01$ ). Females showed further correlations with ( $P < .01$ ): PCSQ-feeling depressed or tearful, KADS items (except worthlessness) and total score, PROMIS-feeling that scary things might happen; and ( $P < .05$ ): PCSQ-double vision, difficulties concentration, difficulties thinking, PROMIS-feeling awful, nervousness, feeling scared, worried what could happen and worriedness at bedtime.

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- B. In 33/49 cases, sleep/wake behavior-related information was available; 33/33 cases reported excessive daytime sleepiness; 26/33 had challenges with keeping/applying routines; 19/33 reported falling asleep and 8/33 sleep maintenance problems (insomnia); only 1 case was at risk for sleep-disordered breathing.
- C. Medication data were available in 31 cases; melatonin was most frequently used (8/31 cases). Blood work was reported in 2 cases, which were taken 6 weeks and 3 years postinjury, respectively.

## Conclusion

This data suggest the need for a prospective approach with implementation of sleep as a core outcome measure during therapeutic interventions—the main question is: how? We propose an international registry, which allows us to become a learning system via monitoring of individual patients and customizing treatments. Further, we are suggesting a home-based assessment concept, which shares data with the clinicians and involves monitoring of postconcussion symptoms and electrophysiological activity during sleep, sleep time/quality, daytime restlessness, and tiredness via vigilance games.

## Acknowledgments

BC Children's Hospital Research Institute & Foundation.

## 0144

### On-Field Video Assessment and Evaluation of 2 Wearable Sensors in American Football Players

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Measurement of on-field head impacts in contact sports is valuable for the understanding of head impact exposure and concussion biomechanics that can be used to reduce the incidence of sport-related concussion and protect athletes. Previous studies incorporated the football helmet-based Head Impact Telemetry System (HITS) to quantify head impact exposure and concussion biomechanics. However, newer wearable sensors with different form factors can be used in other contact sports. These sensors include the xPatch (mounted as a skin patch), MVTRACK (mounted in the ear canal), and mouthguard system Intelligent Mouthguard. While many of these sensors were validated in laboratory testing, the on-field accuracy remains unknown. The objective of this study was to verify and compare the accuracy of 2 common systems.

Consented athletes were dual-outfitted with the "Intelligent Mouthguard" (Prevent Biometrics) and the helmet-based HITS sensor (Riddell) and used both sensors during all games/practices. Two video cameras in conjunction with the Hudl System were time synced and collected play-by-play video. Video assessment tracked players and labeled sensor-collected head impact events. Each event was categorized as Contact-Helmet, Contact-Body, Contact-Unclear, No-Contact, Not-in-Play, and Not-Visible. Discrete events from

helmet and mouthguard sensors were timestamp-matched and compared based on peak magnitude of linear (PLA) and angular (PAA) acceleration.

Video data from 6 athletes were tracked and categorized from 4 games. A total of 587 events were recorded by the HITS and 205 events by the mouthguard system. The HIT system recorded twice as many events and 3 times the number of false positives (No-Contact & Not-in-Play) compared to IMG. There were 95 cases during the sessions where both systems collected events that were coincident in time. Both systems recorded impacts during noncontact activities such as walking and running. Not all recorded events were captured on video, as some events occurred outside the field of view or in between plays.

This study compared head impact data collected in football players outfitted with 2 wearable sensors using video assessment. Matched contact events between the 2 sensors did not show a strong correlation between PLA and PAA. HIT sensor reported higher PLA. The helmet-based system recorded twice as many events compared to the mouthguard-based system. The high number of events and a greater number of false positives may be attributed to decoupling during helmet impact without any appreciable head motion recorded by the mouthguard. These results indicate that tightly fixated mounting systems like the IMG can reduce false positives in contact sports. While the IMG did not capture some video-observed contact events, the resulting head motion may have been below the 10-g threshold. Even though the additional evaluation of IMG is required, it can be a viable alternative for use in helmeted and nonhelmeted sports.

## 0145

### Long-Term Adaptive Strategies of Traumatic Brain Injury Survivors and Caregivers

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Traumatic brain injury (TBI) is a serious public health problem affecting approximately 2.4 million Americans annually. The objective of the research was to explore the long-term adaptive strategies of adult TBI survivors and primary caregivers and with this knowledge add to the development of theory related to rehabilitation and psychotherapy. This study included 17 individuals, 11 participants with brain injury and 6 primary caregivers, who participated in a series of semistructured interviews aimed at discovering the coping and adaptive strategies utilized in dealing with the effects of brain injury. The design was qualitative phenomenological. The study identified specific needs associated with the various deficits incurred by the injury and the adaptive strategies created to address the specific needs. Participants offered suggestions for psychotherapists addressing how to more effectively work with brain injury survivors and their primary caregivers. The findings indicated problem-focused, emotion-focused, and avoidant copings were utilized to some degree throughout the rehabilitation process. As part of the research presentation, Patti Foster, TBI survivor and author, identifies the coping and adaptive strategies she developed to effectively manage the deficits of her brain injury. Research presented was published in *NeuroRehabilitation* (2016).

**0146****The Rehabilitation of Verbal Operants Following Acquired Brain Injury**

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Although verbal deficits are major concerns for individuals following an acquired brain injury (ABI), behavior-analytic research on language training in neurorehabilitation settings is extremely limited. The purpose of the current study was to systematically replicate the work of Sundberg, San Juan, Dawdy, and Arugelles (1990) in which the authors evaluated the acquisition and functional interdependence of verbal operants for adults following ABI. We used slightly modified procedures (eg, inclusion of high-preference activities, progressive prompt delay) and compared acquisition rates of tacts, mands, and intraverbals with 3 adult ABI survivors. We also assessed whether directly training one verbal operant led to the emergence of untrained, topographically similar verbal operants. Contrary to Sundberg et al, we found mand training was successful for all participants and led to the greatest amount of transfer under tact conditions, and we offer potential explanations for our differing results.

**Keywords**

acquired brain injury, functional independence, functional interdependence, language training, verbal behavior

**0147****Effect of Neuregulin-1 Effect on Spatial Learning and Memory After Controlled Cortical Impact in Immature Mice**Lok J<sup>1</sup>, Wu L<sup>1</sup>, Cao F<sup>1</sup>, Lo E<sup>1</sup>, Wang X<sup>2</sup>*<sup>1</sup>Massachusetts General Hospital, Boston, United States, <sup>2</sup>Tulane University, New Orleans, United States***Background**

Traumatic brain injury (TBI) affects individuals of all ages, often causing long-term cognitive impairments. Recent research suggests that neuregulin-1 (NRG1), a growth factor with diverse functions in the brain, may have neuroprotective actions after brain injury, including brain trauma. Adolescents comprise a substantial proportion of TBI patients and further research is needed to investigate possible therapies for this group of patients.

**Objective**

To determine whether administration of NRG1 after TBI has beneficial actions on the cognitive function of mice (5.5 weeks old, corresponding to human adolescence) after controlled cortical impact (CCI).

**Methods**

Mice that were 5.5-week old, corresponding in age to human adolescents, were subjected to controlled cortical impact

(CCI) under deep anesthesia. Two hours after CCI, mice in the treatment group were given an intravenous injection of NRG1, followed by a continuous subcutaneous infusion of NRG1 for 14 days. At 11 to 12 weeks of age (during adulthood), the cognitive function of the mice was tested by evaluating their performance in the Morris Water Maze (MWM).

**Results**

In mice that suffered CCI at 5.5 weeks of age, the group that received an intravenous injection of vehicle did not succeed in decreasing the latency time to reaching the visible platform after 7 trials, while mice that received NRG1 after CCI were able to improve the latency time to reach the visible platform to the level of control mice after 7 trials.

**Conclusions**

These data suggest that the administration of NRG1 at 2 hours after CCI resulted in an improvement in spatial learning and memory in immature mice that correspond in age to human adolescents.

**0149****Objective Assessment of Concussion Using of a Multimodal EEG-Based Marker**Bazarian J<sup>1</sup>, Prichep L<sup>2,3</sup>*<sup>1</sup>University of Rochester School of Medicine, Rochester, United States,**<sup>2</sup>BrainScope Company, Bethesda, United States, <sup>3</sup>New York University School of Medicine, New York, United States*

In the absence of a gold standard for the diagnosis of concussion and reliance on subjective self-report of symptoms, there is a growing consensus related to the importance of multidimensional/multimodal assessments. The goal of this study was to validate an objective multimodal EEG-based biomarker to aid in the assessment of concussion at time of injury, assess the severity of concussion and to aid in the decisions related to readiness to return to activity. Funding for this study was provided in part by DOD under the US Navy (Naval Health Research Center), a grant from GE/NFL Head Health Challenge and BrainScope Company. Concussed athletes and controls represented a convenience sample ( $n = 580$ ) of male and female subjects (55% males) between the ages of 13 and 25 years, enrolled from high school, colleges, and concussion Clinics in the United States. Concussed subjects had a witnessed head impact and were removed from play by site guidelines. Assessments were performed within 72 hours of injury, clinically determined return to play (RTP) and 45 days following RTP. Assessments included EEG (acquired from frontal regions with a BrainScope device), neurocognitive performance tests, and standard concussion assessment tools, acquired on BrainScope devices. This study was an independent validation of a previously derived classifier algorithm, using quantitative EEG, neurocognitive performance, and vestibular measures, as inputs to derive a Concussion Index (CI) to determine the likelihood of concussion. EEG measures of connectivity, significant in the physiology of concussion, contributed most to the algorithm.

High accuracy was obtained in identifying concussion at time of injury with sensitivity = 85.99%, specificity = 70.78%, NPV = 90.10%, and PPV = 62.02. Further analyses demonstrated a significant difference between the CI at time of injury

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compared to the CI at clinically determined RTP ( $P < .0001$ ); significant differences between the CI at time of injury in concussed patients who had rapid ( $<14$  days) compared with those with more prolonged recovery ( $\geq 14$  days) ( $P = .0038$ ); stability of the CI overtime in controls ( $P < .0001$ ); and a significant predictive relationship between CI and total symptom burden (correlation coefficient of 0.8031,  $P < .0001$ ).

This study independently demonstrated that the CI provides an objective measure to aid in diagnosis of concussion, severity of concussion, and to provide an important objective element in the assessment at time of clinically determined return to activity. The neurotechnology platform incorporating this capability is handheld, easy and rapid to use, and enables incorporation of an important objective measure of brain function impairment as a component of the assessment of concussion. It is also noted that the device supports acquisition of other concussion assessments, including a digitized version of the MACE, to facilitate acquisition and review of multimodal assessment components.

## 0150

### Early Brain Injury and Later Childhood Adaptive Functioning: The Mediating Role of Pragmatic Language

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#### Introduction

Traumatic brain injuries (TBI) often adversely affect adaptive functioning (AF). However, the cognitive mechanisms by which AF is disrupted are not well understood in young children who sustain TBI. This study examined pragmatic language (PL) and executive functioning (EF) as potential mechanisms for AF disruption in children with early TBI.

#### Methods

The sample consisted of 76 children between the ages of 6 and 10 years who sustained a TBI ( $n = 36$ ) or orthopedic injury (OI;  $n = 40$ ) before 6 years of age and at least 1 year prior to testing (mean = 4.86 years, SD = 1.59). Children's performance on a PL and an expressive vocabulary task, and parent report of child's EF and AF were examined at 2 time points 1 year apart.

#### Results

Injury type (TBI vs OI) significantly predicted the child's social and conceptual, but not practical AF. Results indicated that PL, and not expressive vocabulary or EF at time 1, mediated the relationship between injury type and both social and conceptual AF at time 2.

#### Conclusions

A TBI during early childhood appears to disrupt complex language skills (ie, pragmatic language), which in turn may disrupt social and conceptual AF in middle childhood. Addi-

tional longitudinal research that examines pragmatic language and adaptive outcomes into adolescence is warranted.

## 0151

### Multimodal Assessment of Goal-Directed Behavior, Sustained Attention, and Behavioral Flexibility After Experimental Brain Trauma

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*University of Pittsburgh, Pittsburgh, United States*

Traumatic brain injuries (TBIs) affect 2.5 million individuals in the United States each year. Moreover, 500 000 yearly emergency department visits are attributed to childhood-acquired brain trauma, with patients enduring long-lasting cognitive, physical, or behavioral effects. Impaired attention is central to the cognitive deficits associated with long-term sequelae for many TBI survivors. Considering that cognitive deficits are often assessed using multidomain neuropsychological cognitive battery tests, we employed, for the first time, multimodal approaches to determine higher-order attentional capabilities after parietal TBI in rats. We hypothesized that rats subjected to pediatric traumatic brain injury (TBI) will display task-dependent impairments in instrumental learning task (ILT) behavior and behavioral flexibility during adolescence, whereas rats subjected to adult TBI will display impaired performance in the operant 3-choice serial reaction time task (3-CSRT) of sustained attention and the digging attentional set-shifting (dAST) paradigms. Moderate parietal lobe (2.2-mm tissue deformation depth) controlled cortical impact (CCI) or sham injury to the right hemisphere was performed in pediatric Sprague-Dawley male rats (postnatal day, PND 17). After 10 days of recovery, they were trained on a fixed-ratio schedule of 1 for 12 consecutive days in operant chambers fitted with 3 nose-poke holes and a food trough, by learning to poke for sucrose pellet reinforcement in the center when illuminated. Outcome measures included the number of total trials completed, task-irrelevant pokes (left or right), and latency for pellet retrieval following instrumental nose-poking. Rats were then trained/tested on the attentional set-shifting test (AST) at PND 42 to 43, which involves simple and compound discriminations, stimulus reversals, and intra-/extradimensional set-shifts. Dependent measures included the number of trials to reach criterion, as well as total and perseverative errors. Statistical analyses employed repeated-measures ANOVA followed by Newman-Keuls post hoc for individual test days. ILT data ( $n = 8$ /group) paradoxically demonstrate increased total trials and reduced task-irrelevant pokes, suggesting attenuated exploratory drive but also reduced impulsivity in adolescent rats after pediatric TBI ( $P < .05$ ). Moreover, no group differences were detected in AST, possibly a result of higher baseline behavior in Sham adolescent rats, as previously reported. Adult male rats were first trained on the 3-CSRT over the course of 3 to 4 months to 70% accuracy, then were also subjected to a moderate TBI of 2.8-mm tissue deformation depth or sham surgery. Rats subjected to TBI displayed reduced percent accuracy and increased omissions responses compared to sham rats, when retested during weeks 3 to 4 postsurgery, as well as executive function deficits on AST, seen as increased trials to criterion and total errors ( $n = 6-7$ /group,  $P < .05$ ). Together, multimodal attentional testing will advance our understanding of long-term higher-order cognitive and motivational deficits in survivors of childhood or adulthood brain trauma and may provide reliable avenues toward developing therapeutic targets.

**0152****University and State ABI Program Collaborations for Policy Development, Change, and Evaluation**Sample P<sup>1</sup>, Greene D<sup>1</sup>, Dettmer J<sup>2</sup><sup>1</sup>Occupational Therapy Department, Colorado State University, FORT COLLINS, United States, <sup>2</sup>MINDSOURCE, Denver, United States

The proposed presentation will discuss the feasibility and efficacy of a research and program development collaboration between Colorado State University (CSU) researchers and graduate students, and the designated state-level brain injury network (in Colorado, this is the MINDSOURCE program). Long-term outcomes from these collaborations, at the local, state, and occasionally national level, along with additional avenues of collaboration will be described and discussed.

For the past decade, Occupational Therapy and Human Development and Family Studies faculty have assisted MINDSOURCE (previously the CO Brain Injury Program) staff's potential program and policy initiatives by facilitating student-directed needs assessment and program development projects through a master's level course on Program Assessment, Development, and Evaluation.

Small-group research projects have assisted in providing a foundation of evidence underneath the state's creation of new special education policy changes. Collaborating faculty conduct research to evaluate possible changes in state law related to school student ABI-disability determination. CSU-OT faculty, along with information and support from service providers and MINDSOURCE staff, develop, test, and revise a screening tool, the Brain Check Survey, that helps schools find and assess students who are struggling in school, possibly from having an undiagnosed brain injury. MINDSOURCE then is able to post the screening tool, with scoring instructions for any districts in Colorado to use in their schools. This on-going collaboration has resulted in important changes in state policies regarding persons with ABI, and CSU faculty and students have the opportunity to conduct evaluation research and to practice program development skills in real-world situations, solving real problems for individuals living with the long-term life consequences of brain injury.

**0153****Unraveling Frontal Lobe Dysfunction After Traumatic Brain Injury With Preclinical Models**

Bondi C, Craine T, Kutash L, Iouchmanov A, Patel A, Sha S, Cheng J, Kline A

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Impaired behavioral flexibility is central to the cognitive deficits associated with long-term sequelae for many traumatic brain injury (TBI) survivors. This study aims to investigate complex cognitive deficits after experimental TBI in male and female rats subjected to a clinically relevant frontal lobe injury, and the beneficial effects of chronic milnacipran treatment, a dual serotonin-norepinephrine reuptake inhibitor. We hypothesized that rats subjected to frontal TBI will display cognitive deficits in both the operant and digging versions of the attentional set-shifting task, and that chronic milnacipran treatment will attenuate these deficits. To maintain a parallel with the clinic where patients are given multidomain cognitive test

batteries, we employed a multimodal approach to determine executive function after moderate frontal lobe TBI, by using 2 prefrontal cortex-dependent attentional set-shifting tasks, the operant (oAST) and digging (dAST) paradigms, as analogs of the clinical Wisconsin Card Sorting Test. The oAST requires rats to perform flexible switches between perceptual dimension rules "light" and "side" to obtain a sucrose pellet reinforcer. The dAST involves a series of increasingly difficult discriminative tasks, including simple and compound discriminations, stimulus reversals, and intra-/extradimensional shifts. Dependent measures for tasks include number of trials to reach criterion (TTC), as well as total, perseverative, and set-loss errors. Adult male and female Sprague-Dawley rats reached oAST baseline in approximately 3 weeks (TTC within 10% variability of previous 3 days) and then were subjected to a controlled cortical impact (2.4-mm cortical deformation depth at a speed of 4 m/s) or sham injury over the prefrontal cortex in the right hemisphere. During surgery, they also received intraperitoneal implantation of osmotic minipumps containing milnacipran (30 mg/kg/day) or vehicle. After 10 days of recovery, they were retested on oAST for 10 days and then trained/tested on dAST, at approximately 26 to 27 days postsurgery. Injured rats required higher numbers of total trials to complete oAST postsurgery compared to sham and to their own preinsult baseline, while also displaying higher numbers of total and perseverative errors ( $n = 7-8$ /group for males,  $P < .05$ ; preliminary  $n = 4-5$ /group for females). These alterations were largely remediated by chronic milnacipran treatment. Statistical analyses employed repeated-measures ANOVA followed by Newman-Keuls post hoc for individual test days when appropriate. A scatter plot correlation for individual male rats' performance on both tests indicated the dAST and oAST are concurrently valid and sensitive to TBI-induced cognitive disturbances. In summary, milnacipran appears to be a potential therapeutic option for managing higher-order cognitive deficits following TBI. Higher-order attentional testing will advance our understanding of long-term cognitive impairments in survivors of brain trauma and may provide reliable avenues toward developing more suitable therapeutic approaches.

**0154****Intranasally Administered L-Myc Immortalized Human Neural Stem Cells Migrate to Primary and Distal Sites of Damage After Cortical Impact and Enhance Spatial Learning**Gutova M<sup>1</sup>, Cheng J<sup>2</sup>, Tsaturyan L<sup>1</sup>, Nelson M<sup>1</sup>, Barish M<sup>1</sup>, Rockne R<sup>1</sup>, Bondi C<sup>2</sup>, Kline A<sup>2</sup><sup>1</sup>Beckman Research Institute at City of Hope, Duarte, United States,<sup>2</sup>University of Pittsburgh School of Medicine, Pittsburgh, United States

Stem cell-based therapies intended to treat tumors and neurodegenerative diseases are contingent upon efficient delivery of cells to damaged areas. Neural stem cells (NSCs) have inherent pathotropism, guiding them to sites of damage in the CNS, a migration that can be exploited for cell replacement, regeneration, and therapeutic delivery strategies. Having demonstrated therapeutic efficacy in preclinical models, NSCs are now being evaluated in clinical trials for their ability to repair damage associated with stroke or multiple sclerosis, and to deliver anticancer agents. The effectiveness of NSC-mediated therapy is determined by the

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engraftment of these cells, the success of which is dependent on the number and quality of NSCs reaching the target site. Moreover, to be clinically useful NSCs must lack tumorigenicity. Here, we utilized volumetric 3D imaging of optically cleared rat brains to quantitatively evaluate the distribution and fate of LM-NSC008 cells after experimental traumatic brain injury (TBI) of moderate severity induced via controlled cortical impact. We visualized LM-NSC008 cells successfully engrafting and surviving for months in the mature adult rat brain, whereas most neural stem/progenitor cells only engraft in neonatal or immature brain. In our model, intranasally administered LM-NSC008 cells migrated specifically to the TBI site and contributed to cognitive improvement. Relative to intracranial administration, intranasally administered NSCs appear to be the less invasive, more feasible, and cost-effective option for delivering cells to the brain during repeated rounds of treatment in patients requiring long-term care. Further, lack of tumorigenicity of LM-NSC008 cells in optically cleared naive mouse brains was demonstrated for up to 12 months after intracranial administrations, which demonstrates their potential for long-term therapeutic efficacy.

## 0155

### Characterization of Gait Asymmetry as Related to Mild TBI

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#### Background

Our study aimed to explore the use of cyclogram analysis of gait to provide an innovative assessment of coordination or symmetry of neuromotor function in persons recovering from mild brain injury.

#### Methods

Eighteen participants were recruited from an outpatient physical therapy clinic according to university guidelines for human study protection. Inclusion criteria were at least 18 years old, with or without a head injury within the past 12 months, and able to walk unassisted for a minimum of 10 m. Exclusion criteria were any neuro- or musculoskeletal disorder or surgical procedure, which prevented full weight bearing on bilateral lower extremities during ambulation or existence of any active pain cycle. All participants were asked to perform a self-paced walk 20 m in both directions. The ProtoKinetics Zeno Walkway was placed in the middle of the 20 m to capture the 10-m Walk Test. The computerized pressure mat provided a step-by-step cyclogram analysis of the alternating center of pressure transitions of bilateral feet to provide measurements of gait symmetry and variability including: Total Gait Variability Index (TGVI), Right & Left Gait Variability (R\_GVI, L\_GVI), Total Cyclogram Interception Point (TCISP), A-P Cyclogram Interception Point (A-P\_CISP), M-L Cyclogram Interception Point (M-L\_CISP), Total Velocity (VEL), and Cadence (CAD).

#### Demographic Variables Included

Gender, age, and mTBI group.

#### Data Analysis

SPSS vs 25 was used for all data analysis including descriptive statistics and multivariate ANOVA and regression statistical methods to address factor contributions to gait variables. An  $\alpha$  level was selected as  $P = .05$ .

#### Results

Results indicated a mean age of  $57.33 \pm 16.69$  years. TCISP times were slower for the mTBI group compared to those without mTBI ( $14.92 \pm 7.0$  vs  $15.73 \pm 6.38$ , respectively), however not significant. Multiple regression analysis indicated GEN and mTBI group category explained 61% of the TGVI ( $P = .032$ ). There was a significant negative relationship between AGE and CAD ( $r = -0.804$ ,  $P = .013$ ) and VEL ( $r = -0.620$ ,  $P = .007$ ) and AVG\_GVI ( $r = -0.860$ ,  $P = .009$ ) and between CISP\_TIME and CAD ( $r = -0.541$ ,  $P = .021$ ), a significant positive relationship between WALK\_RATIO and VEL ( $r = 0.493$ ,  $P = .031$ ).

#### Conclusions

Results indicated significant trends in limb asymmetry during recovery as documented by cyclogram analysis. It can be noted that gait speed was independent from gait variability, however significantly related to mTBI and gender, which was able to explain 61% of the gait variance.

#### Clinical Relevance

Preliminary findings indicate that further research is indicated using a larger sample size to provide further investigation of mTBI patient performance during self-selected activities of daily living. The proposed gait analysis methods should be considered by the rehabilitation specialists to better document patient recovery in response to treatment.

## 0156

### Effect of Minocycline on the Expression Profile of Matrix Metalloproteinase 9 in the Hippocampus of Rats With Diffuse Traumatic Brain Injury

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Traumatic brain injury (TBI) is a public health problem worldwide that annually not only collects thousands of lives but also contributes to cognitive and motor impairment in those who survive. Mild and moderate TBIs do not generate a high mortality but are associated with high comorbidity and are the most prevalent in Colombian population where diffuse lesions are caused by high kinetic involving traffic accidents and falls.

Diffuse injuries are framed by axonal injury rather than neuronal death, ranging from inflammation of the axolemma to deafferentation. Cognitive functions and other mental processes depend on cortical association and therefore the integrity of axons; however, interventions aimed at treatment of diffuse TBI secondary injuries are rare and do not have an impact in reducing the sequelae. Therefore, it is imperative to increase the knowledge about these types of injuries that will

allow a greater understanding of the pathophysiological processes and will contribute to the search of therapeutic targets.

The aim of this project was to evaluate the effect of minocycline on the expression profile of matrix metalloproteinase 9 in the hippocampus of rats with diffuse traumatic brain injury.

We use the model of Marmarou diffuse TBI adapted to moderate injury in Wistar rats; evaluation of the model was made at 24, 48, and 72 hours. Minocycline was used during the first 3 days after diffuse TBI, and samples were collected at 7, 15, and 30 days. Behavior analysis and tissue evaluation were performed by histological and molecular techniques.

We observed a high cellular response and damage in the hippocampus than other cortical regions, indicating neurodegenerative processes and inflammation; we also observed more presence and activity of matrix metalloproteinase 9 (MMP9) in the first 72 hours and the areas with higher glial response in the white matter had higher reactivity to MMP9. The use of minocycline showed an improvement of cognitive task depends of hippocampus and a reduction in gene and protein expression of MMP9 compared to controls.

MMP9 is an endopeptidase known for its high expression in the central nervous system, and it is involved in physiological extracellular matrix changes and has been found up-regulated in ischemia and TBI. Recent literature connects MMP9 with diffuse axonal injury in cerebral hypoperfusion where production would be in charge of oligodendrocytes and contribute to myelin damage. Since other studies have shown that blocking MMP9 improves motor and cognitive response to ischemia, our results show an approach to pathophysiological mechanisms of diffuse trauma and may allow to elucidate the processes that regulate cell survival and help to find more therapeutic options like some blockers of MMP9.

### Funding

Universidad del Valle, Vicerrectoría de Investigaciones, Universidad del Valle, Cali, Colombia.

## 0157

### Tinnitus Clinical Service Needs Among US Military Veterans With TBI

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### Background

Tinnitus, the sensation of ringing or other sound in the ears, is common among Veterans, particularly those with a history of TBI. Left unmanaged, tinnitus can result in significant cognitive, emotional, or sleep dysfunction. Progressive Tinnitus Management (PTM) is an evidence-based program developed in the Veterans Health Administration (VA) that results in clinically significant improvements in Veterans' functioning. To support uptake and implementation of PTM across VA sites, we conducted a national survey to measure (1) the prevalence of Veterans with tinnitus, with and without TBI, who are in need of clinical services for their tinnitus; and (2) the proportion who would participate in PTM if it were available to them.

### Methods

We randomly sampled 1800 Veterans, stratified by age and TBI diagnosis (yes/no), who used VA clinical services between 2011 and 2016. Veterans were surveyed using a Dillman approach. Tinnitus severity was measured using the Tinnitus Functional Index (TFI); comorbid mental health symptoms were assessed using validated screening instruments. Veterans were asked to indicate their past use of tinnitus clinical services and their interest in future receipt of services. We also provided a description of PTM and asked their level of interest if the programs were offered to them by their VA provider. Descriptive statistics were used to estimate Veterans' need for, and interests in, tinnitus clinical services by TBI status and other demographic and clinical factors. We used inverse probability weights in analyses to account for sample stratification.

### Results

More than half of veterans with TBI (56%) indicated their tinnitus was a moderate or very big problem, compared with 37% of those without ( $P < .05$ ). Nearly two-thirds of those with TBI (62%) endorsed having difficulty performing work or other activities compared with 36% of those without ( $P < .05$ ). Veterans with TBI were significantly more likely to have pain, depression, anxiety, and posttraumatic stress disorder symptoms and diagnoses. Despite poorer health and functioning among Veterans with TBI, there were no statistically significant differences in their prior use of tinnitus clinical services or their interest in receiving future tinnitus services; 74% versus 70% of those with and without TBI, respectively, said they were interested in receiving clinical services for tinnitus. After reading a description of PTM, 63% and 61% endorsed being somewhat or very interested in the service.

### Conclusions

These findings highlight the need for coordinated health-care services to address the complex needs of patients with a history of TBI who experience tinnitus-related distress and functional limitations. In particular, Veterans may benefit from the coordination of TBI/polytrauma, audiology, and mental healthcare services in the VA system of care.

## 0158

### The Relationship Between Balance Error Scoring System Scores (BESS) and Cognitive Function With Anxiety Scores as Reported on PROMIS v2.1 in a Sample of Concussion Patients

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### Introduction

An mTBI is characterized by disruption of oculovestibular function, causing impairments in balance control, visual function, and eye/head coordination. These impairments often coexist with dysregulation of autonomic function and cervical dysfunction, contributing to the hallmark symptoms including headaches, dizziness, visual issues, cognitive dysfunction, and emotional dysregulation. Oculovestibular dysfunction is increasingly recognized as a primary factor in prolonged recoveries observed in mTBI patients. Cognitive complaints, along

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with reports of anxiety, often coexist with physical dysfunction following mTBI. While this constellation of symptoms is increasingly well recognized, the interplay between physical impairments and cognitive/ emotional dysfunction is less well understood. Our research aims to highlight the importance of oculovestibular screening and rehabilitation in the multimodal treatment of persistent symptoms in cases of protracted recovery following mTBI.

### Objective

To explore the relationship between BESS scores and cognitive scores with anxiety scores as reported on PROMIS v2.1 in a sample of concussion patients.

### Methods

Data from initial assessments of consented patients were collected. The sample included 73 patients (37 males, 36 females; aged 18–77 years; mean age of 37.3 years, and mechanism of injury; 22 sports-related, 26 motor vehicle accident, 25 other), presenting to Advance Concussion Clinic (ACC), a Vancouver-based interdisciplinary concussion clinic. Raw scores on the Anxiety and General Cognitive Concerns self-report PROMIS (v2.1) measure T-scores were used for analysis. BESS scores were collected by healthcare professionals with expertise in concussion within 1 week of the PROMIS scale administration. A Pearson's correlation and linear regression was calculated using XL Miner Analysis ToolPak.

### Results

A weak positive correlation was observed between BESS total scores and cognitive dysfunction ( $r = 0.25$ ,  $P < .05$ ,  $r^2 = 0.061$ ), and between BESS and anxiety scores ( $r = 0.28$ ,  $P < .05$ ,  $r^2 = 0.078$ ).

### Conclusion

The results highlight a weak positive relationship between balance dysfunction, suggestive of vestibular impairment, and reports of cognitive concerns and anxiety in concussion patients. Stronger correlation would be anticipated given a larger sample size, which is recognized as a potential limitation in this analysis. Other variables that could be considered in future studies include sleep dysfunction and dysfunctional pain beliefs, as magnifying factors in symptom reporting. Nevertheless, the preliminary findings suggest a relationship between vestibular dysfunction and cognitive impairment and anxiety. Assessment of vestibular dysfunction, including balance and oculovestibular screening, should be included in the multimodal assessment of all cases of protracted recovery, and particularly considered by primary care physicians for persistent complaints of cognitive and emotional challenges following mTBI. Greater understanding of the interplay of these complex systems is warranted to better understand treatment trajectories within this population.

## 0159

### Cognitive Rehabilitation for Traumatic Brain Injury Within a Multidisciplinary Treatment Setting

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### Introduction

Within the military setting, Intensive Outpatient Programs (IOPs) are an increasingly available treatment option for patients who have experienced a traumatic brain injury (TBI). The purpose of this study was to investigate cognitive changes following a multidisciplinary IOP for patients with a history of TBI. The treatment program included physical, vestibular, occupational, music, and speech therapy, along with treatment for sleep, psychotherapy, and mind-body medicine.

### Methods

Patients were evaluated at baseline (prior to treatment) and following treatment utilizing the Automated Neuropsychological Assessment Metrics version 4 (ANAM4). The ANAM4 is a computerized neurocognitive test used by the Department of Defense (DoD) to establish baseline performance and screen for cognitive changes following TBI. The cognitive module of the ANAM4 consists of the following measures: simple reaction time 1 & 2 = SRT & SR2, memory = CDS, delayed memory = CDD, processing speed = PRO, working memory = MTH, and visuospatial memory = MSP. The Global Deficit Score (GDS) was computed to interpret the overall performance on the cognitive module. The GDS is a summary score, which allows for detection of subtle and spotty impairment from multiple measures. Paired sample *t* tests were conducted to evaluate individual differences on ANAM4 cognitive measures from baseline to post-IOP treatment.

### Results

Participants consisted of 76 active duty male service members, who completed an IOP and pre-/post-ANAM assessments. Mean age of participants was 32 years (SD = 7.6), of which 12.5% were college graduates and 63% were married. History of blast exposure varied, ranging from 0 to 100; 43% of participants experienced 5 or more blasts within close proximity (within 50 yards). Total number of lifetime concussions ranged from 0 to 7, with a mean of 2.66 (SD = 1.52, median = 2). There was a significant difference on all cognitive scales, with small to moderate effect sizes for simple reaction time 1 ( $P = .025$ ,  $d = 0.23$ ), simple reaction time 2 ( $P = .041$ ,  $d = 0.21$ ), processing speed ( $P = .003$ ,  $d = 0.31$ ), learning ( $P = .001$ ,  $d = 0.41$ ), delayed memory ( $P = .004$ ,  $d = 0.35$ ), and spatial memory ( $P = .033$ ,  $d = 0.18$ ); scores improved following treatment. Working memory was approaching significance ( $P = .057$ ,  $d = 0.17$ ). There was also a significant change on the GDS from pre- to posttreatment ( $P < .001$ ,  $d' = 0.32$ ), with a significant improvement following treatment. Following treatment, 57% of participants showed improvement in the GDS. There was no significant difference on total number of close proximity blast exposures and lifetime history of TBI between those who showed improvement on cognitive scores and those who did not show improvement.

### Conclusions

This study presents data on positive changes in cognition following a multidisciplinary treatment. Number of close proximity blast exposures and lifetime history of TBI did seem to impact this change. Cognitive improvements to reaction time, processing speed, learning, and memory following IOP treatment among this population have important clinical implications.

**0160****Default Mode Network Differences Between Geriatric Mild Traumatic Brain Injury and Alzheimer's Disease**

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Previous studies have used functional magnetic resonance imaging (fMRI) to quantify functional correlation (FC) changes in the brain's default mode network (DMN) due to Alzheimer's disease (AD) and mild traumatic brain injury (mTBI). TBI may increase AD risk, and this study describes our efforts to compare the DMN FC patterns of TBI patients, AD patients, and healthy control (HC) volunteers.

**Methods**

A computational workflow was implemented to utilize the FsFast package within the FreeSurfer software suite to undertake seed-based, group-wise FC analysis of resting-state (rs) blood oxygenation level-dependent (BOLD) signals. rs-fMRI scans were processed to generate a directory tree structure compatible with FsFast. Then, rs-fMRI images were processed for motion correction and to coalign subjects' brains. FsFast was used to implement a brain-wide (left/right cerebrum, subcortical structures) connectivity analysis using a cluster-wise significance threshold of .05 corrected for multiple comparisons. Outputs were organized so that results that specify FC between seed regions and the rest of the brain could undergo additional processing and visualization. For group comparisons, weighted matrices were used to subtract the mean vector of connectivity magnitudes for a study group (eg, TBI and AD) from that associated with the HC group. This facilitated the computation of rs-FC differences between groups and allowed us to monitor the relative strengths of FCs in the DMN of each group.

**Results**

The AD and TBI groups were found to exhibit significant similarities from the standpoint of their DMN connectivity, while also both differing from HC volunteers in statistically significant ways. For example, both anterior and posterior cingulate areas were found to exhibit similar patterns of abnormal DMN rs-FC between the DMN and both cortical and subcortical gray matter regions. These patterns were mapped and characterized systematically.

**Conclusion**

Our study and implementation facilitates the systematic calculation of rs-FC, thereby allowing for greater ease of performing large-scale calculations involving numerous seed regions within the functional connectome of the human brain. Our preliminary results are consistent with prior findings on DMN architecture and on its modification by AD and TBI. Additional research is needed to understand why the rs-FC pattern of mTBI patients becomes more similar to those of AD patients. This research will assist our understanding of how altered fMRI connectivity postinjury may be used to stratify mTBI patients based on their risk for AD.

**0161****Biological Sex/Gender and Biopsychosocial Determinants of Traumatic Brain Injury Recovery Trajectories**

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The proposed presentation aims to report findings of an invited review of traumatic brain injury (TBI) literature of the last 5 years. A biopsychosocial frame is used to discuss moderators and mediators of the effects of the injury. The review results are placed within the context of historic research changes, highlighting significant shifts in TBI research focus and methods. Findings also outline new knowledge and evidence that have resulted from these changes. In particular, the speaker will describe evidence of within- and between-sex differences in response to and recovery from this complex injury. The translational importance of these differences will be characterized. Results are also presented in the context of significant changes in research focus in the face of failed controlled and randomized controlled intervention trials. The speaker will discuss research funding agency-announced priorities for considering sex as a biological variable in all phases of research. In addition, the talk will cover literature, psychosocial, scientific, and language usage-based barriers to understanding sex-based differences in TBI risk, postinjury symptoms, and recovery complex. Exciting new knowledge, in particular about concussion, is presented to encourage investigators to continue drilling down to different foci and more sophisticated statistical approaches in order to continue to elucidate these sex-based differences in mortality, duration, and type of symptoms. For example, sports medicine research consistently reports that women have different and longer duration of concussive symptoms. Trends in these changing research methods, as well as efforts to increase precision of measures, are described. Recommendations for future research are provided.

**0162****Executive Dysfunction Following Acquired Brain Injury in School Age Children and the Outcomes of Cognitive Rehab Therapy Program (Model to Promote Best Practice)**

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*Sultan Bin Abdulaziz Humanitarian City, Riyadh, Saudi Arabia***Introduction**

Acquired brain injury (ABI) in children is often accompanied by cognitive impairment affecting executive functions (EF) like inhibition, working memory, self-regulation planning, and problem-solving, and most of the time these skills are not considered on therapist assessment and intervention or misunderstood by family, school teachers, and community, which is subsequently has an adverse effect on school performance and quality of life of the child. More recently, cognitive rehabilitation therapy (CRT) programs have given more attention to executive dysfunction, which usually presented after ABI, and new strategy and techniques have been developed to deal with these problems. These strategies and techniques

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presented with skill training, accommodation, modification, and adaptation on the home and classroom.

### Aim

First aim is to describe and discuss the impairment of EF after ABI in school-aged children and the correlation with impacting level of function in activity of daily living (ADL) and performance at school. Second aim is to examine the efficacy of structural executive function training program, which based on evidence, in improving executive function skill and functional area of children.

### Design

Prospective case series (uncontrolled longitudinal study).

### Main Outcome Measure

Dynamic Occupational Therapy Cognitive Assessment for Children (DOTCA-CH), Behavior Rating Inventory of Executive Function, Second Edition (BRIEF-2), and Pediatric functional independent measure (WeeFIM) none standardized quantitative and qualitative measure—all assessment will be taken at baseline and 6 weeks after therapy.

### Methods

Children who admitted between December 2018 and December 2019 and meet the inclusion criteria will be enrolled in the study. Inclusion criteria is diagnoses of ABI, age 6 to 12 years, and has (WeeFIM) total cognitive score >15. All children will receive CRT for 1 hour/day, 5 days/week, for 6 weeks. Treatment techniques and strategies were extracted from principles and criteria, which have been proven by evidence.

### Results

Preliminary data show that all the patients who met the inclusion criteria have an impairment on (EF) with different levels, conducting structural CRT (EF) training was associated with positive outcomes in improving overall (EF), and was more predictable in area of inhibition and WM based on standardized outcome measure and nonstandardized measure. Improvement was associated with many factors like date onset, cause of injury, and some socio demographic characteristics like education level of family, social factors, and psychodynamic at home (full data analysis for all the sample size will be provided).

### Conclusion

Despite the limitations of this study, the results provide pediatric clinicians with an overall picture about cognitive impairment on children with ABI, which also presents an evidence-based recommendation of strategies and techniques for (EF) training to those children. Further, more control studies with a randomized sample and longer postintervention follow-up are needed to document the long-term effects of treatment.

## 0163

### Oculomotor Dysfunction Improvement in Moderate TBI Patients With Repetitive Transcranial Magnetic Stimulation (rTMS)

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In the United States, approximately 2.5 million people are diagnosed with a traumatic brain injury annually, and millions more live with undiagnosed TBIs due to cognitive, behavioral, and psychological symptoms, which go unnoticed. When the brain undergoes impact, physiological changes occur in the corpus callosum and the cingulate gyrus. The corpus callosum, the intersection between the left and right brain hemispheres, along with the cingulate gyrus, is involved in decision-making, motivation, error monitoring, and attention. Recent studies have shown that a TBI, although heterogenous in severity, duration, and symptoms, can be unequivocally assessed by the presence of attention impairment. Attention, as a cognitive function, can be visualized through the tracking of eye movements, where the interplay of saccadic and smooth eye movements is managed by higher-order visual tracts crossing the corpus callosum, allowing us to track moving objects while maintaining focus. When impact occurs and disrupts those visual tracts, it causes alteration in eye movement patterns, so often that patients who are diagnosed with postconcussive syndrome are also diagnosed with oculomotor dysfunction (OMD). Current therapies for OMD are generalized and include cognitive training, visual tasks, and lifestyle suggestions; however, a shift to targeting a patient's niche of symptoms in congruence with existing rehabilitation therapies should be explored. One such individualized approach is rTMS, a non-invasive therapy, which delivers magnetic pulses to specific areas of the brain via an electromagnetic field to stimulate or inhibit neural activity. While rTMS magnetic pulses are localized to regions 2 cm below the human skull, both direct axonal and indirect postsynaptic and interneuron stimulation can alter the activity of deeper neural networks. In a TBI-specific protocol, bilateral rTMS treatment occurs twice a day to target the left and right dorsolateral prefrontal cortex and its preceding networks, which cross as the corpus callosum. This therapy is paired with daily cognitive training and self-reporting questionnaires to monitor recovery from postconcussive symptoms. In an effort to standardize evaluation of TBI and induced visual dysfunction, EYE-SYNC—a virtual reality technology—has been implemented in Stanford and Harvard as a biomarker to diagnose and determine the relative severity by capturing alteration in ocular function during visual tasks. For our patient population, we utilize 2 exercises, “smooth pursuit,” which tracks the eye's ability to follow an image travelling in a circle, and “VOR,” which tests the users' vestibular oculomotor functionality while in motion. In our patient case studies, we explain the efficacy of bilateral rTMS treatment for moderate TBIs and their improvement in oculomotor function and other postconcussive symptoms, shown through pre- and posttreatment EYE-SYNC data analysis and clinical presentation.

## 0164

### Lifetime Exposure to Traumatic Brain Injury and Neurobehavioral Symptoms Among Spanish-Speaking Individuals From an International Sample

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## Objective

To examine the relationship between the severity of the worst injury to the head or neck across the lifespan and current neurobehavioral symptoms among Spanish-speaking individuals from an international sample.

## Setting

Web-based survey.

## Participants

A sample of 720 respondents drawn from the general population of Spanish-speaking individuals in the United States (45.8%), Latin America (41.8%), and Spain (12.4%) completed an online survey regarding lifetime history of traumatic brain injury (TBI) and current neurobehavioral symptoms. Ages ranged from 18 to 65 years (mean = 36.8, SD = 12.5) with over half being female (62.5%).

## Design

Secondary data analysis from an international, cross-sectional study that utilized Qualtrics (US sample) and Survey Monkey (Spain and Latin American samples) internet survey platforms to deliver a series of questionnaires.

## Main Measures

Ohio State University TBI Identification Method (OSU TBI-ID) Self-Administered Brief (Lequerica, Lucca, Chiaravallotti, Ward, and Corrigan, 2018), Questions for Other Central Nervous System (CNS) Compromise (Ohio Valley Center for Brain Injury Prevention and Rehabilitation, 2007), Neurobehavioral Symptom Inventory (NSI; Cicerone and Kalmar, 1995), CAGE-AID (Brown and Rounds, 1995; Hinkin et al, 2001), and questions regarding psychiatric history and demographic characteristics. Dependent variables were 3 NSI subscales (Vestibular-Sensory, Mood-Behavioral, and Cognitive) found by Bahraini et al (2018) supported by factor analysis and shown to have satisfactory Rasch measurement properties.

## Results

Thirty-six percent of respondents reported a history of TBI. Of these individuals with a history of TBI, 12.7% were in the moderate-to-severe range of severity. A series of ANCOVA models controlling for age, sex, drug or alcohol history, psychiatric history, and other sources of CNS compromise showed that those with more severe lifetime history of TBI had significantly higher mean item scores on the Vestibular-Sensory [ $F(4,710) = 11.4, P < .001, \text{partial } \eta^2 = 0.06$ ] and Mood-Behavioral [ $F(4,710) = 4.6, P = .001, \text{partial } \eta^2 = 0.03$ ] subscales of the NSI. There was a marginally significant effect of injury severity on the Cognitive [ $F(4,710) = 2.0, P = .098, \text{partial } \eta^2 = 0.01$ ] subscale.

## Conclusion

More than one-third of Spanish-speakers from the United States and abroad reported a history of TBI, with severity of lifetime exposure being associated with current reporting of neurobehavioral symptoms, especially in the Vestibular-Sensory domain, which demonstrated a medium effect size. These results suggest that the occurrence of injuries to the head or neck of varying severity across the lifespan may pose a significant health risk, with lasting consequences among Hispanic individuals from the general population both in the United States and abroad. Healthcare professionals should consider administering a structured interview designed to elicit lifetime exposure to TBI in order to inform case formulation and treatment planning.

## 0165

### Improving Outcomes in the Brain Injury Population Through Standardization of Physician and Nurse Communication Tool for Bedside Rounding

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## Introduction

Neurogenic bowel is a complication that frequently occurs in the brain injury population. Constipation within this patient population can lead to serious complications including delirium, fecal impaction, or bowel obstruction, leading to increased length of stay as well as higher morbidity and mortality. Inadequate communication between nurses and physicians can be a contributing factor to suboptimal care of the neurogenic bowel in this population. In 2017, Memorial Rehabilitation Institute completed a review of 26 patients with diagnoses of TBI, SDH, SAH, or ICH admitted to our Acute Adult Inpatient Rehabilitation Unit over a 3-month period. Data indicated that 21 of 26 patients (76%) had less than 1 bowel movement every other day. In addition, 19 out of 26 (70%) had less than 3 bowel movements per week.

## Intervention

Multiple factors that may impact the execution and follow-up of adequate constipation management were considered including frequency of bowel movements, medication regimen, documentation of bowel movements, FIM scores, use of analgesics, and a survey of physician knowledge regarding bowel reassessment and documentation. As a result, a quality improvement project was initiated that standardized physician and nurse rounding to include a communication tool on bowel habits and the bowel programs. Our aim for this quality improvement project was for 50% or greater of all traumatic brain injury patients admitted in the brain injury unit to have a bowel movement at least 3 times per week. This project ran over an 8-week period from October 2018 to December 2018.

## Results

The standardized physician/nurse rounding tool, which included specific prompt questions for bowel regimens and performance, was initiated in October of 2018. Within 90 days of

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implementation, we achieved our aim of having 50% or greater of our traumatic brain injury patients have bowel movements at least 3 times per week. The number of patients achieving this went from 30% before the implementation of standardized nurse and physician rounding tool to 95% after this implementation for a total increase of 65%.

## Conclusion

Fractured communication between physician and nursing leads to issues in many aspects of patient care. By implementing a standardized communication tool for our daily nurse and physician rounds, improved quality outcomes and patient care especially in the area of constipation and bowel programs were achieved. This proved to be a beneficial tool for improving patient care and satisfaction within this brain injury population. Daily nurse and physician rounding with a standardized communication tool has the potential to continue to improve the quality of care, patient satisfaction, and quality outcomes among other patient populations as well.

## 0166

### Preventing Falls by Engaging Families in Hands-On Training in an Acute Inpatient Rehabilitation Setting

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## Objectives

1. Identify the factors that may contribute to family-related falls in an acute rehabilitation setting in the brain injury population.
2. Describe the essential caregiver training needed to prevent family-related falls in the brain injury population.
3. Understand how early family engagement and caregiver training can assist in decreasing falls in the brain injury unit.

In 2017, our 89-bed adult inpatient rehabilitation program identified a trend of family-related falls, with 10 falls within a 16-month period. Of those 10 falls, 4 patients had a diagnosis of brain injury (traumatic brain injury, intracranial hemorrhage, or cerebrovascular accident). Data collected from post-fall interviews with patients and family members led the team to realize that hands-on caregiver training needed to be initiated. A quality improvement study—"Family in Training"—was created. Families are trained on 5 elements of care: bed-to-chair transfers, walking, wheelchair management, toilet transfer, and toileting. Once the family member is deemed competent, they are issued an orange wristband labeled "Family in Training." This band communicates to the staff that they are able to independently assist the patient in the 5 outlined areas.

The intervention period ran from June 2017 to May 2019.

There were 291 patients with brain injury diagnoses and families trained in the "Family in Training" program. The brain injury diagnosis included traumatic brain injury, nontraumatic brain injury, stroke, and major trauma with brain and spinal cord injury. The aim of this quality improvement project was to decrease family-related falls by 50%.

Over the last 2 years since starting the "Family in Training" program, only 3 family-related falls occurred after family

training and 3 patients (1%) were discharged to an SNF. Furthermore, the FIM change in this group was 33.06 and length of stay (LOS) efficiency was 2.88, which is better than the national FIM change and LOS efficiency in this patient population, 30.8 and 2.68, respectively.

The "Family in Training" program was created to standardize caregiver training and to prevent family-related falls and promote early engagement of family members. After 2 years of this intervention, data indicate a decrease in family-related falls, an increased likelihood to be discharged to home, and improved FIM change and LOS efficiency. This intervention not only helps in decreasing family-related falls in the inpatient rehabilitation setting, but has also shown to aid in discharges to community, improve functional outcomes, and improve patient satisfaction.

## 0167

### Paroxysmal Autonomic Instability With Dystonia Following Severe Traumatic Brain Injury: A Case Report

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## Patient

A 20-year-old man admitted after a fall from 40 ft.

## Case Description

The patient was found unresponsive with agonal breathing and a Glasgow Coma Scale score of 4. He was intubated in the field. Computed tomography of the head (CTH) revealed a right depressed skull fracture, right subdural hemorrhage, scattered subarachnoid hemorrhage, parenchymal contusions, cerebral edema, and a 4-mm midline shift. Additionally, he had multiple facial and orthopedic fractures.

The patient underwent an emergent decompressive right hemicraniectomy and placement of both an intracranial cerebral pressure (ICP) monitor and drain. After the drain was removed on postoperative day (POD) 6, he developed a fixed and dilated right pupil. Repeat CTH revealed a new intraparenchymal hematoma requiring emergent evacuation and drain placement. Electroencephalogram suggested possible subclinical seizures and he was started on antiepileptics. His postoperative course was complicated by fevers and intermittent tachycardia, hypertension, and diaphoresis. His infectious work-up was negative and symptoms were concerning for autonomic instability. The patient was diagnosed with paroxysmal sympathetic hyperactivity (PSH) and started on bromocriptine, propranolol, and gabapentin for symptom management with mild benefit.

On POD 14, he developed decerebrate posturing of his right upper extremity and increased tone in his left upper extremity with concurrent worsening of his autonomic instability. With passive range-of-motion (ROM) exercises, both his tone and tachycardia temporarily resolved. We hypothesized that his dystonia, while part of the syndrome, was also acting as a noxious stimulus. He was started on baclofen with improvement in his episodic dystonia, tachycardia, and hypertension.

## Discussion

Following severe brain injury, patients are in a vulnerable state of chemical imbalance, which may lead to an excess of

adrenergic output. Although the pathophysiology is not well understood, the constellation of symptoms including tachycardia, hypertension, fevers, and tachypnea is termed PSH. This can also be associated with paroxysms of hypertonia and extensor posturing in addition to autonomic stability, and thus the syndrome has also been called paroxysmal autonomic instability with dystonia (PAID). The paroxysms may occur at least once per day with a duration of at least 3 days. These episodic dystonic movements differ from true spasticity, but frequently respond well to similar treatment strategies. While dystonia may be a presenting symptom of PSH, we hypothesize it may also exacerbate PSH by acting as a noxious stimuli itself, and thus warrants targeted management.

## Conclusion

The sequelae of brain injury can vary between patients, and it is important to recognize the signs and symptoms of PSH, which often mimic other medical conditions. Though symptom management is crucial, identifying potential noxious stimuli such as episodic dystonia is essential. This allows the physiatrist to interrupt the cycles of sympathetic hyperactivity that occur in PSH, thereby preventing further complications and secondary injury.

## 0168

### Poor Sleep Quality Predicts Serum Markers of Neuronal Injury and Cognitive Deficits in Warriors With Mild Traumatic Brain Injury

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## Introduction

Sleep disorders affect over 70% of traumatic brain injury (TBI) patients, impacting performance and quality of life. Targeted therapies for TBI-related sleep disorders are not currently available and will rely upon better understanding of their pathophysiology.

A bidirectional model of neuronal injury causing sleep dysfunction that promotes further neurodegeneration has been proposed. Animal and human studies revealed that sleep disruption promotes increased production and decreased clearance (via the glymphatic system) of the neurotoxic byproducts of synaptic activity and injury. Whether sleep dysfunction in TBI patients correlates with neurodegenerative biomarkers is unknown, and we hypothesize that amyloid beta (A $\beta$ 42), tau, and neurofilament light (NFL) correlate with sleep dysfunction, serving as biomarkers for continued neuronal injury or neurodegeneration after TBI.

## Methods

Combat-deployed service members with and without mild TBI (35 controls, 113 TBI) were administered the Pittsburgh Sleep Quality Index (PSQI). A standardized cognitive battery was performed on all subjects. Measurements of A $\beta$ 42, NFL, and tau were isolated from plasma and exosomes. Exosome isolation was achieved via phase separation/precipitation from plasma with Exoquick (SystemBiosciences). Generalized linear

models were constructed with Poisson distributions to test the associations of molecular biomarkers with PSQI. Models were adjusted for age, ApoE status, and TBI count.

## Results

In poor sleepers (PSQI >9) with TBI, serum and exosomal NFL were significantly elevated ( $P = .007$ , and  $P = .00017$ , respectively) compared to good sleepers. Additionally, poor sleepers scored significantly worse than good sleepers in the Categorical Fluency test ( $P = .0007$ ) and the Stop-Go test ( $P = .039$ ). Furthermore, serum and exosomal NFL correlated significantly with PSQI ( $\beta = 0.23$ ,  $P = .0079$ ). Plasma total tau as well as Plasma A $\beta$ 42 ( $\beta = 0.64$ ,  $P = .028$ ; and  $\beta = 0.40$ ,  $P = .049$ , respectively) also significantly correlated with PSQI. Tau and A $\beta$ 42 isolated from plasma total exosomes did not predict PSQI after controlling for the variables noted earlier.

## Conclusions

This is the first data correlating neuronal injury with sleep dysfunction in warfighters and patients with TBI. After TBI, poor sleepers have elevated markers of neuronal injury compared to good sleepers and have relative deficits in executive function compared to good sleepers. Neurodegeneration or neuronal injury, as measured by plasma NFL in a mild TBI population of warfighters, is predicted by sleep dysfunction as measured by PSQI. Plasma tau and A $\beta$ 42 also are significant biomarkers that warrant further study. Prospective trials will be required to help establish directionality of the sleep dysfunction and neuronal injury, which may guide targeted therapeutic development.

## 0169

### The Toronto Concussion Study: Effects of Prescribed Exercise on Recovery and Post-concussive Symptoms in Adults Referred to the Rapid Access Hull-Ellis Concussion and Research Clinic

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## Background

Concussion also known as mild traumatic brain injury (mTBI) affects about 150 000 Ontarians each year. Unfortunately, there are no proven therapies that expedite recovery from concussion and as many as 1 in 5 have prolonged symptoms. Although past consensus guidelines encourage rest after a concussion, recent studies and the latest published guidelines by the Concussion in Sport Group have questioned this approach and strongly discourage rest beyond the initial 24- to 48-hour period after injury. Recent studies have suggested that exercise maybe introduced after the first 24 to 48 hours, but the appropriate dose and time point have not been established in the adult general population.

## Objective

The purpose of this pilot study is to determine whether early return to physical exercise reduces postconcussive symptoms in a heterogeneous population. More specifically, our objective in this pilot study is to investigate the impact of sub-symptom threshold physical activity on symptom trajectory and recovery time and determine the optimal dose and time point, in which exercise could be introduced postconcussion. We will also determine whether standard of care, where any exercise is voluntary as tolerated or moderate activity, should be encouraged postconcussion. We hypothesize that people with concussion who receive structured aerobic exercise early in their recovery from concussion (within the first 7 days), specifically high-intensity aerobic exercise, will experience an overall reduction in the duration and severity of their symptoms.

## Methods

Patients between the ages of 17 and 45 years are recruited for this study. Participants are required to undergo treadmill testing, symptom questionnaires, and a physician examination every week beginning at week 1, and until they are recovered or week 8 (whichever comes first). Participants are randomized into 2 groups. Patients in the structured exercise groups are assigned a heart rate monitor bracelet and required to log their physical exercise, duration, exertion, heart rate, and any symptoms in an activity log. Each week these participants are given explicit exercise instructions based on their achieved heart rate during treadmill testing. The second group gets the standard of care exercise recommendations.

## Results

In this study, data collection and analysis are ongoing. We hope to provide preliminary data to answer our objective questions in addition to providing insight from this pilot study into the feasibility and challenges of undertaking such a study on a larger scale.

## 0170

### Using Virtual Reality (VR) to Objectively Measure Sequelae From Mild Traumatic Brain Injury (mTBI) and Cervical Whiplash With Myelopathy

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## Objective

Neurologic dysfunction in mTBI is often difficult to identify. The examiner usually relies on subtle clinical findings, or on their subjective impression. Without preinjury neuropsychological data, reliance on such testing is scientifically less accurate, subject to the interpreter's bias and has some shortcomings, particularly when measuring speed of neuronal transmission.

The overlap in symptoms between cervical whiplash injuries and mTBI can be perplexing. The purpose of this pilot study was to determine whether objective evidence on neurologic dysfunction in an mTBI patient can be observed using computerized testing and whether or not such a patient could

be distinguished from one with a whiplash injury, who has documented evidence of cord contusion by the presence of hyperreflexia and urodynamic abnormalities.

## Methods

To develop an objective measurement tool for residual neurologic dysfunction, we created a computer-based assessment tool using VR. Previously, we studied over 50 healthy controls to obtain normative data. The VR tests assess both general neurologic functioning and cognitive performance. Speed and accuracy data are collected for an ascending battery of 7 distinct tests that assess visual and auditory performance, visual-spatial accuracy, visual-motor coordination, working memory, and executive function. The precision of this measurement tool, especially when collecting data on the speed of neurologic performance, is much better than simple observation. The computer can measure results in units to the nearest thousandths of a second.

We studied 2 patients. One was injured in a low-speed motor vehicle accident with no concussive injury but suffered an acute central disc protrusion with immediate onset of myelopathic findings. The other patient was injured in a high-speed rollover motor vehicle accident with clear evidence of an mTBI based on physical examination and neuropsychological testing.

## Results

Our results reveal that both patients had abnormalities relative to control data. Both patients made cognitive errors and displayed delays in neuroprocessing speeds. These deficits could be clearly identified with VR computer-based testing. The computer-generated data on these patients, compared to the scores of our controls, revealed abnormalities that were strikingly apparent. The level of dysfunction found in the whiplash patient could not be explained based solely on motor dysfunction. Our results verify why these 2 groups of patients are so often difficult to differentiate.

## Conclusions

This report indicates that patients who suffer mTBIs can have objectively measurable deficits when evaluated using a VR computer-based medium. Unfortunately, our testing cannot distinguish an mTBI from a neurotrauma patient with a subcortical (cervical) injury. Our testing is useful in that it reveals measurable neurologic dysfunction, but etiology determination remains elusive. Our findings suggest that in neurotrauma, like stroke, dysfunction can occur remotely in the neuronal pathways, distinct in location from the directly injured tissue. This observation deserves further investigation.

## 0171

### What Is the Outcome After TBI? The SHEFBIT Cohort Experience

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## Objectives

To investigate global outcome after TBI and to identify relationships that may exist with injury or demographic features with multiordinal regression.

## Background

The results of global outcome studies after traumatic brain injury (TBI) differ widely largely due to differences in measures that are used, the attrition to follow-up, and selection bias. Information on long-term outcome would help inform patients and families guide future service development and target individuals at particular risk of poor outcome.

## Subjects/Setting

A total of 1322 consecutive TBI admissions over 4 years, assessed by face-to-face interviews at a specialist neurorehabilitation clinic at 10 weeks and 1 year.

## Measures

Main outcome was Extended Glasgow Outcome Scale (GOSE) by structured questionnaire.

## Results

At 1 year, follow-up was achieved in 1207 (91.3%). Mean age was 46.9 (SD 17.3) years and 49.2% had mild TBI, 33.9% moderate, and 16.9% severe. The proportion with a good recovery at 1 year was 42.9%. However, 11.4% had deteriorated in GOSE compared to 10 weeks and there were 60 (4.9%) deaths in the cohort. In a multiordinal regression, features of increasing TBI severity, etiology (assault), more prominent CT abnormality, psychiatric history, and alcohol intoxication at time of injury were independent predictors of worse GOSE. These may allow targeting of vulnerable individuals in future especially for those with a psychiatric history or intoxication at admission. Relatively little variance in the whole regression model (38%) could be attributed, suggesting that many unmeasured factors control TBI outcome. Future work needs to identify what these may be and how we may measure them in order to better predict outcome.

## Conclusions

There is still considerable functional disability at 1 year after TBI in a representative TBI population, predominantly of mild injury.

## Keywords

TBI, outcome, GOSE, follow-up, prognosis, cohort, ICF, predictors.

## 0172

### Real-Life Outcomes in Spasticity Management: Features Affecting Goal Achievement

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## Objective

To provide real-world data on goal setting and spasticity treatment, identifying any features that are associated with primary goal achievement.

## Design/outcomes

Prospective clinic attendances over 2 years followed for consecutive appointments. Patient demographics and doses of botulinum toxin injected were documented. Main outcome was achievement of a primary goal, but secondary goals were also recorded. Independent variables were examined for association to the outcome.

## Setting

Multidisciplinary spasticity clinic in a university teaching hospital.

## Results

A total of 606 goals were set in 224 patients. The majority (75.2%) were achieved with similar levels across active (72.5%), passive (75.7%), and pain (78.6%) goals. However, in terms of the primary goal, active primary goals were achieved less frequently (59.7%) than nonactive primary goals (74.2%). A logistic regression confirmed that this was the only independent variable associated with primary goal achievement and only 6% of the variance could be explained by the model. The majority of patients (61.6%) required a change to their treatment between appointments, irrespective of time since diagnosis, age, or etiology.

## Conclusions

Most goals set in spasticity clinic can be achieved irrespective of type of goal. However, active goals may be harder to accomplish when they are set as a primary goal. This may reflect the desire of individuals to prioritize a desirable goal rather than one that is achievable. While goal setting is a helpful process in the management of spasticity patients, very few patient or treatment factors are associated with outcome prediction. In other words, it is impossible to predict those who will benefit from treatment in advance. In addition, most patients also require changes to their toxin treatment from clinic to clinic, emphasizing the evolving nature of spasticity.

## 0173

### The Effect of Socioeconomic Deprivation on Traumatic Brain Injury (TBI) Outcome

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## Objectives

To assess the impact of social deprivation on traumatic brain injury (TBI) global outcome, measured at 12 months after injury.

## Design

The study was a prospective observational study conducted using consecutive admissions with TBI.

## Subjects

A total of 1322 consecutive adult TBI patients were recruited into the study over 4 years. A total number of 1191 completed the 12-month follow-up period.

## Methods

All patients were assessed by the TBI rehabilitation team at both 6 weeks and 12 months postinjury. Injury and demographic data were collated at 6 weeks including age, gender, medical comorbidities, ZIP code, and GCS. The measure of social deprivation that was used was the Indices of Multiple Deprivation (IMD) Score. The outcome measure was the Extended Glasgow Outcome Score (GOSE) at 12 months. Univariate analyses were followed by a multiordinal regression to evaluate independent predictors of outcome.

## Results

With regard to the representation of IMD deciles, the study population approximated to the general Sheffield population ( $P = .139$ ). Within the univariate analyses statistically significant relationships were noted between IMD and GOSE ( $P < .001$ ). There was no relationship noted between IMD and GCS at the time of injury ( $P = .409$ ), or medical comorbidity ( $P = .682$ ). The ordinal regression revealed a significant relationship between worse GOSE and IMD ( $P = .002$ ), age ( $P < .001$ ), GCS ( $P < .001$ ), alcohol intoxication ( $P < .001$ ), and medical comorbidity ( $P = .041$ ).

## Conclusions

Increasing social deprivation is associated with poorer global TBI outcomes at 12 months. Furthermore, age, TBI severity, and preexisting medical comorbidity are all associated with poorer TBI outcome at 12 months. This highlights the importance of social deprivation in determining TBI outcome.

## 0174

### **An Innovative Model for mTBI Screening, Research, and Education: Enhancing Specialized Services, Research Collaborations, Experiential Learning, and Reducing Overhead Costs Through a Coordinated Cost-Sharing System of Existing University and Community Partnerships**

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Many concussion screening clinics and research centers existing outside of medical school settings rely on single operational units or clinics to support both specialized staff and overhead costs. This model may actually increase operational costs and limit the active inclusion of key specialists and team collaborations that are so vital in the field of mTBI.

An innovative alternative model, recently designed and operational at the Neural Injury Center (NIC) at the University of Montana, provides enhanced services and expanded opportunities for screening, education, and research utilizing a cooperative, network-based structure. This model, which incorporates multiple disciplines, local medical practices, university-based departments/specialty clinics, community representatives, and students, provides the framework for specialized screening, collaborative state-of-the-art research, and concussion education.

The NIC model is further strengthened by a primary advisory board composed of specialists from physical therapy, athletic training, physiatry, speech and language, basic neuroscience, pharmacy, pharmacology, social work, neuropsychology, audiology, and the veterans' community. Board members from all specialties participate in regular advisory meetings and committees, but also are active players in providing services to the Center and collaborating on research. The Board also includes a special veteran's outreach advisory committee and a graduate student advisory committee. Additionally, the Center actively encourages student involvement and experiential educational opportunities.

The Center Director initially identified and invited known individuals from across the local academic and medical community to serve as core anchors for the Center, all with long-standing or collaborative relationships and strong reputations for their selfless work in improving brain injury care and innovative research. With this historical basis of mutual professional respect and a developed understanding of multidisciplinary brain injury care and research, the group enthusiastically coalesced around this cooperative operational model in a holistic and willing manner to support the core mission of mTBI screening, research, and education.

Today, the Center offers specialized clinical consults in neuro-PT, pharmacy, physiatry, vestibular testing, osteopathy, speech and language, social work, and athletic training. In addition, multiple research collaborations are underway in innovative areas of diagnosis, diagnostic technologies, treatment strategies, data sharing, and community-engaged efforts.

This model can be easily replicated in both rural and urban university/community settings by first identifying and selecting committed, specialized, collaborative individuals, and then by actively supporting and encouraging a culture of ongoing mutual benefit and professional cooperation united around the shared mission of serving those who are struggling with mTBIs.

## 0175

### **Drug Education for Life: LYPHe (Learn Your Pharmacy Education) Program: A Collaborative Effort**

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## Introduction/Rational

Many people living with TBI require long-term medication management. Compliance with medications in the

nontraumatic brain injury population using more than 3 antihypertensives is estimated to be 3% to 86%. Deficits in language, cognition, and vision can worsen compliance above that expected from a person without traumatic brain injury. In 2017, Craig Hospital completed an evaluation of 10 patients at time of their inpatient discharge to identify patterns of difficulties our patients experience when transitioning from an inpatient rehabilitation setting to their home environment. One pattern identified involved patients failing to adequately manage medications despite prior standardized medication education.

### Method/Approach

Incorporating patient medication management into the course of therapy provides a platform for learning strategies to improve comprehension and recall of medication information, organization of medications, and initiation of medication administration while learning and implementing cognitive and/or communication strategies that can also be used for other facets of recovery.

Education of medication information and instruction in compensatory cognitive strategies currently occurs in the pharmacy, occupational therapy, nursing, and speech therapy departments. However, strategy selection, implementation, and documentation of outcomes/competency related to medication and knowledge and administration are currently not standardized. With the development and use of LYPhE program, we hope to optimize and standardize the process of teaching patient's medication management skills by providing patients with hands-on, procedural training in medication initiation to help them implement this skill in their everyday routines prior to discharge. Using standardized strategy provisions and routine practices, we hope to measure changes in initiation, strategy implementation, and competency with regard to medication management to reduce medication noncompliance at discharge.

### Results/Effects

Data showing progression of skills needed for independence with medication management in the home can be useful as a vehicle for patient buy-in for therapies, procedural and habitual learning of key components needed for independence with medication management, and evaluation that can be used to support need for in-home nursing cares.

### Conclusions/Limitations

Medication compliance can be instrumental or detrimental in a person's health after TBI. We seek to share our attempt to mitigate barriers to noncompliance through the marriage of medication education by pharmacists with the specialized skills and techniques of speech/language pathologists in the development and implementation of LYPhE program.

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## 0176

### Exosomal MicroRNAs in Chronic Mild Traumatic Brain Injury: Preliminary Results From a Chronic Effect of Neurotrauma Consortium (CENC) Biomarker Discovery Project

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### Background

Chronic neurological symptoms following traumatic brain injury (TBI) are common among military personnel and Veterans and mild TBI (mTBI) has been linked to neurodegenerative disease, with those sustaining repeated mTBIs at the highest risk for disease onset. However, the long-term consequences and the underlying pathomechanisms for persistent neurological effects, including neurodegenerative disorders remain unclear. Secondary injury processes have been implicated in the onset and maintenance of chronic TBI symptoms and neurodegeneration. Increasing evidence suggests that CNS-derived exosomes modulate secondary injury processes through the intercellular transfer of signaling macromolecules, including microRNA (miRNA), that have been independently linked to both neuroinflammation and neuronal repair. To date, no studies have evaluated peripherally circulating exosomal miRNA in chronic mTBI within a military cohort.

### Methods

Plasma exosomal miRNA (exomiR) from 153 participants enrolled in the Chronic Effect of Neurotrauma Consortium (CENC) longitudinal study were compared (no TBI,  $n = 35$ ;  $\geq 1$  mTBI,  $n = 118$ ), as well as those with  $\geq 3$  mTBIs (rTBI) to those with 1 to 2 mTBIs and no TBI. Analyses were performed on all samples using nCounter Human miRNA Expression Panels, which contain 798 unique miRNA probes. Ingenuity pathway analysis (IPA) was used to identify pathways and gene networks that are associated with rTBI and 1 to 2 mTBIs. Generalized linear models (GLMs) were performed to assess relationships between differentially expressed miRNA and chronic mTBI symptom burden on the neurobehavioral symptom inventory (NSI).

### Results

Compared to controls without TBI, there were 17 exomiRs in the mTBI group ( $n = 118$ ) that were differentially expressed, whereas among Veterans with rTBIs, there were 32 exomiRs in the rTBI group compared to controls ( $n = 35$ ) differentially expressed. IPA analyses showed that these dysregulated exomiRs best correlated with pathways of inflammatory regulation, neurological disease, and cell development, with the rTBI group having greater miRNA dysregulation than those with 1 to 2 mTBIs. Within the rTBI group, exomiRs correlated with gene activity for hub-genes of TP53, insulin-like

growth factor (IGF-1), and tumor growth factor. Higher expression levels of has-miR-103a-3p and has-miR-139-5p were associated with lower and higher NSI scores, respectively.

### Conclusion

Veterans with mTBI have distinct exomiR profiles compared to controls years after injury, with significant changes in exomiRs closely associated with inflammatory regulation and neuronal repair processes. A differential effect in repetitive mTBI and a correlation with clinical symptoms were also observed. Exosomal miRNA expression analysis may provide novel insights into the underlying pathobiology of chronic symptom persistence in Veterans with remote rTBI.

### Funding

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### 0177

#### Belonging and Doing: A Social Identity Approach to ABI

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The central argument put forward in this presentation is that, in the context of acquired brain injury (ABI), social identity, that is who we understand ourselves to be as a function of the groups that we belong to, matters. This notion is consistent with an emerging literature that draws together social psychology and neuropsychology in the study of ABI, and neurorehabilitation. The argument put forward here is that the social identity approach is an appropriate vehicle for such integration. Building on the social identity approach, a novel aspect of our research is the important, and useful, concept of identity subtypes. Contemporary social identity research reports that social identity is both a source of social support, and that social identity is driven by social support. The subtypes focused on here explore whether, in the context of postacute neurorehabilitation, those identities based on affiliation/belonging (eg, family and community identities) and those identities based on participation in activities (eg, runner, soldier, and artist) could be used to address the circularity whereby identity was regarded as both source and consequence of social support. Results align with a hypothesized model indicating that affiliative identities have a significant indirect relationship with emotional status via social support and self as doer identification. Evidence suggests an “upward spiral” between social identity and social support such that affiliative identity, or belonging, makes social support possible and that, in turn, social support drives self as doer identities. In sum, belonging generates social support, which in turn facilitates participation in activities that participants identify with. The initial study was then extended into a longitudinal investigation, which explored how the understandings that people have of themselves, as expressed in their affiliative and self as doer self-categorizations, might affect anxiety. Anxiety is of particular importance following ABI because anxiety has been identified as a significant predictor

of functional outcomes. Results indicate that, over time, identity continuity and multiplicity following ABI contribute to lower levels of anxiety. Examined both cross-sectionally, and longitudinally, social identities matter.

### 0178

#### Back to Basics: Early Caregiver Training and the Impact on Discharge Disposition

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Patient and caregiver training is an essential component of the rehabilitation model of care having a pivotal influence on discharge disposition following acute inpatient rehabilitation. Previous research has demonstrated the impact of initiating caregiver training early in the individual’s stay to allow sufficient time for the patient and caregiver to develop confidence and competence in the many skills required to ensure a safe and successful community discharge.

In recent years, the field of rehabilitation for individuals with brain injury has experienced many advancements with the increasing availability of sophisticated technology for improving mobility, upper extremity functioning, ADL, and IADL skills. The technology affords clinicians with the tools to achieve outcomes previously thought to be unattainable for patients with moderate to severe brain injuries. With patients moving through the healthcare continuum at an accelerated pace with decreasing length of stays, acute rehabilitation providers face the challenge of incorporating advanced technology interventions into the patient’s program while still allowing adequate opportunities for effective caregiver training.

The technology explosion also affects allied health academic programs, forcing many to evaluate and revise their curriculum. Due to time constraints, some occupational therapy, physical therapy, speech and language pathology, and nursing programs are deemphasizing caregiver training in their curriculums to allow exposure to the many technology interventions that graduates will be expected to use in their clinical practice. This academic shift has resulted in a knowledge gap. Many new hires demonstrate limited aptitude for effectively addressing the challenge of supporting the caregiver through the family education/training process and in working collaboratively with the caregiver to resolve barriers to discharge.

Our facility saw this knowledge gap as a staff training/competency opportunity and instituted a multifaceted early caregiver training initiative with the following objectives:

1. Provide individualized training for less experienced front-line staff to improve their comfort and aptitude for incorporating caregivers earlier in the patient care process.
2. Revise clinical competencies and expand staff training in the use of safe patient handling lifts/equipment in the home setting including knowledge about insurance coverage guidelines.
3. Increase caregiver participation in patient community outing experiences to model the use of appropriate therapeutic strategies in “real life” situations.
4. Appropriately utilize therapeutic passes and home evaluations to educate/prepare patients and caregivers for discharge.
5. Increase utilization of “functional assessment” learning situations to allow extended training opportunities for developing patient and caregiver competence.

Since instituting this performance improvement initiative, we have seen an increase in our discharge to community performance, as well as elevated patient/family satisfaction. The staff are more confident actively engaging caregivers earlier in the rehabilitative process and are better equipped to support persons with brain injury and their caregivers during this very emotional and overwhelming period in their lives.

## 0179

### Examination of Racial Disparities in Adolescent Patients Seen at the Emergency Department for Head, Neck, or Brain Injury

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Given the frequency, severity, and attention of head and traumatic brain injury in children, benchmarking racial disparities and injury characteristics for adolescent head injury patients is pivotal in understanding and enhancing both clinical care and outcomes. Thus, the purpose of this study was to investigate racial disparities on functional outcomes (eg, Glasgow Coma Scale [GCS], mechanism of injury), clinical outcomes (eg, primary diagnosis), and social health factors (eg, primary insurance) among adolescents treated in an emergency department (ED) for a head, neck, or brain injury. This epidemiological study was a retrospective cohort chart review of adolescent patients, aged 13 to 19 years, seen at 3 regional EDs and a stand-alone emergency center over a 6-year period. The study exposure included race (African American or Caucasian) and the outcomes of interest included GCS, mechanism of injury, primary diagnosis, and primary insurance. Statistical analyses included descriptive statistics, followed by a series of Pearson's  $\chi^2$  tests to determine racial differences in mechanism of injury, primary diagnosis, and primary insurance status. Finally, an independent *t* test was conducted to determine racial differences in GCS. Statistical significance was set a priori  $\alpha = 0.05$ . There were a total of 2857 adolescent patient charts reviewed, with a sample mean age of  $16.41 \pm 1.90$  years. Participants consisted of 60.6% males, 39.4% females, 81.5% Caucasians, and 16.1% African Americans. By race, there were significant differences in MOI between African American and Caucasian patients ( $\chi^2 = 75.3, P < .001$ ). Sport injury (37.8%) and motor vehicle incidents (27.1%) were the leading mechanisms among Caucasians, whereas assault (32.0%) and motor vehicle incidents (27.8%) were leading mechanisms among African Americans. Assessing racial differences in primary diagnosis following the ED or EC visit, there were significant differences between African American and Caucasian patients ( $\chi^2 = 18.5, P = .01$ ). Nonspecific head, face, or neck injury was the leading primary diagnosis among Caucasian and African American patients followed by concussion. Concussion as a primary diagnosis demonstrated the largest proportional spread between African Americans (19.8%) and Caucasians (27.7%). No racial differences were identified in GCS ( $t(1971) = -0.21, P = .83$ ). Finally, there were significant differences in insurance status by race ( $\chi^2 = 163.1, P < .001$ ). The majority of Caucasian patients had private insurance (66.3%) versus the majority of African American patients having Medicaid (60.0%). Results from this study provide evidence of racial disparities among

adolescents treated for head, neck, or brain injuries in an ED. Differences related to functional and clinical outcomes exist between African American and Caucasian patients—in particular, primary mechanisms for injury and concussion diagnoses. It is imperative for clinicians to understand the implications of these disparities and the contributing social determinants of health. Further, understanding these disparities on a national scale warrants attention.

## 0180

### Management of TBI and Chronic Headache in Returning Veterans

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#### Objective

Examines relations among deployment-related mild traumatic brain injury (mTBI) and co-occurring conditions impacting postdeployment health in Veterans, while also describing a novel VA neurocognitive rehabilitation program that utilizes an integrated interdisciplinary treatment approach including an emphasis on community reintegration. The prevalence and significance of service-related mTBI history and co-occurring conditions among postdeployment Veterans are described along with outcomes data following completion of the rehabilitation program. This study aims to provide information to advance treatment options for returning Veterans presenting with deployment-related mTBI and complex polytrauma presentations.

#### Background

TBI has been identified as the “signature injury” of the Iraq and Afghanistan wars. Incidence of mild to moderate TBI is reported to be as high as 20% to 25% in returning Veterans. An average of 1 in 6 Veterans report persistent postconcussive symptoms following deployment, often alongside constellations of co-occurring physical and psychiatric difficulties. TBI has been shown to significantly increase risk for the development of psychiatric disorders including PTSD and depression, as well as physiological symptoms including pain syndromes and disordered sleep. Little consensus exists regarding the relations between deployment-related mTBI and associations with adverse health outcomes postdeployment. Furthermore, a consensus is lacking regarding best practices for treatment of mTBI in Veterans, particularly when mTBI is accompanied by multiple and/or complex co-occurring conditions that may complicate treatment in traditional single-specialty programs while also being associated with high rates of utilizing care. Further understanding and advancement of treatment options is needed.

#### Methods

A novel neurorehabilitation program is described serving Veterans with complex postdeployment needs, including integrated interdisciplinary care, individual and group therapies, and emphasis on community reintegration. Symptoms of TBI, depression, PTSD, and co-occurring conditions were evaluated

via chart review and formal assessments. Symptom rating reductions following treatment within our VA Post-Deployment Assessment & Treatment (PDAT) program are described.

## Results

Preliminary analyses indicate that program participants experienced significant subjective improvements in cognition ( $2.75 \pm 0.46$ ) and other areas following treatment. Formal assessment of PTSD and depression using the PCL-M and BDI-II demonstrated significant and clinically meaningful improvements on both measures ( $n = 15$ , paired  $t$  test,  $P < .05$ ). Further results will be presented for additional symptom ratings and community reintegration measures.

## Conclusion

PDAT program outcomes demonstrate the effectiveness of our interdisciplinary approach to neurocognitive rehabilitation, mental health, and emphasis on community reintegration for postdeployment Veterans with mTBI and polytrauma presentations characterized by complex often-chronic symptom constellations. After completing the program, Veterans showed clinically significant symptom reductions. Future research should examine the comparative effectiveness of different interventions, both in isolation and in combination, for treatment of mTBI symptoms and co-occurring conditions among returning combat Veterans.

## 0181

### The Effects of Moderate Exercise and Cumulative Purposeful Heading Exposure on Electroencephalogram Activity in Female Youth Soccer Players

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## Background

Electroencephalogram (EEG) recordings reveal abnormal brain functioning in individuals diagnosed with a concussion that otherwise show no deficits in clinical concussion measures. This suggests some type of compensatory brain mechanism exists to achieve what appears to be normal brain functioning. The cumulative effect of soccer heading may cause similar effects; participants can successfully perform a continuous performance test (CPT), but they engage additional brain resources to compensate for the inability to produce the necessary power.

## Objective

To evaluate the relationship between cumulative soccer heading and EEG activity in female youth soccer players both at rest and during exercise. It is expected that exercise will result in increased EEG activity across all electrode sites compared to rest, and that such differences will be amplified with increasing cumulative headers.

## Methods

Twenty-three female youth soccer players ( $13.1 \pm 0.8$  years) were followed during their soccer season. EEG was recorded while participants completed a CPT at rest and during exercise at 4 time points during the soccer season. A Wilcoxon signed-rank test evaluated the difference between rest and exercise commission errors as well as omission errors. EEG frequency bands were divided into theta (4-7 Hz), low  $\alpha$  (8-10 Hz), high  $\alpha$  (11-12 Hz), low beta (13-18 Hz), and high beta (19-30 Hz). Electrode sites Cz, Pz, P3, and P4 were assessed given their association with the cingulate and posterior cingulate cortex, which is implicated in head injury. Power for each frequency band was considered as dependent variables. A linear mixed-effects model evaluated whether condition, site, and cumulative number of headers predicted EEG power for each frequency band. The main-effects model (condition and electrode site) was tested against the null hypothesis as well as a model that included their interaction (condition by site by time).

## Results

The mean cumulative number of headers experienced by players at follow-ups 1, 2, and postseason was 6.4 (range: 0-29), 15.4 (range: 1-49), and 23.5 (range: 6-61), respectively. Omission errors significantly increased during exercise compared to rest at each time point ( $P < .05$ ), while there were no significant changes in commission rates (time nor exercise). Linear mixed-effects models revealed no statistically significant interaction (time by condition by electrode site) for all frequency bands ( $P > .05$ ). It did reveal a statistically significant main effect (condition and electrode site) across all frequency bands ( $P < .05$ ). As expected, compared to the resting condition, power increased during exercise at each electrode site across all frequency bands.

## Conclusion

Our findings indicate that the power for each frequency band was significantly influenced by both condition and electrode site. This greater EEG power with maintained performance on the CPT is consistent with the hypothesis that exercise increases EEG activity compared to rest. However, cumulative heading exposure does not appear to influence EEG activity.

## 0183

### Neuroinflammatory Pathways in Moderate to Severe TBI: An Exploration Using Protein and MicroRNA Analysis

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## Introduction

Traumatic brain injury (TBI) releases a cascade of messengers, which activate processes leading to secondary brain injury. These include excitotoxicity, reactive oxygen species

production, disruption of the blood-brain barrier, and mitochondrial dysfunction. Neuroinflammation and the release of cytokines are a common mechanistic link between these processes. Attempts to develop clinically applicable blood tests have been hampered by heterogeneity in pathology and inter-patient variability in injury response.

### Objectives

To understand the temporal profile and underlying epigenetics of the immune response that contributes to neuronal death in patients with moderate to severe TBI.

### Methods

Nine moderate to severe TBI patients admitted to neurocritical care had serum samples drawn at the time of injury and then every 24 hours up to 72 hours. Protein analysis was conducted by O-link using their systemic inflammatory and neurology protein biomarkers immunoassay. Whole-genome microRNA (miRNA) sequencing was performed by Qiagen using their next-generation sequencing technology.

We performed a univariate Student *t* test with the Benjamini-Hochberg (BH) method to control the False Discovery Rate (FDR) and Random Forest (RF) machine learning to identify relevant markers for TBI. Missing values were imputed using the minimum concentrations across all patients and protein and miRNA data further normalized using autoscaling (subtracting the mean and dividing by standard deviation).

### Results

Univariate *t* test analysis identified 5 serum proteins with differential expression over time: PLXNB1, PDGF-R- $\alpha$ , IL10-RB, PD-L1, and CDH3. The most consistent change in expression was found in PLXNB1, PDGF-R- $\alpha$ , and IL-10RB. RF machine learning analysis ranked the top 4 proteins as GFR- $\alpha$ -1, IL-10RB, PLXNB1, and PDGF-R- $\alpha$ .

RF analysis ranked the greatest change in normalized concentration in microRNAs: miR-1296-5, miR-206, miR-195-5p, miR-143-3p, and miR-1307-5p over the first 72 hours after injury. miR-1296-5 and miR-206 showed an increase over time whereas miR-195-5p and miR-143-3p expression value was decreased. Pearson correlation analysis demonstrated several proteins interacting around miR-206.

### Conclusion

Using a data-driven unbiased approach, we identified proteins and microRNAs that display differential temporal expression in the 72 hours after moderate to severe TBI. We demonstrated strong correlation between miR-206 expression and the proteins that are significantly upregulated.

PLXNB1 is involved in neuroplasticity and microglial nitric oxide synthase production. PDGF-R- $\alpha$  signaling on astrocytes promotes blood-brain barrier permeability and neuronal injury in a range of neuropathological conditions. IL-10 is a prototypical anti-inflammatory cytokine that has neurotrophic effects in vivo.

miR-206 has been recently described in an assay that classifies mild TBI patients from healthy controls. miR-206 is over-expressed in Alzheimer's patients and in experimental models regulates brain-derived neurotrophic factor.

Understanding temporal changes in inflammatory response and the epigenomic signature after TBI will enhance our

knowledge of the disease process, guide neurotherapeutic interventions, and identify putative biomarkers to assess treatment response.

### 0184

#### Impact of the Sympathetic Storm on Apoptosis in an Organotypic Ex Vivo Hippocampal Slice Model

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### Introduction

Following traumatic brain injury (TBI), 2 cellular injury patterns are present. Primary injury results in necrosis, while secondary injury leads to an apoptotic pattern. Selective neuronal loss may be driven by sympathetic hyperactivity. Observational studies demonstrate early administration of  $\beta$ -blockers results in improved patient survival.  $\beta$ -Blockers demonstrate antiapoptotic effects in the heart and kidneys, and recent evidence suggests an antiapoptotic action in the brain. Propranolol, a nonselective  $\beta$ -adrenoceptor antagonist, inhibits cytochrome-c release from isolated rat brain mitochondria. Hippocampal slice culture provides a controlled organotypic environment in which to determine whether catecholamine-induced neurotoxicity can be ameliorated by  $\beta$ -blockers.

### Objectives

To assess whether  $\beta$ -blockers can ameliorate catecholamine excess and reduce apoptotic cell loss in an ex vivo brain tissue model.

### Methods

Male Sprague-Dawley rats were culled using a rising concentration of carbon dioxide. The brains were removed, cerebella excised, and the cerebral hemispheres divided. The hippocampus was isolated using blunt dissection and divided into 250- $\mu$ m slices. Slices were cultured on sterile 0.4- $\mu$ m Millicell micropore membrane in 1 mL of supplemented neurobasal A medium. On day 3, the slices underwent complete media change and each well was dosed as below. On day 5, the slices were stained with Nucview 488 caspase-3 substrate, a cell membrane permeable fluorescent marker, which labels cells undergoing caspase-3-mediated apoptosis.

Treatment Group	Dosing Concentrations
sNBA only (control)	–
sNBA plus catecholamine	30 $\mu$ M
Noradrenaline	
Adrenaline	5 $\mu$ M
sNBA plus $\beta$ -blocker	Propranolol 30 $\mu$ M
sNBA plus catecholamines	30 $\mu$ M
and $\beta$ -blocker	
Noradrenaline	
Adrenaline	5 $\mu$ M
Propranolol	30 $\mu$ M

## Results

Cell survival is presented as a percentage of total cells counted across 3 regions in the hippocampus—the dentate gyrus, CA1, and CA2. The control sample exhibited the most apoptosis with a cell survival of 36%, 39%, and 38% in CA1, CA2, and dentate gyrus, respectively. Treatment with propranolol alone reduced mean apoptotic cell loss by 12.2% ( $P < .0001$ ) and treatment with propranolol in the presence of catecholamines led to a similar reduction in apoptosis (12.2%,  $P < .0001$ ). Treatment with catecholamines alone did not reduce the levels of apoptosis compared to control,  $P = .06$ .

## Conclusion

Treatment of brain tissue slices with propranolol led to a reduction in caspase-3-mediated apoptosis across all studied regions of the hippocampus. This antiapoptotic effect was independent of the presence of catecholamines and direct catecholamine treatment did not promote caspase-3-mediated apoptosis. This suggests propranolol may exert pleiotropic effects to reduce levels of apoptosis. Interestingly, high concentrations of catecholamines did not induce more apoptosis than the control slices. This may be owing to a downregulation of the  $\beta$ -adrenergic receptor in response to tonic stimulus.

## 0185

### Brain Injury Among Justice-Involved Youth: Findings and Implications for Rehabilitation Practitioners

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## Background

It is well-established that the prevalence of brain injury among justice-involved populations is significantly greater than that of the general population. This is true for both adults (Shiroma, Ferguson, and Pickelsimer, 2010) and juveniles (Hughes et al, 2015). While a large proportion of adolescents who are on probation or incarcerated have a diagnosis of mental illness, very few have been diagnosed with brain injury (Hughes et al, 2015).

## Objectives

From 2014 to 2018, a demonstration project was conducted in conjunction with the Pennsylvania Department of Health in 2 juvenile detention centers in southeastern Pennsylvania. Its core strategy was to identify detained youth with a history of brain injury; determine their medical/physical, neurocognitive, and behavioral barriers to successful reentry; and implement release plans including connections to brain injury resources and community supports. Ultimately the goal was to reduce risk and to increase responsivity to treatment by connecting to services that address their brain injury-specific needs while educating and building capacity among juvenile service providers.

## Methods

Screening was conducted utilizing the Ohio State University Traumatic Brain Injury Identification Form (OSU TBI-ID) and its CNS supplement (Corrigan and Bogner, 2007). Memory and executive functioning were measured with the Wide Range Assessment of Memory and Learning (WRAML-2) or Repeatable Battery for the Assessment of Neuropsychological Status (RBANS); Wechsler Individual Achievement Test (WIAT-III); Behavior Rating Inventory of Executive Function-Adult Self-Report Version (BRIEF-A); and Delis-Kaplan Executive Functioning System (D-KEFS).

## Results

Forty-nine percent of those screened had a history of brain injury according to the OSU TBI-ID. On average, youth reported 2.59 episodes, which could have caused brain injury. Average age of injury was 12 and 62% of injuries did not involve a loss of consciousness, and two-thirds of those youth who screened positive never sought treatment for injury. Causes of reported injuries included sports/recreation (25%), vehicle crashes (20%), falls (20%), hit by/against (17%), fights (16%), and blast (2%). Additionally, 40% of those who screened positive also reported a period of time during which they experienced repetitive blows to the head. Fifty-six percent of those injuries were sports-related and 40% were violence-related. A total of 147 youth were subsequently evaluated for cognitive impairment. Fifty-seven percent showed evidence of significant cognitive impairment, with the most common impairments being in Working Memory—62%, Behavioral Regulation—48%, and Delayed Recall of Novel Information—47%. Resource connections included referrals to brain injury school reentry programs, vocational rehabilitation, and medical rehabilitation.

## Conclusion and Implications

Brain injury screening and assessment are both necessary and feasible in justice settings. However, additional work is needed to determine how to best operationalize such programming and train juvenile service providers. It also appears necessary to continue to encourage youth and families to recognize the seriousness of head injuries and to pursue specialized care.

## 0186

### The Work Experience Survey: An On-the-Job Needs Assessment Tool to Promote Successful Career Outcomes for Young Adult Central Nervous System Cancer Survivors

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## Purpose

Four employed young adults who survived brain cancer participated in an evaluation of barriers to their continued employment and career development.

## Methods

A trained interviewer completed the Work Experience Survey (WES) in teleconsultation sessions with each participant to identify his or her (a) barriers to worksite accessibility, (b) difficulties performing essential functions of his or her job, (c) concerns regarding job mastery, and (d) extent of job satisfaction.

## Results

Resulting largely from the medical and psychosocial sequelae of their illnesses (especially cognitive and mobility impairments), participants reported a wide range of difficulties in performing essential functions of their jobs (5-19) that have the potential to significantly affect their productivity. Job mastery problems reflected outcomes associated with cancer such as “believing that others think I do a good job” and “having the resources (eg, knowledge, tools, supplies, and equipment) needed to do the job.” Other job mastery concerns reflected idiosyncratic aspects of a specific job setting such as “being able to speak with my supervisor about promotion.”

## Conclusions

Although all 4 participants expressed a strong desire to continue and advance in their careers, they reported significant barriers to job satisfaction that must be addressed in order for that to happen. The interviewer concluded the WES interview by recommending a job accommodation plan, which included suggestions from Job Accommodation Network (JAN) consultants.

## Implications

The WES can be used in psychosocial treatment planning to offer guidelines for young adult CNS survivors to follow in requesting job modifications and assistive technology to improve career development and employment outcomes.

## 0188

### Asking: “What Did/Do You Feel?” Instead of “How Did/Do You Feel?” and Its Impact on Emotional Lability in People With ABI Using the 3-Dimension Model, or Now Named, JKS-Model

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Using the 3-dimension model, now named the JKS-Model, has shown that it could be a useful instrument in the rehabilitation of people with emotional lability (EL) and an acquired brain injury (ABI) (12th Annual NABIS Conference on Brain Injury). In 2016, we presented a pilot study that demonstrated that the JKS-Model can be better than traditional cognitive behavioral therapy (11th Annual world congress IBIA) in the rehabilitation of people with ABI and EL. During the last study in which we demonstrated that involving relatives can have a positive impact on reducing EL (NABIS conference 2018), we noticed that patients had difficulty answering how they felt.

In this prospective open-label study, we describe the improvement of emotional stability using the Lability Affect Scale-Short Form (LASSF). We compared whether there was a difference on the improvement of EL depending on asking what they felt (WDF) instead of how they felt (HDF). We included 28 outpatients, 18 men and 10 women, with ABI. All subjects were adults. We started the first measurement EL before the first JKS session. We repeated the sessions 1 and 2 months later and repeated the measurements 1 month after each session. In 14 patients we started each session asking WDF, and in the other 14 patients we asked HDF. All 3 sessions were mediated by the same investigator in presence of the patient. Sessions were limited in time to 45 minutes.

Nearly all subjects showed a marked improvement in the LASSF 1 month after the first JKS session compared with the LASSF before starting the JKS sessions. Two and 3 months later, less improvement in the LASSF has been showed in HDF patients compared with the WDF patients.

This pilot study suggests that asking patients what they feel instead of how they feel improves emotional stability after brain injury. It seems that if you ask patients what they feel and not how they feel, they seem to gain more insight and control.

Further observations and investigations are needed to evaluate and confirm this pilot study.

## 0189

### BrainEx90 Improves Goal Performance and Satisfaction in Adults With Persistent Symptoms Post-concussion/Mild Traumatic Brain Injury

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## Background

Clinical practice guidelines for concussion/mild traumatic brain injury (mTBI) and persistent symptoms describe the importance of an interdisciplinary approach that addresses client-specific goals, provided by clinicians with expertise in brain injury rehabilitation. However, there is no recommendation on how best to provide these services to maximize patient outcomes. BrainEx90 is a combined physiotherapy and occupational therapy group treatment program that uses a circuit training model to address impairments of cognition, balance, activity tolerance, vision/vestibular function, and integration through 5-minute exercise stations; a 10-minute session addressing self-management strategies through one-to-one interaction with an occupational therapist; and a 20-minute education session on various topics (eg, nutrition, anxiety, and mindfulness).

## Objective

The purpose of this study was to evaluate whether patient performance and satisfaction of self-identified goals improved after completing 16 90-minute sessions of BrainEx90.

## Methods

As part of usual care, an occupational therapist administered the Canadian Occupational Performance Measure (COPM) to

217 concussion/mTBI patients ( $44.4 \pm 13.5$  years old) before and after completing BrainEx90. Patients rated their performance and satisfaction on up to 6 self-identified rehabilitation goals. Goals were categorized as leisure, performance, or self-care. These data were analyzed using linear mixed-effects models to evaluate the model that best predicted patient-reported performance and satisfaction.

## Results

The majority of patients selected productivity goals ( $n = 457$ ), followed by leisure ( $n = 371$ ) and self-care ( $n = 108$ ). Performance ratings for self-care significantly increased following BrainEx90 compared to leisure ( $P = .01$ ) and productivity ( $P = .03$ ) ratings. Patients also reported statistically significant increases in performance ratings over time ( $P < .01$ ). Similarly, satisfaction ratings for self-care were significantly greater than leisure ( $P = .02$ ) and productivity ( $P = .01$ ) ratings after completing BrainEx90. On average, patients reported increased satisfaction ratings over time ( $P < .01$ ).

## Conclusion

Participants reported improved performance and satisfaction ratings after completing BrainEx90. The greatest improvements in performance and satisfaction were for self-care goals. Interdisciplinary rehabilitation programs should target productivity and leisure-based activities, as these were the most commonly self-identified goal categories, yet showed the least improvement following BrainEx90.

## 0190

### Evaluating the Usability of a Mobile Pacing and Planning Points Program for Individuals With Persistent Symptoms Post-concussion/Mild Traumatic Brain Injury

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## Background

The “Parkwood Pacing and Planning Points Program” was designed by an occupational therapist to help adults postconcussion/mild traumatic brain injury (mTBI) manage persisting symptoms and gradually return to daily activities. In the program, the occupational therapist assigns point values to the patient’s daily activities based on difficulty and symptom aggravation; these contribute to a daily point maximum each patient can spend. In an effort to improve community and global access to this successful program, a mobile application version of the Pacing and Planning Points Program, The Parkwood Pacing and Planning App, was developed in partnership with patients, clinicians, researchers, and mobile application developers.

## Objective

The purpose of this study was to evaluate the usability of the Parkwood Pacing and Planning App. The main objectives of the study were to gather clinician and patient feedback on

the application’s ease of use and acceptability, and to identify sections that required improvement.

## Methods

Four patients ( $45 \pm 13.7$  years old) and 4 experienced clinicians from Parkwood Institute’s Acquired Brain Injury Out-patient Program (3 occupational therapists and a speech and language pathologist) participated in 2 focus groups and 2 follow-up surveys. The focus groups consisted of an interactive scenario-based review of the mobile application. Participants then completed a questionnaire to describe each section of the application from a word bank. Lastly, participants completed a quality improvement survey to rate the ease of use and acceptability of the application on a 5-point Likert scale. Results from the quality improvement survey were assessed using visual inspection.

## Results

The average answer to the quality improvement survey for clinicians and patients was “somewhat” ( $3.94 \pm 0.21$  and  $3.67 \pm 0.84$ , respectively). Clinicians most frequently used “useful,” “easy,” and “attractive” to describe each section of the mobile application, while patients most frequently used “useful,” “easy,” and “complete.” The most frequently used words to describe the Parkwood Pacing and Planning App were “useful,” “easy,” and “not useful.” “Not useful” was mainly used to describe the symptom tracker and my data sections.

## Conclusion

Clinicians and patients described the Parkwood Pacing and Planning App as an easy and useful rehabilitation aide for persistent symptoms postconcussion/mTBI. Improvements to the symptom tracker and my data sections were noted, and this work is currently the focus of a continued improvement initiative.

## 0191

### Sex, Gender, and Related Information Needs of Patients With Traumatic Brain Injury: In-Depth Interview Study

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## Objective

This study collected and interpreted data on the topics of sex and gender through in-depth interviews with patients with traumatic brain injury (TBI) in order to gain a broader understanding of biological sex and social gender phenomena experienced by patients in recovery, as well as patients’ educational needs.

### Setting/Participants

Forty adult patients (22 men, 18 women) of different ages, education levels, and ethnicities, with diagnoses of mild and moderate-severe TBI at various stages postinjury, were recruited through inpatient and outpatient neurology services units at a large Canadian rehabilitation research and teaching hospital.

### Design

A qualitative study. Classic content analysis with inductive coding of data obtained through semistructured interviews.

### Main Measures

Not applicable

### Results

Three overarching themes related to injury experiences and perceived familial and societal norms and expectations that limited patients' knowledge and subsequent efforts to obtain information on the topic emerged: (1) the complexity of sex and gender subject matters, (2) patients' dependence on others, and (3) uncertainty about the course of recovery. The first diminished the patient's desire to seek further information. Dependence on others and trust that others were in a better position to use the information compelled patients to redirect the need for education to clinicians, significant others, on the unique postinjury experiences of men and women. Uncertainty about what to expect in the acute phases, and a feeling of identity loss in the chronic phases, established patients' desire to seek out only the information they believed to be necessary for them to carry on with life.

### Conclusion

In developing recommendations for patient education, variations in patients' knowledge and desire for information, and the reasons behind these variations, should be considered. Improving TBI prognosis requires taking into account the social context of injured persons, and the changing nature of the established relationships between injured men and women and their families and communities as a result of injury.

## 0192

### The Impact of a Comorbid Spinal Cord Injury on Cognitive Outcomes of Patients With Traumatic Brain Injury: A Matched Inpatient Rehabilitation Study

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### Objectives

Little is known about the effect of comorbid spinal cord injury (SCI) on cognitive outcomes in people undergoing rehabilitation due to newly diagnosed traumatic brain injury (TBI). To address the gap, we compared cognitive outcomes of patients with TBI with and without a comorbid SCI in a

population-based cohort study. We analyzed data separately for male and female patients.

### Setting/Participants

All adult patients diagnosed with TBI at the emergency department or acute care hospitals between 2002 and 2017 were identified and followed up for 1 year through provincial health administrative data (Ontario, Canada); those who entered inpatient rehabilitation were studied.

### Design

A retrospective matched cohort study using the National Rehabilitation Reporting System data of all acute care and freestanding rehabilitation hospitals in Ontario, Canada.

### Main Measures

The exposure was a comorbid SCI in patients with the diagnosis of TBI. Exposed patients were matched to nonexposed (TBI-only) on sex, age, injury severity, and income, in a ratio of 1 to 2. Differences in cognitive outcomes between the admission and discharge from inpatient rehabilitation, as measured by FIM scores in cognitive domain, were compared between exposed and unexposed patients using linear mixed-effects models, controlling for comorbidity propensity score, FIM gain in motor domain, and indicators of rehabilitation care.

### Results

Over a first year after the injury, 12 750 (0.84%) of all TBI patients entered inpatient rehabilitation, of whom 1359 (10.66%) had a comorbid SCI. A total of 1195 exposed patients (65.4% male, mean age 50.9 ± 20.6 years for male and 61.8 ± 21.8 years for female patients) were matched on sex, age, injury severity, and income to 2390 unexposed patients. Controlling for confounding, exposed patients had lower cognitive gain ( $\beta$  value, -0.43; 95% CI, -0.72 to -0.15), seen in both male ( $\beta$  value, -0.39; 95% CI, -0.75 to -0.03) and female ( $\beta$  value, -0.51; 95% CI, -0.97 to -0.05) patients. The adverse effects of comorbid SCI were driven largely by lower gain in problem-solving and comprehension. Additional analyses confirmed that these findings were unlikely a result of SCI misclassification or unmeasured confounding.

### Conclusions

Adult patients with TBI and a comorbid SCI respond worse to inpatient rehabilitation on a cognitive domain than do those without. Identifying patients at risk for worse cognitive outcomes would allow development of targeted strategies that improve cognitive outcomes.

## 0193

### Subjective Cognitive Complaints in Iraq and Afghanistan Veterans Are a Significant Contributor to Treatment Outcome in a Residential VA Post-deployment Treatment Program

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Providing appropriate treatment programs for Veterans with complex medical, cognitive, and psychological issues following Iraq (OIF) and Afghanistan (OEF) military service is an imperative goal. In regard to neurorehabilitation treatment programs, those that have full Veteran participation and progress and meeting many/most/all of the Veteran's treatment goals are the ideal and lead to better program outcomes. Identifying those factors that are associated with Veterans not completing treatment programs before reaching predefined treatment goals can help address factors that negatively influence program goal attainment, program efficacy, and overall healthcare utilization.

One of the "signature" negative conditions affecting many OIF/OEF Veterans is traumatic brain injuries (TBIs; Cifu et al, 2013). In comparison to penetrating, severe, moderate, and "unclassified" TBIs, mild TBIs were by far the most common in OIF/OEF Veterans (DoD, Brown et al, 2016). Sustaining a mild TBI has been shown to have negative consequences for neurocognitive, social/family, occupational functioning, and developing or augmenting comorbid psychiatric conditions, as well as reducing treatment outcomes. Meterko et al (2012) showed that TBI symptoms were associated with poorer prognosis during cognitive rehabilitation and psychiatric treatment.

This outcome evaluation sought to identify the influence of neurobehavioral symptoms commonly associated with mild TBI as a whole, and/or subtypes of postconcussive symptoms, as reported on the Neurobehavioral Symptom Inventory (NSI) in OIF/OEF Veterans participating in a residential Post-Deployment Assessment and Treatment (PDAT) program. This neurorehabilitation program is for Veterans with posttransitional and/or postdeployment conditions (cognitive complaints, insomnia, chronic pain, stress management and mood problems, chronic pain, communication issues, and substance use/overuse) and consists of comprehensive medical evaluations/treatments, PT/OT/RT, cognitive rehabilitation, individual and group psychoeducation, and individual and group psychotherapy within an inpatient milieu and a co-associated "clubhouse" and treatment classroom. It is staffed by an attending neurologist, neuropsychologists/cognitive rehabilitation specialists, PT/OT/RT therapists, a psychiatrist, a chaplain and a dedicated RN PDAT case coordinator, and unit nursing staff.

Postconcussive symptoms, as measured by the overall NSI severity rating score, and its subgroup symptom ratings according to "affective," "cognitive," and "vestibular/somatic" severity scores were compared across a group of OIF/OEF PDAT participants who either completed ( $n = 32$ ) or did not complete ("noncompleters,"  $n = 10$ ) their predefined treatment goals/length of stay. *t* Test comparisons failed to show a significant difference between "completers" (mean = 48, SD = 14.32) and "noncompleters" (mean = 45.90, SD = 9.62) overall. However, when examined by postconcussive subtypes, whereas affective and vestibular/somatic symptoms did not show differences, the subgroup of "cognitive" postconcussive complaints did differ significantly with noncompleters having significantly more cognitive complaints (mean = 12.80, SD = 2.10) than completers (mean = 10.55, SD = 3.97,  $P = .03$ ).

Finding that "cognitive" postconcussive symptoms were significantly greater for program "noncompleters" is discussed in relation to the literature, possible ways to accommodate

or ameliorate these effects and improve program efficacy in OIF/OEF Veterans in neurorehabilitation.

## 0195

### Top-Down and Bottom-Up Cognitive Approaches in mTBI Rehabilitation

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Cognitive rehabilitation following a traumatic brain injury (TBI) is an interplay between bottom-up and top-down approaches. Evidence supports generalized long-term benefits of top-down approaches in improving functional cognition in adults with mild-TBI (mTBI). Top-down approaches/activities draw upon skills of reasoning, inhibition, creative problem-solving, and goal attainment. Bottom-up approaches that predominately involve "drill and practice" and "recall exercises" target domains such as mastery of specific skills, memorization, and improving processing speed.

The current study examined occupational therapists' (OTs) awareness and practice of top-down versus bottom-up cognitive approaches in cognitive rehabilitation of adults with mTBI. For this study, a TBI expert team (clinicians, faculty, and researchers) developed a case study with 30 functionally based treatment approaches/activities that closely align with current rehabilitation practice. Of the 30 strategies, the team identified 15 as top-down and 15 as bottom-up, based on established definitions in literature and clinical experience.

The case study was sent in a survey format to OTs across the country. The survey was deployed via PsychData program to OTs practicing TBI-cognitive rehabilitation. The OTs were identified via ACRM ListServ and AOTA's CommunOT. Out of 67 participants who agreed to participate, 30 OTs completed the survey. Descriptive results demonstrated that 78% of the OTs concurred with the expert team on identifying the top-down strategies. However, only 49% of the participants concurred with the expert team on the bottom-up strategies. That is, 50% of the bottom-up strategies were identified as top-down strategies (false hits). These responses were consistent across OTs with varying levels of education, experience, and geographical locations. The survey also included open-ended questions to gather information on OTs' knowledge and awareness of top-down and bottom-up approaches/activities. Analyses of narrative responses are ongoing.

Increased knowledge and awareness of the distinction between top-down and bottom-up approaches/activities could equip clinicians with effective training tools to improve cognitive training. Additionally, overidentifying bottom-up strategies as top-down may not adequately challenge an individual with mTBI. Conversely, top-down strategies may offer the "just right" challenge to facilitate neural repair and optimize function.

## 0196

### Delirium as a Risk Factor for Acute Care Transfers in the Brain Injury Population of an Acute Care Rehabilitation Center

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## Objective

Acute care transfers (ACTs) impede patients' participation in rehabilitation and increase burden on the healthcare system. The objective of this study is to investigate whether delirium is a risk factor for ACTs in the brain injury population.

## Design

Retrospective data analysis.

## Setting

A free-standing inpatient rehabilitation facility (IRF).

## Participants

Patients admitted to an IRF in a 12-month period during 2016.

## Interventions

Not applicable.

## Main Outcome Measures

Status of transfer from IRF to acute care hospital.

## Results

A total of 472 patients (46.19% female, mean age 70.75 ± 14.6) were included in the analysis. Of these patients, 71 (915.0%) were found to have a positive score on 3D-CAM indicating delirium upon admission. Of the 71 that were positive, 17 (23.9%) had ACTs, whereas only 47 (13.6%) of those with negative 3D-CAMs had ACTs. A  $\chi^2$  analysis shows statistical significance in association between those transferred with those having delirium ( $P = .02$ ). However, a multiple logistic regression within the whole brain injury population shows admission motor function to be an independent predictor with lower function predicting increased ACTs with odds. More importantly, a multiple logistic regression within the nontraumatic brain injury population, most of whom are brain tumor diagnoses, showed an increased risk for ACT for patients who are considered to have delirium with an odds ratio of 5.15 (0.78-33.9,  $P = .09$ ) after adjusting for age, gender, and motor function on admission.

## Conclusions

This study finds that delirium is an independent predictor for ACTs at IRF specifically in the nontraumatic brain injury population. Given the vast majority of IRF being the older population, these results inform the early identification and intervention of delirium to prevent ACTs.

## 0304

### Time Course of Deficit and Recovery Following Repetitive Mild Traumatic Brain Injury in a Rodent Assay of Cognitive Flexibility

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Mild traumatic brain injury (mTBI) occurs as a result of impact to the head. mTBIs are frequently associated with sports-related activities that typically occur repeatedly over the course of an athlete's career. mTBI symptoms include impairments in prefrontal cortex (PFC)-mediated functions, including attention, memory, processing speed, reaction times, and cognitive flexibility. To date, there remains a major gap in our understanding of the consequences and lasting effects of mTBI in terms of behavioral manifestations, underlying neurobiology, and potential treatment strategies—especially for repetitive mTBI events. The goal of the present work was to examine the time course of deficit and recovery from repetitive mTBI using a rodent assay of cognitive flexibility. Rats were exposed to a series of 3 closed head injuries (controlled cortical impact model) each separated by 1 week. At 1, 2, and 4 weeks postfinal injury (PFI), they were evaluated in an automated strategy shifting task, which required the rats to learn and shift strategies according to changing task demands. Rats initially acquired a visual cue strategy in which a light illuminated above 1 of 2 levers (left or right) indicated the correct lever press response for reward. Twenty-four hours after initial acquisition, rats were assessed for retrieval of the visual cue strategy followed by a series of strategy shifting and reversal learning challenges. One-week PFI, injured animals required more trials to reach criterion, omitted more trials, and performed with reduced accuracy as compared to sham controls during acquisition of the initial visual cue strategy. During the strategy shifting test, injured animals required more trials to reach criterion, omitted more trials, responded with increased latency, and performed with decreased accuracy compared to shams. Throughput scores, a performance index that blends accuracy and response speed, were also reduced in injured animals. When evaluated again at 2 and 4 weeks PFI, all impairments observed 1-week PFI were no longer significantly different than sham controls. These results indicate that initial acquisition and strategy shifting performance in an operant test of cognitive flexibility are impaired but gradually recover after repetitive mTBI. Repetitive mTBI-induced deficits in cognitive flexibility can be comorbid with negative changes in arousal, attention, and decision-making, all of which are mediated by PFC. As such, this model presents a useful approach for further investigating the time course of an array of behavioral deficits and potential treatment strategies following multiple mTBI insults.

## 0305

### Cannabis Use Trends in a Mild Traumatic Brain Injury Cohort

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## Introduction

Cannabis products, including cannabidiol (CBD) and tetrahydrocannabinol (THC), have become increasingly easy to procure and use in many states in the United States. The 2018 National Survey on Drug Use and Health (NSDUH) reported a past-month cannabis use rate of 8.6% among adults 26 years or older. Cannabis use is frequently reported by Veterans with histories of mTBI and associated health issues receiving services at the Marcus Institute for Brain Health (MIBH), a specialty multidisciplinary clinic serving this population. The aim of this investigation was to describe the frequency and characteristics of cannabis product use among participants in MIBH programs and to compare the rate of cannabis product use in this context to that in the general population.

## Methods

Study data were collected among patients participating in MIBH programs between January 2018 and July 2019. As part of their clinical evaluations, patients were asked about current use of cannabis products; affirmative responses prompted additional questions about cannabis product use, including frequency of use, method of administration, product ingredients (ie, THC and/or CBD), and reasons for use.

## Results

Among 127 MIBH patients (94% male), 52 (40.9%) endorsed use of cannabis products in the past month. The frequency of past-month cannabis use was significantly greater than that reported in the comparably aged NSDUH survey population (40.9% vs 8.6%,  $\chi^2 = 169$ ,  $df = 1$ ,  $P < .01$ ). Among MIBH patients, 88.5% (46/52) of cannabis users were using THC or combination products and 11.5% (6/52) were using CBD products. Inhalation was the method of cannabis product administration among 37.5% (18/48) of MIBH patients, with the rest of this group reporting use of multiple administration methods (ie, oral, inhaled, and topical). Self-reported reasons for cannabis use included anxiety ( $n = 15$ ), sleep disturbance ( $n = 13$ ), and pain ( $n = 10$ ), as well as irritability, depression, and headache ( $n = 1$  each). Noncannabis users were taking  $4.3 \pm 3.7$  (range: 0-16) concurrent medications and cannabis users were taking  $3.7 \pm 3.5$  (range: 0-16) concurrent medications ( $t = 0.92$ ,  $df = 125$ ,  $P = .36$ ). The average number of psychotropic medications used was  $1.2 \pm 1.4$  (range: 0-6) among noncannabis users and  $1.3 \pm 1.6$  (range: 0-5) among cannabis users ( $t = 0.37$ ,  $df = 125$ ,  $P = .71$ ).

## Conclusions

Cannabis use is significantly higher in the MIBH population compared to similarly aged individuals in the general population. Persons in this population present with mTBI-associated neuropsychiatric symptoms, sleep disturbances, and pain for which they report that standard treatments (pharmacologic and nonpharmacologic) have provided insufficient benefits or produced treatment-limiting adverse events. Studies of the factors driving cannabis use in this cohort of veterans are needed to evaluate the relative benefits, risks, and safety of, as well as potential pharmacological and/or nonpharmacologic therapeutic alternatives to, cannabis use for the complex and sometimes treatment refractory mTBI-associated symptoms reported by these patients.

## 0308

### Understanding of Brain Trauma Through Brain Frequency Analysis

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The brain has a small number of “modes,” conferred by its anatomical structure, which may explain the consistency of white matter fiber damage across patients. One perspective on neuroimaging results can be achieved through the analysis of trauma. Historically, this evaluation was done through the study of contact force, translational acceleration, rotational acceleration, intercranial pressure (ICP), stress, strain, strain energy, and rate, as well as a combination of any of these. Like every other structure, the human brain has its own natural frequency. When an applied load is close to that frequency, high deformation of brain tissue is expected. Therefore, an additional approach to consider in evaluating TBI should include examination of vibration (excitation) of the brain at different frequencies. Preliminary results from finite element (FE) analysis of head impact and blast loading indicates some regions of the brain reach the lower natural frequencies (20-40 Hz) and resonate with higher amplitudes. Given these findings, the use of neuroimaging and in-depth biomechanical analysis of brain dynamics can provide for more robust evaluation and treatment of TBI.

## 0310

### Augmentative and Alternative Communication (AAC) Program at Craig Hospital

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Over the past several years, Craig Hospital has put focus on the development of an Augmentative Alternative Communication (AAC) program, driving the imperative need to increase the participation of those with Complex Communication Needs (CCN) in their rehabilitation program. Patients with CCN in our rehabilitation environment are all a result of an acquired event, with diagnoses varying from apraxia of speech to severe cognitive-communication limitations. Craig Hospital has explored and continues to problem-solve through best intervention opportunities, given the complex nature of inpatient rehabilitation including utilizing AAC as a tool to target speech/language recovery, addressing the continually changing communication needs of each patient, and educating staff on communication best practices. This poster will outline the supportive evidence for a comprehensive inpatient AAC program for acquired cognitive-communication impairments, describe the current AAC program and structure at Craig Hospital, and identify areas of growth and barriers to implementation of this program.

## 0311

### Environmental Enrichment and Its Benefits After Experimental Traumatic Brain Injury

Kline A

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Each year over 10 million people worldwide incur a traumatic brain injury (TBI), of which an estimated 2.8 million are in the United States. Brain traumas range from mild to severe with the former being the case in most occurrences and generally not displaying marked behavioral symptoms, while the latter occurs less often, but presents significant motor and/or cognitive dysfunction. Numerous preclinical pharmacotherapies have been evaluated but have not translated to the clinic. Rehabilitation is currently the best option for TBI patients. Hence, in this presentation, environmental enrichment (EE), a preclinical model of neurorehabilitation that has been shown to confer motor, cognitive, and histological benefits after TBI, will be discussed. Specifically, EE studies that range from the early and continuous exposure paradigm (ie, typical EE) to some of the latest work where delayed and abbreviated EE, that more closely mimics the clinic, will be described. The data presented are derived from adult male/female rats that received a cortical impact of moderate severity or sham injury and were then randomly assigned to EE or standard (STD) housing. The results generally show that motor and cognitive function is significantly improved in the EE versus STD control groups and that EE can be considered a robust preclinical model of neurorehabilitation.

### 0312

#### **The Deleterious Effects of Antipsychotic Drugs After Experimental Traumatic Brain Injury**

Kline A

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Most traumatic brain injury (TBI) patients display agitation and aggression that is disruptive and potentially dangerous, and thus it is imperative that these maladaptive behaviors are managed so that they can be evaluated and treated while keeping them and staff safe. Antipsychotic drugs (APDs) are the go-to-treatment despite data showing that they impair neuro-motor and cognitive recovery in preclinical models of TBI. Specifically, it has been shown that chronic administration of APDs that exhibit high affinity for D2 receptors where they act as antagonists such as haloperidol and risperidone impedes cognitive recovery in male and normal cycling females. Additionally, the impeded recovery, relative to vehicle controls, continues for up to 3 months after drug withdrawal with no signs of improvement. Moreover, combining APDs with a clinically relevant model of neurorehabilitation attenuates the benefits of rehabilitation. However, APDs that rapidly dissociate from D2 receptors or exert no D2 receptor antagonism such as aripiprazole have been shown to enhance recovery after TBI. The data discussed are from adult male/female rats that received a cortical impact of moderate severity or sham injury.

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