Head Kinematics by Contact Scenarios in Youth Ice Hockey

Authors: Joel Stitzel

Objective: The objective of this pilot study was to characterize head impact exposure in a sample of youth boys’ ice hockey using a novel instrumented mouthpiece, improving accuracy.

Background: From 2010 to 2018 youth ice hockey saw a 15% increase in participation, despite growing concerns for concussion risk in contact sports. While contact sports with similar rates of concussion have been subjected to rigorous study, head impact exposure in youth ice hockey has been largely underexplored. Existing youth studies have utilized helmet-mounted sensors, which are associated with error due to poor coupling with the skull.

Design/Methods: Custom mouthpieces containing a tri-axial accelerometer and gyroscope were fit to seven enrolled athletes, and monitored during practices and games throughout the season. Linear acceleration and rotational velocity of the head were recorded for 60 ms when 5 g was exceeded on any axis for at least 3 ms. Time-synchronized film was reviewed to identify the contact scenario and head contact. Summary statistics of kinematics were calculated by scenario and presence of head contact.

Results: A total of 465 events were recorded over 25 weeks. Of these events 25% involved head contact; 92% of all contact scenarios were board checks, falls, or ice checks. Events involving head contact (i.e. head impacts) had median [95th percentile] peak linear acceleration, rotational velocity, and angular acceleration of 8.1 [30.9] g, 7.9 [20.2] rad/s, and 614 [2673] rad/s², respectively. Events not involving head contact had median [95th percentile] peak linear acceleration, rotational velocity, and angular acceleration of 6.6 [43.8] g, 6.5 [17.5] rad/s, and 455 [4115] rad/s², respectively.

Conclusions: The majority of the recorded events could be classified as board checks, falls, or ice checks. Median peak kinematics were higher for head impacts than non-head impact events. In contrast, 95th percentile linear and angular accelerations were greater for impacts not involving head contact.

Study Supported By:

Disclosure: Dr. Stitzel has nothing to disclose.
Characterization of the Biomechanical and Situational Aspects of High Magnitude Subconcussive Impacts in Collegiate Football

Authors:
Kristen Lila Lacelle, Mario Stampanoni Bassi, Allen Anthony Champagne

Objective: The objective of this study was to characterize high magnitude subconcussive impacts in football to identify injurious relationships between player/game-based characteristics and impact magnitude and frequency.

Background: Subconcussive impacts are asymptomatic head impacts thought to induce alterations in the brain after repetitive exposure. Understanding factors that lead to higher magnitude or frequency of head impacts in football is crucial to develop harm reduction and prevention strategies.

Design/Methods: Eighty-one male university level football players were equipped with helmet accelerometers to capture linear acceleration (LA), impact frequency and helmet impact location. Impacts with LA = 60g were included in the analysis. Video footage from 15 games over three seasons was analyzed to characterize aspects of play including play type, position, closing distance, player technique, tackling versus blocking and impact type (helmet-to-helmet/body/ground).

Results: A total of 570 impacts were included in the analysis with a mean LA of 83.44g +/- 23.60. Impacts with a closing distance of =10 yards resulted in higher LA compared to <10 yards and occurred most frequently in run plays. Wide receivers and defensivebacks were most often involved in impacts with a larger closing distance and experienced the highest average LA behind quarterbacks. Helmet-to-body impacts generated significantly higher LA compared to helmet-to-helmet, though helmet-to-helmet occurred more often. Players involved in a tackle sustained significantly higher LAs than those involved in a block. Impacts in which players exhibited poor technique lead to higher LA and occurred more frequently in tackling versus blocking impacts.

Conclusions: The results of this work suggest that rules regarding offensive backfield running starts could be adjusted to decrease risk of impact after a larger closing distance. Behavioral modifications and coaching approaches aimed at improving tackling technique could decrease exposure to threshold impacts at the level of the individual player.

Study Supported By:

Disclosure:
Dr. Lacelle has nothing to disclose. Dr. Bassi has nothing to disclose. Dr. Champagne has nothing to disclose.
Prevalence of Impaired Orthostasis after Concussion Injury

Authors:
Michael F. La Fountaine, EdD, ATC, Asante Hohn, Caroline Leahy, Anthony Testa

Objective: To determine the prevalence of orthostatic hypotension (OHypo) and hypertension (OHTN), respectively after a concussion in collegiate athletes.

Background: Orthostasis causes a gravity-dependent redistribution of blood volume to the lower extremities. The baroreflex coordinates the cardiovascular autonomic nervous system to mitigate aberrant changes in systolic blood pressure (?SBP). In autonomic dysfunction (AD), impaired accommodation may lead to a clinically significant ?SBP decreases (OHypo: SBP fall =20 mmHg) or paradoxical increases (OHTN: SBP rise =20 mmHg) within 3 minutes of assuming the standing (STND) posture. Concussion injuries may induce a transient state of AD. A clinical approach to surveil this state has yet to be defined.

Design/Methods: A prospective study was performed in 36 concussed (gender: 23 female, 13 male; age: 20± 1 years; height: 1.75± 0.12 meters; weight: 73± 14 kilograms) and 20 non-concussed athletes (gender: 12 female, 8 male; age: 21± 2 years; height: 1.74± 0.15 meters; weight: 72± 18 kilograms). Continuous beat-to-beat SBP was collected for 10-minutes in a resting supine position (SUP) and then for 3-minutes in the STND position within 48 hours (48H) of concussion. The average ?SBP was computed from the difference between SUP and the final 15 seconds of STND. ?SBP were then categorized: Normal (NR: ?SBP -15 to +15 mmHg); Borderline OHypo (BordOHypo: ?SBP -16 to -19 mmHg) and OHTN (BordOHTN: ?SBP +16 to +19 mmHg); OHypo; and, OHTN.

Results: In concussed athletes, the ?SBP prevalence rates were 42% NR, 31% OHypo, 11% OHTN, 11% BordOHTN, and 6% BordOHypo compared to 90% NR, 5% OHypo and 5% OHTN in the non-concussed athletes. 2 test revealed a significant difference in this distribution (p=0.012).

Conclusions: Within 48H of concussion injury, a combined 42% of injured athletes had an abnormal ?SBP response to orthostasis and a further 6% had borderline responses that warrant re-evaluation. The incidence rates for each circumstance exceeded the control group.

Study Supported By:

Disclosure:
Dr. La Fountaine has nothing to disclose. Dr. Hohn has nothing to disclose. Dr. Leahy has nothing to disclose. Dr. Testa has nothing to disclose.
Exploratory Use of Pupillometry in Patients with History of Headache/Migraine and Concussion

Authors:
Stephen Bunt, Mathew Stokes, MD, DalWai Olson, Morgan Michelle Heinzelmann, MD, Bert B. Vargas, MD, FAAN, Munro Cullum, PhD

Objective: To investigate a quantitative measurement of pupillary response (PLR) to light in subjects with a history of headache/migraine and concussion.

Background: Automated infrared pupillometry (AIP) has been used to assess abnormalities in PLR in moderate and severe and brain injuries but less is known about PLR in individuals with a history of concussion.

Design/Methods: Participants (n=96, Mean age 27.2 years) were recruited from neurology clinics at UT Southwestern Medical Center and athletic teams at the University of Texas Dallas. They were grouped by history of concussion, history of headache/migraine, and no history of either (normal). AIP (Neuroptics PLR 3000 Pupilometer) was used to measure PLR. Data included: pupil diameter (mm) before and after light stimulation, pupil reaction time (seconds), pupil constriction and dilation velocity (mm/second), and maximum constriction velocity (mm/second). Independent t-tests and ANOVA were conducted to determine if differences in PLR would be seen between groups.

Results: Subjects with a history of concussion differed in left eye maximum constriction velocity from the other groups (Concussion 4.95, SD=1.56, Headache/Migraine 3.32, SD=1.02, Normal 4.09, SD=0.78), (p<0.001). In the right eye, maximum constriction velocity in the concussion group was similar to the normal group, and both groups were significantly different than the headache/migraine group (p=0.001). The concussion history and normal groups were also faster than the headache/migraine group in constriction velocity (p<0.005) and in dilation velocity (p<0.024). There were no sex differences in PLR across groups.

Conclusions: This pilot study demonstrates the feasibility and potential use of AIP in measuring PLR in patients with a history of headache/migraine and concussion. Differences in specific PLR measures found between concussion history vs headache/migraine and normal groups merit further investigation into broader applications of AIP in concussion assessment.

Study Supported By:

Disclosure:
Dr. Bunt has nothing to disclose. Dr. Stokes has nothing to disclose. Mr. Olson received personal compensation from Hannah, Estes, and Ingram Law Firm for consulting services. Mr. Olson received financial support for research activities from Aspect Medical. Dr. Heinzelmann has nothing to disclose. Dr. Vargas has nothing to disclose. Dr. Cullum has nothing to disclose.
**Oculomotor, vestibular, reaction time and cognitive eye-tracking mild traumatic brain injury assessment**

**Authors:**
Alex Kiderman, PhD, Sara Murphy

**Objective:** Can oculomotor, vestibular, reaction time and cognitive eye-tracking tests (OVRT-C) assess mild traumatic brain injury?

**Background:** OVRT-C tests using eye tracking technology have been employed in our previous studies for assessing mild traumatic brain injury (mTBI). Here we present a composite Concussion Assessment algorithm that incorporates these findings.

**Design/Methods:** Concussion Assessment algorithm was based on a data analysis from 406 males and females 18-45 years old. The subjects included 106 patients diagnosed with mTBI and 300 healthy controls. Diagnosis of mTBI was made using accepted medical practice. The participants were tested with a battery of OVRT-C tests delivered on the I-Portal Neuro Otologic Test Center (Dx NOTC) device (NeuroLign Technology). A logistic regression model was used to derive the algorithm using a random sample of 70% of the data-set and validated on the remaining 30% of the data-set.

Device test-retest reliability and inter-rater variability were assessed in a separate study in healthy control volunteers, ages 19-43 (n=30). Subjects were tested with OVRT-C tests using the Dx100 which is equivalent to the NOTC. Test-retest reliability was assessed using Intraclass Correlation Coefficient (ICC) and Cronbach’s alpha; testers and devices influence were assessed using a random effect regression model.

**Results:** Test-retest reliability of OVRT-C tests using eye tracking technology was acceptable (ICC>0.6 for all variables).

The Concussion assessment algorithm was based on six OVRT-C tests. In the validation data Concussion Assessment algorithm was able to separate concussed versus controls with a sensitivity of 78.6% and specificity of 72.3%.

**Conclusions:** OVRT-C tests delivered on I-Portal devices are repeatable and reliable. The assessment can identify mTBI subjects within an acute time post-injury with high sensitivity and specificity. The results support the use of this eye tracking device as well as the assessment to aid in the diagnosis of mTBI for patients 18-45 year old.

**Study Supported By:**

**Disclosure:**
Dr. Kiderman has nothing to disclose. Dr. Murphy has nothing to disclose.
A study on the usefulness of a new evaluation method using virtual reality for post-concussion dizziness

Authors:
Haruo Nakayama, Yu Hiramoto, Yurika Numata-Uematsu

Objective: To clarify the effect of visual system on the post-concussion dizziness by using virtual reality system (VR).

Background: the post-concussion dizziness is most commonly reported and associated with prolonged symptom recovery. Therefore, the post-concussion dizziness is one of the most important issues.

Design/Methods: The study design was retrospective study. Facility is Toho University Ohashi Medical Center Neurosurgery Sports-related head injury clinic.

The search period is April 2018 to February 2019. Inclusion criteria were as follows: 1) Sports-related head injury cases, 2) Physician-diagnosed Sports-related concussion, 3) Underwent evaluation by the same neurosurgeon, 4) More than 28 days continued follow-up. The examination items were as follows: 1) Age/sex, 2) Competition item, 3) The prediction score of persistent post concussive symptoms (PPCS) at the time of the first visit, 4) PPCS cases, 5) Reproducibility of symptoms by Virtual reality System, 6) The presence or absence of PPCS at the invasion after 60 days. Statistical analysis used t test.

Results: The 18 SRC participants (Group VR: GVR) were selected and matched with 18 healthy controls (Group HC: GHC). The average Age of both GVR and GHC was 23.1 (16-30) vs 21.7 (16-31) years. The most majority competition item of GVR was Rugby football. The prediction score of PPCS (Low: Medium: High) of both groups was the same as 10: 8: 0 (p> 0.05, no significant). PPCS cases of both GVR and GHC were 12 vs 18 (p 0.05, no significant).

Conclusions: Our result suggests that a certain number of post-concussion dizziness cases that include visual system elements, leading to prolongation of symptoms if appropriate therapeutic intervention is not performed.

Study Supported By:

Disclosure:
Dr. Nakayama has nothing to disclose. Dr. Hiramoto has nothing to disclose. Dr. Numata-Uematsu has nothing to disclose.
Correlation between Pupilometer and the Vestibular/Ocular Motor Screening in Division I Female Collegiate Soccer Athletes

Authors:
John Heick

Objective: The objective of this study was to explore the correlation between pupilometer and Vestibular Ocular Motor Screening on Division 1 female collegiate soccer players.

Background: Concussions are one of the most prevalent acquired neurologic conditions occurring in young adults with an estimated 1.6 to 3.8 million head injuries.1,2 Concussions are assessed with a variety of measures such as the Vestibular/Ocular Motor Screen (VOMS). Visual disruptions are frequently observed following concussion with an estimated 65% to 90% of patients complaining of visual disruption.4,5 A pupilometer measures objective pupillary activity such as pupil constriction latency, diameter, speed of constriction and dilation, and reflex recovery time.5

Design/Methods: This prospective study recruited Division I female soccer athletes aged 18 to 28. Athletes were excluded if they had a lower extremity injury in the past 3 months that caused the athlete to miss more than 1 day of practice, had a history of a head injury in the past 6 months, or were diagnosed with a visual, vestibular, or balance disorder.

Results: Twenty-six female Division I collegiate soccer athletes (mean age of 20.46±2.36 years) completed baseline pupilometer and VOMS testing. Three of the twenty-six had borderline pupillary index scores and five had abnormal VOMS scores at baseline. One athlete had a concussion during the 2019 season and at retest, pupilometer results were normal but two VOMS components were abnormal. The pupilometer and VOMS were poorly correlated.

Conclusions: While the neurocognitive consequences of participation in soccer is becoming uncertain, the current study suggests that 11% of female soccer athletes without a diagnosis of a concussion had abnormal pupilometer results and 19% had abnormal VOMS scores. Evidence is mounting that repetitive hits to the head can lead to potential neurocognitive impairments. Future studies are warranted to examine baseline measures across age in female soccer athletes.

Study Supported By:

Disclosure:
Dr. Heick has nothing to disclose.
Elevated In-Season Presentation of Concussion-Like Symptoms in the Absence of Diagnosed Concussion

Authors:
Emily Kieffer, Steve Rowson, Jr. MD

Objective: The objective of this study was to quantify elevated in-season presentation of concussion-like symptoms in the absence of diagnosed concussion in a cohort of collegiate rugby players.

Background: It is well known that many sports-related concussions are unreported. Athletes that do not immediately report concussion symptoms and continue to participate in activities are at higher risk for longer recoveries and sustain post-concussion symptoms longer. How regularly athletes experience elevated concussion symptoms in-season is unknown.

Design/Methods: Athletes from men’s and women’s rugby teams were recruited and consented in accordance with the Virginia Tech Institutional Review Board. 63 males and 78 females participated over three seasons. Subjects completed a symptom and exposure query (SEQ) weekly throughout their season. The SEQ asked subjects if, in the past week, they experienced the 27 symptoms from the Graded Symptom Checklist for concussion. Subjects graded each symptom on a scale of 0-6, with 0 being no presentation and 6 being the most severe presentation. The graded severities of each symptom were summed to compute the overall Symptom Severity Score (SSS). Surveys that indicated confounding circumstances leading to symptoms were removed from analysis. The 99th percentile of SSS from baseline data was used as a metric of “elevated SSS,” which corresponded to an SSS of 11.

Results: 1,214 SEQs were collected. There were 77 surveys from 43 athletes, 10 (15.8%) men and 33 (42.3%) women, who reported elevated SSS. In a given season, 16.3% of males and 41.7% of females reported elevated symptoms at least once. The surveys identified 11 additional suspected concussions based on symptom scores beyond the 8 that were clinically diagnosed.

Conclusions: This provides some evidence that constellations of concussion symptoms are commonly experienced by collegiate rugby athletes in-season. Some are at severities typically associated with concussion, but most are below current clinical concussion diagnostic thresholds.

Study Supported By:

Disclosure:
Dr. Kieffer has nothing to disclose. Dr. Rowson has nothing to disclose.
A Follow-Up Study on the Effects of Football Scrimmages on Blink Reflex Parameters in Division I Athletes

Authors:
Dena Garner, PhD

Objective: The objective was to conduct a follow-up study to access the effects of football scrimmages on blink reflex parameters using the Eyestat.

Background: Eyestat is a noninvasive diagnostic tool measuring changes in blink reflex parameters. Prior research cited significant differences in various blink reflex parameters between active play, concussion, and baseline; however, the number of subjects for the active play population was small and within a football practice versus a football scrimmage.

Design/Methods: Fifty-eight division I male football players, between the ages of 18 and 22 years, participated in multiple sessions during a 3 week period of football scrimmages and a spring game. In addition, a subgroup of these subjects (N=20) provided a minimal of 3 or more scans throughout the study. During various points of play, subjects completed the blink test and had heart rates assessed. For the blink test, subjects placed their face against the apparatus, which directed a puff of air to the corner of the subject’s eye to stimulate the blink. Five puffs were administered in a random fashion over a 20-second period while videography captured and recorded the blink.

Results: The results of the study cited significant differences in heart rates above 55% of predicted heart rate maximum in excursions only (p=0.00), while significant differences were found in under the threshold (p= 0.05) and excursions (p=0.00) in heart rates less than 55% of maximum heart rate. In those athletes (N=20) where 3 scans were taken, there were no significant differences within subjects in any of the blink reflex parameters.

Conclusions: Future studies should continue to evaluate the timing of post exercise visual tracking assessments within healthy populations to determine the effects on ocular changes as eye-tracking devices are becoming increasingly popular to assess neurological health.

Study Supported By:

Disclosure:
Dr. Garner been assigned stock options for the company (Blinktbi) which bought the product and which I researched and tested.
Predictors of cognitive performance after sports concussion: preliminary report of Arg-SCARS

Authors:
Maria Julieta Russo, MD, Fernando Salvat, Gustavo Sevlever

Objective: To investigate the predictors of cognitive performance of adult rugby players with concussion during the first 72 h.

Background: Patients with sports concussion may present cognitive deficits within the first days after neurotrauma, which in turn may lead to post-concussion syndrome and/or long-term cognitive dysfunction. Few studies investigated factors related to cognitive performance in rugby concussions players during the first 72 h.

Design/Methods: The participants were drawn from the Argentina- Sports Concussion Assessment & Research Study (Arg-SCARS). The Arg-SCARS was created to assess all rugby players in the office setting two or three days after concussion. Such multimodal assessment includes a clinical interview, symptom self-report, neurocognitive testing, and vestibular-oculomotor screening. A multiple linear regression was calculated including all participants to determine which variables predicted global cognitive performance as assessed by a global composite score.

Results: Ninety-two rugby players with concussion (aged 17–34 years) participated in the study. The mean age was 22 years-old and 71.7% of the subjects had more than 15 years of education. 20% competed in elite teams. The number of years playing rugby and of concussions was 14.72 and 1.94, respectively. The average severity score of post-concussion symptoms was 14.49. 47.3% had post-traumatic amnesia. Compared to normative data, 13.2% of subjects had reduced global memory as measured by the memory composite score. The ANOVA test showed the existence of a linear relationship between the set of predictor variables and cognitive performance (F (6) = 6.708, p = 0.002). A higher duration of post-traumatic amnesia (p=0.037) and higher severity of post-concussion symptoms (p=0.01) were associated with lower global cognitive composite score even after adjusting for the other variables in the model.

Conclusions: The major determinants of poor cognitive performance in adult rugby players within the first 72 h after concussion were duration of post-traumatic amnesia and severity of post-concussion symptoms.

Study Supported By:

Disclosure:
Dr. Russo has nothing to disclose. Dr. Salvat has nothing to disclose. Dr. Sevlever has nothing to disclose
Immediate and 20-Minute Post-Exercise Performance On Vestibular/Ocular Motor Screening (VOMS) and Near Point of Convergence (NPC)

Authors:
Ryan Moran

Objective: To examine VOMS and NPC performance immediately and 20-minutes after a bout of maximal exercise.

Background: The Vestibular/Ocular Motor Screening (VOMS) and Near Point of Convergence (NPC) have received increased implementation for assessment and management of sport-related concussion. As athletes are often in a state of physical exertion during the immediate or sideline evaluation for concussion, it is imperative to understand the effects of exercise on these two tools.

Design/Methods: Seventeen, healthy college-aged individuals (20.7± 2.3 years) free of any modifiers for performance, completed a pre-test VOMS and NPC, followed by a graded maximal exercise treadmill test. Participants were re-assessed immediately following exercise and again 20-minutes later. Measures consisted of VOMS symptom provocation change scores per item and NPC distance (cm) averaged across 3 trials. A series of non-parametric Friedman tests and follow-up Wilcoxon signed rank tests were conducted to determine the effects between pre-test, immediate-, and 20-min post-exercise.

Results: Pre- to immediate post-exercise differences did not exist on any VOMS item, specifically, smooth pursuits (0.12 vs. 0.29, p=0.18), saccades (horizontal: 0.18 vs. 0.29, p=0.70; vertical: 0.24 vs. 0.41, p=0.70), convergence (2.78cm vs. 3.99 cm, p=0.27), vestibular ocular reflex (VOR) (horizontal: 0.59 vs. 0.94, p=0.31; vertical: 0.41 vs. 0.65, p=0.27), and visual motion sensitivity (VMS) (0.47 vs. 0.94, p=0.13). No differences were reported between pre- and immediate post-exercise on NPC distance (2.78 vs. 3.99 cm, p=0.48). The only change from immediate to 20-min post exercise was an improvement in VMS of the VOMS (0.94 vs. 0.29, p=0.05). No changes occurred between pre- and 20-min post-exercise.

Conclusions: VOMS items and NPC distance remained consistent from pre- to immediate and 20-min post exercise, which may further validate their utility as sideline assessment tools. More research is needed to determine if these results extend across graded exercise testing in acute concussion and post-concussion syndrome return-to-activity management.

Disclosure:
Dr. Moran has nothing to disclose.
Brief Autonomic Assessment in Concussion Clinic

Authors:
Meghna Patel, Aliyah Ryan Snyder, PhD, Robert Asarnow, Talin Babikian, Meeryo Choe, MD, FAAN, Christopher Giza, MD, FAAN

Objective: To examine the feasibility and tolerability of administering a brief autonomic assessment via capnometry and pupillometry in an outpatient concussion clinic.

Background: Both acute and chronic phases of concussion have been associated with autonomic nervous system (ANS) dysregulation. Few concussion clinics currently employ autonomic assessments, which could enhance diagnostic accuracy and treatment recommendations. Although less-studied in outpatient concussion clinics, pupillometry and capnometry are two well-validated, peripheral autonomic assessment approaches that together provide information about both sympathetic and parasympathetic responses. In addition to being objective measures, they are fast and non-invasive. In order to investigate the potential utility of these measures as an addition to clinic procedures, the present study sought to examine their feasibility and tolerability as an adjunctive assessment in clinic.

Design/Methods: This project employed a prospective, observational research design. Eight patients (ages 20-65, 4 females) diagnosed with concussion (>1 month post injury) underwent a 2-minute baseline capnometry that measured end-tidal CO2, respiration rate, pulse rate, and oxygen saturation. Their pupillary response to light was captured using a pupillometer. Tolerability and feasibility were measured via the following metrics: patient tolerability and comfort Likert scales and administration details (e.g. total duration, logistical difficulties, clinic flow variables).

Results: Average rating of comfort for the capnometer and pupillometer were between comfortable (4) to very comfortable (5) on a 5-point Likert scale. There were no difficulties due to participant discomfort or time limitations among all patients, and minimal issues with administration logistics were noted. Both measures were completed for all participants in <5 minutes.

Conclusions: Capnometry and pupillometry were found to be both tolerable among patients and feasible to administer in a concussion clinic. Given the ease of administration, further studies should investigate the utility of these portable devices in concussion clinics to objectively identify those at risk for persistent post-concussion symptoms and for early treatment stratification.

Study Supported By:

Disclosure:
Dr. Patel has nothing to disclose. Dr. Snyder has nothing to disclose. Dr. Asarnow has nothing to disclose. Dr. Babikian has nothing to disclose. Dr. Choe has nothing to disclose. Dr. Giza has nothing to disclose.
Driving Reaction Time Versus Computerized Reaction Time Deficits Following Concussion: Implications for Return to Driving Recommendations

Authors:
Landon Bryce Lempke, ATC, Hannes Devos, Julianne Schmidt

Objective: To compare simulated driving reaction time (RT) between concussed and control individuals and examine Driving-RTs relationship with computerized neurocognitive testing RT (CNT-RT).

Background: Concussed patients have impaired RT and neurocognition following injury that may linger and impair driving performance. Limited research has used direct methods to assess driving-RT post-concussion.

Design/Methods: We employed a cross-sectional laboratory study among 14 concussed and 14 healthy age, sex, and driving experience-matched controls (female: 60%; Age: 20.3 ± 1.1 years). Participants completed driving-RT and CNT-RT (CNS Vital Signs) within 48 hours of asymptomatic (15.9 ± 9.8 days post-concussion). Driving-RT consisted of two simulated driving scenarios: Stoplight (green to yellow stoplight change) and Pedestrian (child running in front of vehicle). CNT-RT outcomes included: simple-, complex-, Stroop-, and composite-RT. Independent t-tests and Hedges’ g effect sizes assessed between-group RT differences (seconds), and Pearson correlation coefficients examined relationships between driving-RT and CNT-RT (a = 0.05) outcomes.

Results: Concussed participants demonstrated slower complex-RT than controls (mean difference: 0.06s; 95% CI: 0.11, 0.01; p = 0.03; g = 0.86). No other driving- or CNT-RT outcomes were statistically significant (p = 0.06), but Stoplight- (p = 0.13; g = 0.61) and Pedestrian-RT (p = 0.40; g = 0.36) demonstrated low- to high-magnitude effects for concussed deficits. Complex-, Stroop-, and composite-RT moderately correlated with Stoplight-RT (p 0.05; r range: -0.19, 0.05).

Conclusions: Post-concussion driving- and CNT-RT outcomes overall normalized once asymptomatic, but complex-RT and large magnitude effects may indicate lingering deficits. Driving- and CNT-RT measures moderately correlated with each other, but a lack of strong correlation likely indicates driving responsiveness is not thoroughly assessed using traditional CNT post-concussion, which may have vital driving safety implications.

Study Supported By:

Disclosure:
Dr. Lempke has nothing to disclose. Dr. Devos has nothing to disclose. Dr. Schmidt has nothing to disclose.
Balance and Pain Scores Improve After Occipital Nerve Blocks from Initial Cranio-cervical Trauma

Authors:
Brittany Poinson, Anthony Mercoli, Andrew Thomas Guidry, MD, Kevin E. Crutchfield, MD

Objective: Patients with occipital neuritis/neuralgia secondary to craniocervical trauma obtain improvement in pain and balance scores with occipital nerve blocks.

Background: Concussions result from craniocervical trauma, frequently leading to post-traumatic occipital neuritis. Studies have shown that occipital neuritis triggers headaches, neck pain, insomnia, cognitive changes, and imbalance; symptoms similar to concussions.

Design/Methods: This is a retrospective cohort study of patients who have sustained craniocervical trauma. Documented was mechanism of injury, diagnosis of concussion, occipital neuritis on exam, and imbalance. Balance was quantified by using number of errors in tandem stance and modified BESS scoring from SCAT-5. Also included, number of steps in tandem gait with eyes open and closed. Pain was measured using 100mm visual analog scale (mean VAS). Objective findings were measured before and after occipital nerve blocks. Occipital nerve blocks were a combination of lidocaine, bupivacaine, and either triamcinolone or methylprednisolone. Symptomatic sides had blocks placed over greater occipital, lesser occipital, and third occipital nerves.

Results: Data results were collected from 205 patients, ages 4-85 years old, and 127 females. Occipital nerve blocks with steroids showed significant reduction in mean VAS pain scores from 39.6mm to 24.9mm (P<0.001). Tandem stance assessment of balance showed reduction of errors from 3.9 to 1.2 (P<0.001). Steps taken during tandem gait increased from 8 to 9 steps (P<0.001) and 4.3 to 6.2 (P<0.001) for eyes opened and eyes closed, respectively.

Conclusions: There was a statistically significant improvement in pain and balance scores after occipital nerve blocks. Then what is the prevalence of occipital neuritis in concussions? How do we differentiate concussion symptoms from occipital neuritis/neuralgia symptoms? Pain and balance disruption are found in each disorder, but with occipital nerve blocks, we're able to alleviate both symptoms. Therefore, it is important to evaluate for both concussion and occipital neuritis when assessing craniocervical trauma.

Study Supported By:

Disclosure:
Dr. Poinson has nothing to disclose. Dr. Soruco has nothing to disclose. Dr. Guidry has nothing to disclose. Dr. Crutchfield has nothing to disclose.
Intranasal (IN) Oxytocin Relieves Pain and Depressive Behavior in a Rodent Model of Mild Traumatic Brain Injury (TBI)

Authors:
Shashidhar Kori, MD

Objective: Evaluate the efficacy of intranasal oxytocin in relieving pain and associated depressive behavior in a rat model of mild TBI.

Background: Pain, anxiety, depression and cognitive impairment after TBI are sources of long-term disability for which there is no effective treatment. Decreases in endogenous oxytocin are associated with chronic pain and headache, and exogenous oxytocin reduces both pain and depressive behavior in animals and humans. This study examined the effects of intranasal oxytocin in pain and depressive behavior following TBI in rats.

Design/Methods: A standardized, reproducible, lateral fluid percussion rat model was employed using male Sprague–Dawley rats. Sham animals underwent the same procedure as the TBI animals except for the pressure pulse upon the dura. At 48-hours post procedure and establishment of hind paw and facial allodynia, 6 rats received IN oxytocin, 6 received IN vehicle. In 12 other rats, 16 ug oxytocin or vehicle was administered intravenously (IV). An additional 6 rats each received either IN oxytocin plus intraperitoneal (IP) oxytocin receptor antagonist atosiban or oxytocin plus vehicle. Rats were assessed on mechanical allodynia, conditioned place preference, and the forced swim test (FST). Oxytocin concentrations in trigeminal ganglia (TG), pons, spinal cord, and olfactory bulb were measured by ELISA immunoassay.

Results: IN oxytocin, but not IV or vehicle, attenuated both reactive and spontaneous pain following mild TBI as well as depressive behavior upon FST. This effect was blocked by atosiban, confirming an effect via oxytocin receptors. Immunoassay demonstrated concentrating of oxytocin primarily in TG.

Conclusions: IN oxytocin was effective in relieving pain and associated depressive behavior of TBI in this model and has potential to be a safe and effective treatment for TBI headaches and post-concussion syndrome.

Study Supported By:

Disclosure:
Dr. Kori has received personal compensation in an editorial capacity for Current Pain & Headache Reports. Dr. Kori holds stock and/or stock options in GlaxoSmithKline.
Neurocognitive measures and self-reported symptoms following a short intensive multimodal neurorehabilitation program in individuals with post-concussion syndrome: Retrospective case-series study

Authors: Kenneth Jay, Derek Barton, Matthew Antonucci, DC, DACNB, FACFN

Objective: This case-series study investigates the effect of a condensed multi-modal neurorehabilitation program on neurocognitive measures and self-reported symptoms using the C3Logix assessment tool on 137 individuals with diagnosed Post-Concussion Syndrome (PCS).

Background: In PCS, neurocognitive dysfunction is typically accompanied by symptoms of the physical, affective, and sleep domains. While most individuals recover within weeks of sustaining a head injury, evidence shows that those who do not recover in 3 months, may never. Recovery methods are usually prescribed with varying success, but the pathophysiological complexity of concussion may require additional rehabilitation strategies that address the impaired neural networks to accelerate recovery.

Design/Methods: 137 individuals (M: 81, F:56; mean (SD) age: 32.0 (14.0)) with a diagnosed PCS were treated at an outpatient rehabilitation center specializing in functional neurology. Using the C3Logix platform, individuals were evaluated at the intake and discharge of a 5-day program. Interventions included neuromuscular re-education, vestibular rehabilitation, orthoptics and cognitive training. Neurocognitive components and symptoms were exported and analyzed in Graphpad PRISM v. 8.4.3 using an rmANOVA. Results are reported as difference-of-means (95% CI). An alpha level of 0.05 was considered statistically significant.

Results: The C3Logix modified Graded Symptom Checklist score (0-150) decreased by 19.45 (15.16 – 23.75) (p<0.0001), Trails A and B decreased 3.9s (2.2 – 5.5) and 4.8s (2.1 – 7.5) (p<0.0001), respectively. Simple- and Choice Reaction Time decreased 31.3ms (21.5 – 41.1) and 50.7ms (37.9 – 63.6) (p<0.0001), respectively. Static and Dynamic Visual Acuity decreased 0.03 LogMAR (0.0085 – 0.059) (p=0.0021) and 0.05 LogMAR (0.021 – 0.073), respectively. Standardized Assessment of Concussion score (0-30) increased 0.8 (0.3 – 1.3) (p=0.001) and digit-symbol coding increased 4.6 symbols (3.0 - 6.2) (p<0.0001).

Conclusions: The results of the present case-series study suggest clinically relevant improvements in neurocognitive measures and subjective symptoms in individuals with PCS following a multi-modal 5-day rehabilitation program.

Study Supported By:

Disclosure: Dr. Jay received personal compensation for employment, consulting, serving on a scientific advisory board, speaking, or other activities from Plasticity Services Corporation. Dr. Barton received personal compensation for employment, consulting, serving on a scientific advisory board, speaking, or other activities from Plasticity Services Corporation of Orlando, LLC and Neurosynergy Associates, PA. Dr. Antonucci received personal compensation for employment, consulting, serving on a scientific advisory board, speaking, or other activities from Plasticity Centers. Dr. Antonucci holds stock and/or stock options in TBIC, Inc. Plasticity Brain Centers of Orlando, LLC, and Neurosynergy Associates, PA.
Steady-State Visual-Evoked Potentials as a Biomarker for Concussion: A Pilot Study

Authors:
Adrian Cohen, MD, David Putrino, Neil G. Simon, MD

Objective: This study aims to utilize a portable system capable of measuring steady-state visual evoked potentials (SSVEP) to investigate their use as an objective electrophysiological biomarker for concussion.

Background: The most pressing issues in relation to sports related concussion (SRC) involves accurate and timely diagnosis, for a safe return to play criteria. Despite the vast range of tools available to help clinicians assess concussion, most are subjective, non-portable, and therefore non-ideal for unbiased application at the site and time of a suspected injury.

Design/Methods: This system applied a smartphone housed in a VR-frame delivering a 15-Hz flickering stimulus while a wireless electroencephalography (EEG) headset recorded EEG signals. Sixty-five male amateur rugby athletes (20.9 ± 2.3 years-old) were tested throughout a season and were stratified into healthy, concussed, and recovered groups based on clinical examinations pre- and post- competitive games. Players SSVEP responses was quantified into a signal-to-noise ratio (SNR) and summarized into respective study-groups for comparison of medians with 25th-75th interquartile range.

Results: All sixty-five participants completed a baseline evaluation preseason. Twelve participants sustained a diagnosed concussion during the season and were retested within 72 h of injury. Eight concussed players received additional SSVEP testing following a 2-week recovery period. Concussed participants had a significantly lower SNR [2.20 (2.04–2.38)] when compared to their baseline [4.54 (3.79–5.10)]. When clinically recovered, participant SNR [4.82 (4.13–5.18)] was not significantly different to their baseline. Baseline SNR of concussed and non-concussed participants [4.80 (4.07–5.68)] did not significantly differ.

Conclusions: This is the first study to show that SSVEPs are significantly attenuated in the presence of concussion in male athletes. Concussed individuals’ ability to generate SSVEP appear to recover following clinical recovery. The observations of this study indicate SSVEP have the potential to be a supplemental aid for the assessment and management of concussion at point-of-care.

Study Supported By:

Disclosure:
Dr. Cohen has received compensation for serving on the Board of Directors of HeadsafeIP. Dr. Cohen holds stock and/or stock options in HeadsafeIP, which sponsored research in which Dr. Cohen was involved as an investigator. Dr. Cohen holds stock and/or stock options in HeadsafeIP. Dr. Cohen has received research support from HeadsafeIP. Dr. Putrino has nothing to disclose. Dr. Simon has nothing to disclose.
Relationship Between Mood and Somatic Symptom at Initial Presentation of mTBI to a Concussion Clinic

Authors:
Nicole Dorothy Reams, MD, Erik John Beltran, MD, Roberta Frigerio, MD

Objective: To examine the relationship between self-reported mood symptoms and severity of presenting concussion symptoms in an adult sports and non-sports post-concussion population

Background: Past studies have identified a relationship between pre-morbid and concurrent anxiety and depression and number, severity, and duration of postconcussion symptoms.

Design/Methods: Using our structured clinical documentation support toolkit for concussion patients, we analyzed previously collected discrete standardized data. Each patient with a confirmed mTBI diagnosis by the clinician, reported mood symptoms on the Generalized Anxiety Disorder 7-item (GAD-7) scale and Center for Epidemiology Studies Depression (CES-D) scale. Rivermead Post-concussion Symptoms Questionnaire (RPQ) was self-reported for non-sports concussion patients and the Sport Concussion Assessment Tool (SCAT) symptom checklist was self-reported for sports concussion patients. RPQ or SCAT scores were correlated with GAD-7 and CES-D scores at initial visit. Cohorts were stratified by gender and age decile.

Results: RPQ score was weakly correlated with GAD-7 scores and peaked at 0.71 for males in their 40s and 0.69 for females in their 50s. RPQ was weakly correlated with CES-D for males: corr=0.65 for all age groups, and females around 0.50, peaking at 0.76 for females in their 50s. For SCAT and GAD-7, males had a stronger correlation than females (0.58 to 0.21) in their 20s, while females exhibited a stronger correlation for SCAT and CES-D than males (0.63 to 0.23) in their 20s.

Conclusions: Correlations were found between symptom scores and mood scores. Strongest correlations were found for non-sports mTBI patients between RPQ scores and GAD-7 scores in males in their 40s and females in their 50s, and between RPQ scores and CES-D scores in females in their 50s. This analysis lends support to the relationship between mood symptoms and intensity of somatic concussion symptoms following injury and may encourage clinicians to discuss mental health treatment or resources when appropriate.

Study Supported By:

Disclosure:
Dr. Karis has nothing to disclose. Dr. Beltran has nothing to disclose. Dr. Frigerio has nothing to disclose.
Post-Concussion Psychological Distress at Return to Play Does Not Predict Subsequent Musculoskeletal Injury

Authors: Alexander Enrique, Katie Hunzinger, Kelsey Bryk, MSc, Thomas A. Buckley, PhD

Objective: To assess the association between the Brief Symptom Inventory 18 (BSI-18) response at post-concussion return to play (RTP) and subsequent lower extremity musculoskeletal injury (LE-MSI).

Background: Concussion evaluation includes a multifaceted neurological assessment at baseline and post-injury. Despite emotional sequelae after concussion, psychological assessments have received limited attention thus athletes may RTP despite persistent psychological distress post-concussion. Recent evidence has suggested an ~2x elevated rate of post-concussion LE-MSI in collegiate athletes; however there is limited understanding of potential mechanisms. As psychological distress has been associated with MSI, the purpose of this study was to assess BSI-18 as a potential predictor of subsequent MSI.

Design/Methods: This analysis utilized a cross-sectional design of 67 NCAA intercollegiate students-athletes with a diagnosed concussion (59.7% female, age: 19.7 ± 1.4 years). Participants completed the BSI-18, an 18-item questionnaire based on a 5-point Likert scale (0-4) used to measure psychological distress at the RTP clinical time-point. Outcome measures were the Global Severity Index (GSI) which is the total score of symptoms (0-72) with higher scores representing greater psychological distress and subsequent MSI (yes or no) collected retrospectively through an electronic medical record in the year following diagnosed concussion. Binary logistic regression was used to assess the predictive capabilities of BSI-18 GSI and subsequent LE-MSI.

Results: The BSI-18 GSI did not significantly predict subsequent LE-MSI (p=0.095, Exp(B)=2.436, Nagelkerke R2=0.181).

Conclusions: The BSI-18 GSI at RTP did not predict post-concussion subsequent LE-MSI. While the underlying mechanism for post-concussion MSI remains to be fully elucidated, results suggest that psychological health, as measured by the BSI-18 GSI, at RTP is not associated with subsequent LE-MSI. If MSI risk can be predicted then targeted, established, and clinically feasible injury prevention programs can be implemented to reduce injury risk.

Study Supported By:

Disclosure: Dr. Enrique has nothing to disclose. Dr. Hunzinger has nothing to disclose. Dr. Bryk has nothing to disclose. Dr. Buckley has nothing to disclose.
Identifying Occupational Therapy Referral Patterns in an Interdisciplinary Concussion Clinic

Authors:
Shannon Westerberg, OT, Madison Brooke Harris, OTR/L, David McArthur, Samia Rafeedie, Christopher Giza, MD, FAAN

Objective: To identify whether patients referred to occupational therapy (OT) in a specialty concussion clinic differ clinically from those not referred.

Background: Literature pertaining to OT’s role in concussion management is limited (Finn, 2019) and research primarily explores moderate to severe traumatic brain injury (TBI) (Cogan 2014).

Design/Methods: Using a cohort from an interdisciplinary concussion clinic at an academic institution, demographics, injury characteristics, patient/family history, and neurological exam results were obtained from complete medical records of patients 8-75 years with mild TBI. Patients with moderate or severe TBI were excluded. Records were reviewed from initial neurology visits between January-April 2020 if OT was present or patient was referred to OT. Outcomes included days since initial injury, days missed/current participation in school, work, exercise, social and leisure activity, impacted sleep and routine. Referrals were decided by visit physician. R Version 3.6.3 was used to analyze data.

Results: 42 of 48 records met inclusion criteria. 16 were referred (REF) to OT, 26 not referred (NOT). REF were 81% female, mean age 21.9 years. NOT were 46% female, mean age 26.4 years. The robust Yuen test showed REF were further post-initial injury (204.9 days vs 90.44 days; p=0.043), missed more school or work (35.9 days vs 7.5 days, p=0.015) and exercise (58.6 days vs 16.81 days; p=0.022) following concussion. REF also lacked a daily routine (p=0.029) and were not socially active (p<0.001). Current participation in school, work, exercise, or leisure, as well as impacted sleep showed no statistically significant group differences.

Conclusions: Patients referred to OT after evaluation in an interdisciplinary concussion clinic experienced prolonged recovery with protracted durations of inactivity, lack of daily routine and absence of social activity. Future research should explore whether factors like symptom burden, pain, or co-morbidities may account for these differences and provide clinicians with earlier indication for OT referral.

Study Supported By:

Disclosure:
Dr. Westerberg has nothing to disclose. Dr. Harris has nothing to disclose. Dr. McArthur has nothing to disclose. Dr. Rafeedie has nothing to disclose. Dr. Giza has nothing to disclose.
Clinical Experience with Calcitonin Gene-Related Peptide (CGRP) in Patients with Post-Concussion Headaches.

Authors: Warren D. Spinner, DO, Shakira S. Shanker, MD

Objective: To evaluated the role of CGRP Antagonists in the management of Post-Concussion Headaches.

Background: Headaches are one of the most common, debilitating symptoms experienced in post-concussion patients. Previous studies show these symptoms are mediated through a CGRP dependent mechanism. Injectable monoclonal antibodies directed against CGRP have seen widespread use for the management of migraines since their approval in 2018, however there has been minimal evaluation of their effectiveness in managing post-concussion headaches.

Design/Methods: A retrospective review of post-concussion patients who were administered intramuscular CGRP Antagonists once monthly in a fixed dose. This study examined reported severity of headaches evaluated at the initial clinical examinations compared to subsequent examinations post-administration of medication.

Results: Of 3 subjects evaluated and receiving erenumab (n=2) or fremanezumab (n=1), all showed some form of improvement in their symptoms. Mean (SD) age was 51.7 (6.23). Of these subjects, one patient reported 1 adverse event (AE). No subjects had serious AE that required discontinuation of treatment.

Conclusions: CGRP Antagonists show potential to be a useful approach for the management of post-concussion headaches.

Study Supported By:

Disclosure: Dr. Spinner has nothing to disclose. Dr. Shanker has nothing to disclose.
Improvements in Cognition and Balance Following Neurological Rehabilitation for a 17-year-old female hockey player with Post Concussive Syndrome

Authors:
Emily Kalambaheti

Objective: Objective is to show improvements in cognition and balance following neurological rehabilitation for patient with post-concussive syndrome (PCS).

Background: A 17-year-old, female, patient presented to Plasticity Brain Centers for evaluation and treatment of persistent symptoms following 3 diagnosed concussions. Her first concussion occurred via a motor vehicle collision and the two latter concussions were obtained while playing hockey. Her primary symptoms included headaches and vision issues, which she has been experiencing for over 3 years. Upon intake, she reported on the graded symptom checklist (GSC) a symptom severity score of 32. During neurocognitive testing on the C3Logix program, her Trails A time was 14.1 seconds; Trails B time was 32.6 seconds; digit symbol matching score (DSMS) was 56; simple reaction time (SRT) was 299 milliseconds and her choice reaction time (CRT) was 381 milliseconds. A Comprehensive Assessment of Postural Systems (CAPS®) was performed assessing balance and stability, on both a solid and foamed surface, with eyes opened, eyes closed, and multiple head positions. An average stability score was calculated as 39.2%.

Design/Methods: A 5-day intensive with multi-modal neurological exercises was administered in ten one-hour treatment sessions. Each session consisted of repetitive peripheral somatosensory stimuli, cognitive exercises, neuromuscular reeducation exercises, balance exercises, vestibular rehabilitation exercises, orthoptic exercises, and off-vertical axis rotation utilizing a multi-axis rotational chair.

Results: Upon exit, the symptom severity score decreased to 5 (-80.0%); Trails A time decreased to 10.9 (-22.7%); Trails B time decreased to 25.3 seconds (-22.4%). DSMS representing processing speed increased to 59 (+5.4%). SRT improved with a time of 245 milliseconds (-18.1%); and CRT was 311 milliseconds (-18.4%). Stability scores improved, with the average stability score calculated as 83.2% (+112.4%).

Conclusions: The authors suggest further investigation into multi-modal, intensive approaches to improve cognition and balance in patients with PCS.

Study Supported By:

Disclosure:
Dr. Kalambaheti has received personal compensation for consulting, serving on a scientific advisory board, speaking, or other activities with Plasticity Centers.
Relationship between a single quality-of-life question score and Graded Symptom Checklist score in 350 people with a diagnosed concussion: A chart review study

Authors:
Kenneth Jay, Derek Barton, Matthew Antonucci, DC, DACNB, FACFN

Objective: The objective of the study was to analyze the relationship between a single question on quality of life and composite Graded Symptom Checklist (GSC) score in a population of 350 individuals diagnosed with a concussion seeking treatment at an outpatient neurorehabilitation center.

Background: While the majority of people subjected to a concussion recover within the first two weeks of injury, up to 30% experience persistent symptoms lasting for months. Symptoms of concussion include dizziness, fatigue, and balance problems. These symptoms may have consequences that affect the quality of life of the individual.

Design/Methods: From July 2016 to April 2020, 350 individuals diagnosed with a concussion sought treatment at an outpatient rehabilitation center. Questionnaire-based symptom severity using the GSC was collected. Additionally, answers to a single question on “quality of life” on a modified Visual Analog Scale (0-100) were also collected.

A linear regression analysis was performed between quality of life score and GSC composite score in Graphpad PRISM v. 8.4.3. Results are reported as R2-value, slope and y-intercept (95% confidence intervals) and an alpha level of 0.05 was considered statistically significant (slope different from 0).

Results: The regression analysis showed a significant negative relationship with an R2-value of 0.26 between quality of life and GSC score (p<0.0001) representing a weak effect size. The regression equation slope and y-intercept were -0.6385 (95%CI: -0.7516 to -0.5254) and 89.15 (95%CI: 83.15 to 95.16), respectively.

Conclusions: The present study showed a significant, albeit weak, relationship between quality of life and GSC score. Short questions that provide meaningful insight into the wellbeing of the patient allow for long distance progress monitoring and follow-up consultations. More studies are needed to establish exactly what questions provide the best possible information as the present study is limited by its retrospective design using chart review data.

Study Supported By:

Disclosure:
Dr. Jay received personal compensation for employment, consulting, serving on a scientific advisory board, speaking, or other activities from Plasticity Services Corporation. Dr. Barton received personal compensation for employment, consulting, serving on a scientific advisory board, speaking, or other activities from Plasticity Services Corporation of Orlando, LLC and Neurosynergy Associates, PA. Dr. Antonucci received personal compensation for employment, consulting, serving on a scientific advisory board, speaking, or other activities from Plasticity Centers. Dr. Antonucci holds stock and/or stock options in TBIC, Inc. Plasticity Brain Centers of Orlando, LLC, and Neurosynergy Associates, PA.
Improvements in Cognition and Balance Following Neurological Rehabilitation for a 23-year-old Male with Post Concussive Syndrome and Subsequent Minor Head Traumas

Authors: Emily Kalambaheti

Objective: Objective is to show improvements in cognition and balance following neurological rehabilitation in patient with post-concussive syndrome (PCS) and subsequent minor head traumas.

Background: A 23-year-old male presented to Plasticity Centers for evaluation and treatment of persistent symptoms following a sports-related concussion that occurred two years prior with subsequent minor head injuries. His symptoms included fatigue, concentration/focus difficulties, and issues when reading or looking at screens. Upon intake, he reported on the graded symptom checklist (GSC) a symptom severity score of 35. During neurocognitive testing on the C3Logix program, Trails A time was 28.8 seconds; Trails B time was 68.2 seconds; digit symbol matching score (DSMS) was 55 correctly matched digits/symbols; simple reaction time (SRT) was 303 milliseconds and choice reaction time (CRT) was 388 milliseconds. A Comprehensive Assessment of Postural Systems (CAPS®) was performed assessing balance and stability, on both a solid and foamed surface, with eyes opened, eyes closed, and multiple head positions. Average stability score upon intake was calculated as 75.8%.

Design/Methods: Three separate intensives of 4 to 5 days, with multi-modal programs of neurological exercises were administered in multiple one-hour treatment sessions over the course of 19 weeks. Each session consisted of repetitive peripheral somatosensory stimuli, cognitive exercises, neuromuscular reeducation exercises, vestibular rehabilitation exercises, orthoptic exercises, and off-vertical axis rotation utilizing a multi-axis rotational chair.

Results: Upon exit, the symptom severity score decreased to 7 (-80.0%); Trails A time was 16.8 (-41.7%); Trails B time was 31.8 seconds (-53.4%). DSMS representing processing speed increased to 60 correctly matched digits/symbols (+9.1%). SRT was 253 milliseconds (-16.5%); and CRT was 319 milliseconds (-17.8%). Average stability score was calculated as 84.0% (+10.8%).

Conclusions: The authors suggest further investigation into multi-modal, intensive approaches to improve cognition, balance, and cognitive impairment in patients with PCS who have sustained subsequent minor head traumas.

Study Supported By:

Disclosure: Dr. Kalambaheti has received personal compensation for consulting, serving on a scientific advisory board, speaking, or other activities with Plasticity Centers.
Eating Disorder Risk Among Patients Presenting to a Specialty Concussion Clinic

Authors:
Rachel Pearson, MD, Kevin Bickart, Meeryo Choe, MD, FAAN, Talin Babikian, Christopher Giza, MD, FAAN

Objective: In this pilot study, we aim to assess the prevalence of eating disorder (ED) risk in patients presenting to a multi-disciplinary concussion clinic.

Background: Anxiety and depression are commonly seen after concussion. However, other post-concussive psychiatric disorders, including EDs, have not been as extensively studied. Athletes represent a population at higher risk for concussion; they also have increased risk of EDs, partly due to emphasis placed on body composition for athletic performance.

Design/Methods: Consecutive new patients evaluated in a multi-disciplinary concussion clinic received questionnaires: the SCOFF ED Screening Tool, Patient Health Questionnaire (PHQ-9 or PHQ-A for adolescents), and Generalized Anxiety Disorder 7 (GAD-7). Patients 12-52 years old referred for concussion were included. A positive screen for ED behavior was defined as answering ‘yes’ to ≥1 question on the SCOFF and/or reported poor appetite, weight loss, or overeating on the PHQ. Independent Samples Mann-Whitney U Tests were used to assess group differences in demographic and questionnaire data.

Results: Twenty-two patients (55% female, mean age 20.2 ± 10.4 years) completed questionnaires. Time from injury ranged from 3 days to >1 year. Injury mechanisms included sport (n=16), fall (n=4), struck (n=1), and other (n=1). Ten (45% total, 80% female) had positive ED screens. Significant associations were found between positive screens and total PHQ-9 (p=0.017), GAD-7 scores (p=0.025), and time since injury (p=0.036), but not for age. Findings were no longer significant after controlling for gender.

Conclusions: A significant proportion of females who present to a concussion clinic may be at risk of EDs. Because ED behaviors may affect concussion management and recovery, routine screening for ED in concussion clinics should be considered. Those with positive screens would benefit from a referral to a registered diettian for additional evaluation. Further research is needed to verify the prevalence and characterize the effect of subclinical and clinical EDs in this population.

Study Supported By:

Disclosure:
Dr. Patterson has nothing to disclose. Dr. Bickart has nothing to disclose. Dr. Choe has nothing to disclose. Dr. Babikian has nothing to disclose. Dr. Giza has nothing to disclose.
Improvements in Cognition, Graded Symptom Checklist Score, Balance and Memory Following Neurological Rehabilitation for a 58-year-old Male Patient with Post-Concussion Syndrome: Case Report

Authors: Emily Kalambaheti

Objective: To suggest the efficacy of multi-modal, intensive, neurologic rehabilitation approaches to improve cognition, balance, and cognitive impairment in patients with post-concussion syndrome.

Background: A 58-year-old male patient presented to Plasticity Brain Centers for evaluation and treatment of persistent symptoms following a previously diagnosed concussion. His symptoms followed rapidly after injury and included headaches, neck pain, and difficulty with sleeping.

Upon intake, he reported on the graded symptom checklist (GSC) a symptom severity score of 59. A Comprehensive Assessment of Postural Systems (CAPS®) was performed assessing balance and stability on both a solid and foamed surface with eyes opened, eyes closed, and multiple head positions. An average stability score upon intake was calculated as 53.9% overall. Neurocognitive testing utilizing C3 Logix Neurocognitive Assessment Suite, Trails A time was 28.6 and standardized assessment of cognition (SAC) score was a 28/30 with specific difficulty in delayed memory.

Design/Methods: A 5-day, intensive, multi-modal program of neurological exercises was administered in 10 one-hour treatment sessions. Each session consisted of repetitive peripheral somatosensory stimuli, cognitive exercises, neuromuscular reeducation, vestibular rehabilitation, orthoptic exercises, and off-vertical axis rotation utilizing a multi-axis rotational chair.

Results: Upon exit, symptom severity score decreased to 35 (-40.6%); Trails A time decreased to 19.7 (-31.1%); balance improved from an average stability score of 75.5% to 79.6% (+5.4%); and standardized assessment of cognition (SAC) score increased to an overall score of 30/10 (+7.1%) with an improvement in delayed memory.

Conclusions: The authors suggest further investigation into multi-modal, intensive approaches to improve cognition, balance, and cognitive impairment in patients with post-concussion syndrome.

Study Supported By:

Disclosure: Dr. Kalambaheti has received personal compensation for consulting, serving on a scientific advisory board, speaking, or other activities with Plasticity Centers.
Characteristics of Potential Concussive Events in Three Elite Soccer Tournaments

Authors:
Nicholas Charles Armstrong

Objective: To determine the characteristics of potential concussive events (PCEs) in professional soccer.

Background: Soccer players are at risk of sustaining sport-related concussions. The acute and chronic effects of concussive and sub-concussive impacts to the head are potentially detrimental to both players and healthcare systems worldwide. Identifying patterns in the nature and characteristics of these injuries may help sporting organizations understand how to reduce the burden of sport-related brain injuries.

Design/Methods: The present study analyzed the 2014 and 2018 FIFA World Cups (WC), and the 2016 Euro Cup (EC). Between the three tournaments, a total of 179 professional international matches were played. The researchers collected data pertaining to PCEs including mechanism of injury, location on the head, and number of concussion symptoms.

Results: A total of 237 PCEs were identified over 179 matches (1.32 per match, 40.12 per 1000 hours of exposure). The most common mechanism of injury was elbow-to-head (n=68, 28.7%), followed by head-to-head (n=55, 23.2%) and hand/fist-to-head (n=36, 15.2%). The impact locations most frequently affected were the frontal region (n=54, 22.8%), followed by the parietal and occipital regions (n=47, 19.8%), temporal region (n=46, 19.4%), anterior surface of the mandible (n=43, 18.1%), and nasal/maxilla region (n=39, 16.5%). Most players (n=210, 88.6%) showed two or more signs of concussion.

Conclusions: Our study intended to investigate the prevalence, identification and nature of PCEs in professional soccer tournaments. Our findings indicate that different contexts and mechanisms of head contact and contact to different regions of the head can be associated with varying signs of concussion. Ultimately, promoting and enforcing enhanced concussion prevention initiatives in elite soccer can have an impact at all levels of the game.

These findings may assist physicians, athletes, soccer organizations and other stakeholders worldwide with the care of injured players and the implementation of new rules and regulations to better protect their players.

Study Supported By:

Disclosure:
Dr. Armstrong has nothing to disclose.
Incidence of Neck Pain in Pediatric Mild Traumatic Brain Injury in the Emergency Department

Authors:
Brieana Hope Rodriguez

Objective: To determine (1) the frequency of reported cervical spine pain in patients diagnosed with mild traumatic brain injury (mTBI) in the Children’s Hospital of Wisconsin emergency department (ED), and (2) the predictors of number of follow up visits for concussion related symptoms between those with and without neck pain.

Background: There has been little research on the frequency of concomitant injury, specifically neck pain associated with TBI in the pediatric population. Given the potential influence of neck pain on recovery from mTBI, we sought to report on the frequency of reported neck pain in the sample of pediatric ED patients reporting mTBI symptoms.

Design/Methods: The sample was obtained through a retrospective analysis in the setting of Children’s Hospital of Wisconsin Emergency Department with a subject selection of patients diagnosed with a concussion/mTBI between the dates of 11/1/2015-06/30/2018.

Results: We analyzed 652 charts. The frequency of reported neck pain in the pediatric population being evaluated for mTBI in the ED was 13.8%. Of these patients, 32.2% had subsequent follow up visits related to their concussion/neck pain compared to 31.1% in patients without neck pain in the ED. In regards to the TBI cause, 47.8% were due to accidental falls, 40.3% were due to other accidents not related to motor vehicles, and 10.0% were due to motor vehicle accidents.

Conclusions: In comparison to the adult mTBI population, the pediatric mTBI population had a significantly less reported frequency of neck pain in the ED. This is not surprising as the majority of adults presenting for concussions and neck pain are post-motor vehicle accidents, whereas the majority of children are presenting after accidental falls. There did not seem to be an association between concussions with concomitant neck pain and prolonged recovery or increased morbidity as determined by follow up visits.

Study Supported By:

Disclosure:
Dr. Rodriguez has nothing to disclose.
Increasing Traumatic Brain Injury Incidence during COVID-19 Pandemic in the Emergency Department of Cipto Mangunkusumo National General Hospital – A National Referral Hospital in Indonesia

Authors:
Pukovisa Prawiroharjo, MD, Diatri Lastri, Ramdinal Aviesena Zairinal, MD

Objective: Evaluating the TBI incidence during the COVID-19 pandemic era compared with similar period in previous year.

Background: The emergence of SARS-CoV2 influenced the evolution of governmental and hospital policy worldwide, which might eventually impact many aspects. The incidence of many diseases in the Emergency Department (ED), especially traumatic brain injury (TBI), has been an area of interest.

Design/Methods: Retrospective study comparing TBI incidence before and during COVID-19 pandemic era starting from the declaration of national pandemic date (March 16, 2020) until June 14, 2020 with the comparison of the same period in the previous year.

Results: There was an increase in admission rate due to TBI during COVID-19 pandemic compared with the previous year (157/752 (20.9%) vs 106/766 (13.8%), p<0.001, respectively). While the range of age was similar between COVID-19 and non-COVID-19 era (37.9± 14.8 vs 38.6± 15.4 years, p=0.712), male was higher in percentage to experience the injury (131/157 (83.4%) vs 67/106 (63.2%), p<0.001). During the pandemic era, road traffic injury (97/157 (61.8%) vs 56/106 (52.8%), p=0.149) as well as moderate-to-severe brain injury tended to increase (30/157 (19.1%) vs 17/106 (16.0%) p=0.524) albeit statistically insignificant. Although the mortality rate was similar (12/157 (7.6%) vs 9/106 (8.5%), p=0.804), higher hospitalization rate was observed in the pandemic era (81/157 (51.2%) vs 37/106 (34.9%) p=0.008).

Conclusions: TBI incidence remained increasing despite entering the COVID-19 era. These phenomena required further investigation and analysis that may possibly be unrelated with the COVID-19, but due to the change of the government policy and its impact, such as the more quiet road after national social distancing.

Study Supported By:

Disclosure:
Dr. Prawiroharjo has nothing to disclose. Dr. Lastri has nothing to disclose. Dr. Zairinal has nothing to disclose.
Age of First Exposure to Collision Sports Does Not Affect Quality of Life Outcomes in Community Rugby Players

Authors: 
Katie Hunzinger, Katelyn Costantini, Thomas A. Buckley, PhD

Objective: To determine the relationship between exposure to repetitive head impacts (RHI) through collision sports prior to the age of 12 and quality of life measures in community rugby players.

Background: It is suggested that RHI incurred before age 12 may be associated with later life neurological impairments. However, research on age of first exposure (AFE) to collision sports and psychological outcomes has not be explored in rugby, a sport which participants often continue in community settings beyond college.

Design/Methods: Individuals over 18 years old who currently or previously played contact rugby completed an online questionnaire. To assess quality of life and psychological status, participants completed the Brief-Symptoms Inventory 18 (BSI-18), Short Form 12 (SF-12), and Satisfaction with Life Survey (SWLS). Participants were dichotomized into AFE to collision sports (12); AFE to rugby was not used since most participated in other collision sports prior to rugby. Data were not normally distributed; therefore, a Mann-Whitney U test was performed to compare outcomes between AFE groups.

Results: 1,037 rugby players (31.6 + 11.3 years, 59.1% male) participated in this study. There were no significant differences between AFE 12 groups on all outcomes: BSI-18 Somatization (U=97,286, p=.307), BSI-18 Depression (U=100,267, p=.778), BSI-18 Anxiety (U=98,851, p=.531), SF-12 Physical (U=94,413, p=.241), SF-12 Mental (U=96,517, p=.512), SWLS (U=98,866, p=.537). Mean scores for all outcomes were: BSI-18 Somatization (2.33 + 2.99), BSI-18 Depression (4.20 + 4.91), BSI-18 Anxiety (3.32 + 3.75), SF-12 Physical (52.40 + 7.25), SF-12 Mental (46.20 + 11.45), SWLS (24.86 + 6.31).

Conclusions: Consistent with recent cohort studies, there was no observed difference on three common measures of psychological well-being and quality of life in rugby players based upon AFE to collision sports. However, later life potential consequences of RHI in rugby players remains to be elucidated.

Study Supported By:

Disclosure:
Dr. Hunzinger has nothing to disclose. Dr. Costantini has nothing to disclose. Dr. Buckley has nothing to disclose.
The Role of Blame Attribution in Post-Concussion Syndrome Morbidity: A Retrospective Analysis of Patients at a Subspecialty Clinic

Authors: Graeme Battigelli, Mohammed Wasif Hussain, MD

Objective: To compare the presentation of Post-Concussion Syndrome (PCS) based on whom the patient blames for the initial concussion.

Background: Psychological risk factors, such as pre-injury psychiatric disease and ongoing litigation, are associated with worsened PCS. We investigated whether blame attribution is another one of these psychological risk factors.

Design/Methods: 111 new patients presenting with PCS at a Canadian subspecialty concussion clinic were seen over 2 years. 91 patients (56 females, 35 males) were included. 20 patients were excluded for inability to define specific causative event (n=13), underlying structural lesion (n=1) or evidence of intracranial bleed (n=6).

Patients were separated into three groups: those attributing external blame (n=70) those describing the incident as accidental (n=20) and those attributing internal blame (n=1).

Patient observations included: subjective percentage of recovery (SPR), presence and severity of both headaches and psychiatric symptoms, and duration of symptoms at initial presentation. Psychiatric symptoms were graded 0-3 (0-absence, 1-mild, 2-moderate, 3-severe). Headache frequency was graded 0-4 (0-absence, 1-rare, 2-episodic, 3-chronic, 4-persistent).

Results: More patients belonged to the External group compared to Accidental or Internal groups (p<0.0001). Mean SPR in the Accidental group was 73% as compared to 44% in External (p<0.0001). Mean headache frequency was 1.7 for Accidental and 2.64 for External (p=0.001). Mean severity of psychiatric symptoms was 0.55 in Accidental and 2.24 in External (p<0.0001). 77% of patients in the External group were diagnosed with post-injury PTSD, with 0% diagnosed in the Accidental group (p<0.0001). Post-injury depression and anxiety each occurred 3 times more frequently in the External group compared to Accidental (p<0.0001). Mean symptom duration at initial presentation was 10.2 months in Accidental and 22.49 months in External (p=0.001).

The External and Accidental groups did not differ significantly in age (p=0.938), number of concussions (p=0.72), gender (p=0.908), or pre-existing psychiatric illness (p=0.735).

Conclusions: This study suggests blame attribution may be an important factor in determining patients at risk of a more severe and prolonged course of PCS.

Study Supported By:

Disclosure: Dr. Battigelli has nothing to disclose. Dr. Hussain has nothing to disclose.
No Sex Differences in Risk for Lower-Extremity Musculoskeletal Injury in Concussed Amateur Rugby Players

Authors: Katelyn Costantini, Katie Hunzinger, Thomas A. Buckley, PhD

Objective: To examine sex differences between concussion and lower-extremity musculoskeletal injury (LE-MSI) in community male and female rugby players.

Background: There is an ~2x elevated risk of post-concussion subsequent MSI in high school through professional athletes. However, the effect of sex on risk is inconsistent and sparse, and rugby provides an ideal population as it’s the only collision sport with the same rules for both sexes.

Design/Methods: 1,037 rugby players (31.6 ± 11.3 years, 59.1% male), with at least one year of rugby playing experience, participated in this study, completing an online injury history questionnaire to ascertain concussion (yes/no) and LE-MSI (yes/no) history. A chi-squared test was performed to determine the association between concussion and any LE-MSI; significant findings were followed up with a post hoc odds ratio test. A binary logistic regression with any LE-MSI (yes/no) as the outcome and concussion (yes/no) and sex (male/female) as predictors was performed to determine if there was a sex by concussion interaction.

Results: There was a significant association between concussion and any LE-MSI for all groups (Overall: ?(1) =13.06, p <0.001, OR = 2.30 [95%CI: 1.45,3.65]; Males: ?(1) =7.43 p = 0.006, OR = 2.21 [95%CI: 1.24-3.96]; and Females: ?(1) = 5.78, p = 0.016, OR = 2.48 [95%CI: 1.16-5.31]). However, there were no differences for risk of LE-MSI between males and females (p=0.99, R2=0.024).

Conclusions: Both male and female community rugby players had a 2x greater risk of LE-MSI, given a history of concussion compared to those without a history of concussion, which aligns with previous studies focused on collegiate athletes. However, there was no difference in risk of LE-MSI between sexes, contrary to smaller, but more controlled studies. Future research should investigate the potential physiological mechanisms for increased risk of LE-MSI.

Study Supported By:

Disclosure: Dr. Costantini has nothing to disclose. Dr. Hunzinger has nothing to disclose. Dr. Buckley has nothing to disclose.
Concussion History Does Not Adversely Affect Trail Making Test Performance

Authors: Zarek Fasoranti, Alexander Enrique, Katie Hunzinger, Kelsey Bryk, MSc, Thomas Kaminski, Thomas A. Buckley, PhD

Objective: To determine the effect of concussion history on the electronic version of the Trail Making Test (TMT) A and TMT-B performance.

Background: The effects of concussion history on cognitive performance when the individual is still young has received limited attention. There are inconsistent results in prior studies using computerized neurocognitive tests however the TMT assesses divergent neurological systems including working memory, horizontal and vertical saccades, attention, cognitive processing, and executive function. While the TMT has routinely identified deficits acutely post-concussion, the long-term effect of prior concussions has not been established.

Design/Methods: This study utilized a cross-sectional design of 50 current intercollegiate division I athletes (56% female, age: 19.8 ± 1.3 y.o.). Participants completed a reliable concussion history questionnaire as well as the TMT-A and TMT-B on an iPad at baseline. The independent variable was concussion history and the dependent variables were total time on TMT-A and TMT-B which were compared by independent samples t-tests or Mann-Whitney U test.

Results: Of the 50 student athletes 26 (52%) reported at least one previously diagnosed concussion. There was no significant difference between groups for the TMT-A (No prior concussion: 22.9 + 6.1 sec and Concussion history: 19.7 + 4.1, U=227.0, p=0.10) or TMT-B (No prior concussion: 42.1 + 13.2 sec and concussion history: 38.1 + 11.3, t=1.17, p=0.25).

Conclusions: The results of this study suggest that while still in college, a history of one or more prior concussions, did not adversely affect neurocognitive performance on either the TMT-A or B test. As concussion history is sometimes associated with later life neurocognitive performance, future studies should assess TMT-A and B across the lifespan.

Study Supported By:

Disclosure: Dr. Fasoranti has nothing to disclose. Dr. Enrique has nothing to disclose. Dr. Hunzinger has nothing to disclose. Dr. Bryk has nothing to disclose. Dr. Kaminski has nothing to disclose. Dr. Buckley has nothing to disclose.
Handball concussion case series in a Brazilian Team

Authors: Carlos Pinheiro

Objective: To analyze the history of self-reported head impacts, prevalence of post-concussion symptoms and performance in motor coordination tests in amateur handball athletes.

Background: Handball is a contact sport where athletes can suffer collisions through different mechanisms and there are few published data about brain concussion in handball, mainly in Brazilian athletes.

Design/Methods: Amateur male athletes aged between 18 and 35 years, with 4 to 6 hours of training per week and an average of 12.5 games in the last 6 months were evaluated regarding to the head impact history during handball games and practices. The athletes were also evaluated regarding of the most common kind of impact mechanism, loss of consciousness (LOC), reported cervical injury (pain and decreased range of motion), symptoms prevalence and their severity using the Post Concussion Symptom Scale (PCSS), time to execution of single-task tandem gait (TG) and performance in the Finger-to-Nose test (> 4 seconds to perform five successive finger to nose repetitions was considered abnormal).

Results: Six athletes reported direct impacts on the head while playing handball. Falls, elbow to the head, trunk to the head and hit by the ball were the most reported mechanisms of head impact in handball athletes. Two athletes reported LOC and all of them denied cervical injury after trauma. Regarding the PCSS score, three athletes had a score between 6-21 and five athletes had a 22-84 score. The most reported symptoms were sleeping more than usual, drowsiness, fatigue, changes in behavior (nervousness, feeling more emotional and irritability), trouble falling asleep and dizziness. However, athletes shown a normal performance in the single task TG (14.6-17.2 seconds) compared to normative data and three athletes shown altered performance on the Finger-to-Nose test.

Conclusions: Amateur handball athletes had significant scores of PCSS mainly related to sleep, emotional and possibly to the vestibular function.

Study Supported By:

Disclosure: Dr. Pinheiro has nothing to disclose.
Creation of the Argentina- Sports Concussion Assessment & Research Study (Arg-SCARS)

Authors:
Maria Julieta Russo, MD, Fernando Salvat, Gustavo Sevlever

Objective: To investigate how and why, over time, rugby union players might vary in their cognitive and behavioral functioning, whilst exploring modifying and contributing factors for the development of clinical symptoms and problems in association with repetitive neurotrauma.

Background: There is an urgent need for an improved understanding of the relationship between repetitive sports concussion and cognitive decline risk given that sports concussion prevention may plausibly impact upon neurodegeneration prevention. The Argentina- Sports Concussion Assessment & Research Study (Arg-SCARS) aims to explore the association between sports concussion and cognitive function over time in two cohorts of participants: active and retired rugby players.

Design/Methods: The Arg-SCARS is a longitudinal, prospective, naturalistic (nontreatment) study of rugby union players. It will be conducted in one Institute for Neurological Research (FLENI) in Buenos Aires, Argentina. The "active rugby players cohort" will consist of approximately 100 men aged between 18 and 35 years. The "retired rugby players cohort" will consist of at least 140 men aged between 35 and 65 years. All participants will be evaluated in a uniform manner at entry and longitudinally thereafter with instruments that include a clinical and neuropsychological test battery, biological fluids collection, and structural neuroimaging. In those with and without sports concussion, cognitive and behavioral functioning will be assessed at biannual intervals for 12-year follow-up.

Results: Outcome Measures will include: 1) rate of change for each cognitive and behavioral marker; 2) rate of volume change of whole brain, hippocampus, and entorhinal cortex; 3) rates of change for each biological marker; 4) group differences for each cognitive and biological marker measurement; 5) assessing interrelationships among cognitive and biological markers.

Conclusions: The findings of this study will provide us with greater insights and therefore better understanding of how repetitive head trauma influence rugby union player’s risk of getting cognitive impairment later on in life.

Study Supported By:

Disclosure:
Dr. Russo has nothing to disclose. Dr. Salvat has nothing to disclose. Dr. Sevlever has nothing to disclose
Effects of Persistent Concussion Symptoms on Executive Function in Working-aged Adults using a Novel Sensorimotor Assessment Tool.

Authors: Kelsey Bryk, MSc, Thomas A. Buckley, PhD

Objective: To examine neurocognitive performance of persistent concussion symptom patients using a novel sensorimotor technology.

Background: In patients with persistent concussion symptoms, neurocognitive deficits have been routinely identified; however, most of the current literature focuses on athletes and military veterans. Middle aged community members face unique challenges related to jobs, family, and transportation which can all be adversely affected by neurocognitive deficits.

Design/Methods: Thirteen adults (44.3±12.6 years) with self-reported persistent concussion symptoms (PCS) at least 3 months post-injury, and thirteen sex and age matched healthy controls (37.5±8.8 years) were recruited. Participants performed the Trail-Making Test A (TMT-A) and Trail-Making Test B (TMT-B) on a novel sensorimotor assessment tool, the KINARM (BKIN Technologies, Kingston, ON, Canada). Using their dominant hand, TMT-A required participants to connect numbered dots in ascending order as quickly as possible. TMT-B required connecting dots with either a number or letter inside, in an alternating number-letter fashion (i.e.: 1-A-2-B-3-C…). Total number of symptoms and a symptom severity score were assessed using the Rivermead Post Concussion Symptoms Questionnaire (RPQ). An independent samples t-test was used to analyze group differences of total time to completion, dwell time, and number of errors.

Results: As expected, PCS patients had a significantly higher number of symptoms and severity score (PCS: 13.4±2.3 and 36.2±14.5, respectively; Controls: 3.4±3.7 and 5.3±5.6, respectively, p<.001). PCS patients were significantly slower on TMT-A (46.3±20.1 sec; and 34.7±6.5 sec respectively, p=.047). There were no group differences in TMT-B.

Conclusions: Our results suggest that neurocognitive function may remain unaffected by persistent concussion symptoms in working-aged adults. The lack of task performance differences may be a result of neurocognitive function recovery, or the need for a more sensitive task to assess neurocognitive function in this population.

Study Supported By:

Disclosure: Dr. Bryk has nothing to disclose. Dr. Buckley has nothing to disclose.
Hyperhomocysteinemia: A Risk Factor for Cognitive Decline in mTBI Patients

Authors:
Suresh Kumar, MD

Objective: Our quest was to find an answer for “Why are some people able to recover 100% from a concussion/traumatic brain injury while others tend to have prolonged symptoms after their concussion/traumatic brain injury?”

Background: The prevalence of hyperhomocysteinemia in general is 5% - 7% with increasing evidence showing higher prevalence of HHcy as age increases. The prevalence of vitamin D deficiency was 41.6% in the American population. The prevalence of vitamin B-12 deficiency is at least 40% in the patients of the Americas. With recent data, the prevalence of magnesium deficiency is around 10% - 30% of the population. Hyperhomocysteinemia due MTHFR gene mutation B-12, B-6, magnesium, and folic acid deficiency is well established.

Design/Methods: A retrospective study involving 45 patients was conducted in order to correlate the persistent symptoms concussion head injury/traumatic brain injury and their bio nutraceutical deficiency

Results: This data provides evidence that a patient’s Homocysteine levels are significantly linearly related with their MoCA scores (t = -5.837, df = 34, p-value = 1.403e-06, [95% CI: -0.8406114, -0.4936554]). In the mTBI group, for every 1 umol/L increase in Homocysteine levels, there is a 0.54217 decrease in MoCA scores. mTBI patients that had Homocysteine levels greater than 14 umol/L were 76% more likely to experience cognitive decline. The mean MoCA score of mTBI patients is significantly lower than the mean MoCA score of patients in the control group (t = -3.2898, df = 67, p-value = 0.0016, [95% CI: -6.710893, -1.642642]). The mean Homocysteine levels of mTBI patients are significantly greater than the mean Homocysteine levels of patients in the control group (t = 2.2182, df = 85, p-value = 0.0292, [95% CI: 0.3039847, 5.5603010]).

Conclusions: mTBI patients should be routinely screened for serum homocysteine, vitamin D, B12, B6 and magnesium levels to know their risk for cognitive decline.

Study Supported By:

Disclosure:
Dr. Kumar has nothing to disclose.
Inpatient infusion treatments of headache in patients with chronic migraine and a reported history of head trauma and endocrine co-morbidities.

Authors: Nina Yakovlevna Riggins, MD, Henna Sawhney, MBBS, Annika Ehrlich, NP, Mira Parekh, Morris Levin, MD, FAAN

Objective: To evaluate if inpatient infusion treatments for patients with chronic migraine (CM) and history of head trauma and endocrine abnormalities can lead to headache improvement.

Background: Many patients with CM and history of head trauma have endocrine co-morbidities that can interfere with successful management of headache. In this study, we evaluated if inpatient infusion treatments improved headache outcomes for this patient population.

Design/Methods: Retrospective chart review of patients admitted and treated with 4-5 days of intravenous (IV) Dihydroergotamine (DHE), Chlorpromazine, or Valproate for headache.

All cases were presented at the Headache Center Case Conference before admission, and plans for addressing co-morbidities were discussed with appropriate specialists and primary care providers. Co-morbidities addressed included diabetes mellitus, pituitary and thyroid dysfunction and endometriosis.

During admission, vital signs and appropriate lab work such as serum glucose, thyroid, liver and renal function were monitored.

Lifestyle recommendations provided during admission and appropriate follow ups after discharge were arranged with Headache Clinic, primary care, and specialists, when applicable.

Results: 53 patients with CM were included in the analysis.

12 (22.6%) of the 53 patients had both reported history of head trauma and endocrine comorbidity. Of these 12 patients, 8 (66.7%) had improvement in headache up to 6 weeks after admission. Of the 8 that improved, 6 (75%) received DHE and 2 (25%) received Chlorpromazine.

Conclusions: Inpatient infusion treatments for patients who have CM with history of head trauma and endocrine abnormalities can lead to headache improvement, potentially due to IV infusion therapy along with holistic approaches which include addressing co-morbidities and education on lifestyle modifications. Future studies are needed to evaluate if specific endocrine system dysfunction can predict outcomes from repetitive infusion therapy for persistent headache in patients with CM and a reported history of head trauma.

Study Supported By:

Disclosure: Dr. Riggins has nothing to disclose. Dr. Sawhney has nothing to disclose. Dr. Ehrlich has received personal compensation for consulting, serving on a scientific advisory board, speaking, or other activities with Eli Lilly. Dr. Parekh has nothing to disclose. Dr. Levin has received compensation for speaking and or advisory board for the following entities: Ortho-MacNeil, Pfizer, Merck, Allergan Contributing author and editor for journal HEADACHE - Web Alert column. Travel to meetings supported by my employer -
Dartmouth Hitchcock Medical Center and the Headache Cooperative of New England (both academic, non-commercial organizations). I have also been a co-investigator for a research project supported by Allergan.
 Persistent Visual and Vestibular Impairments for Postural Control Following Concussion

Authors:
Jaclyn B. Caccese, PhD, Fernando Santos, PT, Felipe Yamaguchi, John Jeka, PhD

Objective: The purpose of this study was to examine sensory reweighting for upright stance in three groups (i.e. sub-acute concussion, concussion history, control).

Background: Balance impairments are common following concussion; however, the physiological mechanisms underlying these impairments are not well understood.

Design/Methods: There were 13 participants (8 women, 21± 3 years) between 2 weeks and 6 months post-injury who reported being asymptomatic at the time of testing (i.e. sub-acute concussion group), 13 participants (8 women, 21± 1 years) with a history of concussion (i.e. concussion history group, >1 year following concussion), and 26 participants (8 women, 22± 3 years) with no concussion history (i.e. control group). We assessed sensory reweighting by simultaneously perturbing participants’ visual, vestibular, and proprioceptive systems. The visual stimulus was a sinusoidal translation of the visual scene at 0.2Hz, the vestibular stimulus was ± 1mA binaural monopolar galvanic vestibular stimulation (GVS) at 0.36Hz, and the proprioceptive stimulus was Achilles’ tendon vibration at 0.28Hz. The visual stimulus was presented at two different amplitudes (low vision=0.2m, high vision=0.8m). We computed center of mass gain to each modality.

Results: The sub-acute concussion group (95% confidence interval=.078-.115, p=.001) and the concussion history group (95% confidence interval=.056-.094, p=.038) had higher gains to the visual stimulus than the control group (95% confidence interval=.040-.066). The sub-acute concussion group (95% confidence interval=.795-1.159, p=.002) and the concussion history group (95% confidence interval=.633-1.012, p=.018) had higher gains to the vestibular stimulus than the control group (95% confidence interval=.494-.752). There were no group differences in gains to the proprioceptive stimulus and there were no group differences in sensory reweighting.

Conclusions: Following concussion, participants responded more strongly to visual and vestibular stimuli during upright stance, suggesting they may have abnormal dependence on visual and vestibular feedback. These findings may indicate an area for targeted rehabilitation interventions.

Study Supported By:

Disclosure:
Dr. Caccese has nothing to disclose. Dr. Santos receives personal compensation from Bertec Corporation for employment, consulting, serving on a scientific advisory board, speaking, or other activities. Dr. Yamaguchi has nothing to disclose. Dr. Jeka has nothing to disclose.
Compromised Resting Cerebral Metabolism After Sport-Related Concussion: A Calibrated MRI Study

Authors:
Allen Anthony Champagne

Objective: Use calibrated MRI to model baseline cerebrovascular physiology parameters and investigate whether changes in resting cerebral blood flow (CBF0) following sport-related concussion (SRC) are concordant with changes in resting and dynamic cerebral physiological markers, within two weeks of the injury.

Background: Altered CBF0 in the acute phase post-concussion may contribute to neurobehavioral deficiencies, often reported weeks after the injury. However, in addition to changes in CBF0, little is known about other physiological mechanisms that may be disturbed within the cerebrovasculature. The aim of this study was to assess whether changes in baseline perfusion following SRC were co-localized with changes in cerebral metabolic demand.

Design/Methods: Forty-two subjects (15 SRC patients 8.0 ± 4.6 days post-injury and 27 age-matched healthy control athletes) were studied cross-sectionally. CBF0, cerebrovascular reactivity (CVR), resting oxygen extraction (OEF0) and cerebral metabolic rate of oxygen consumption (CMRO2|0) were measured using a combination of hypercapnic and hyperoxic breathing protocols, and the biophysical model developed in calibrated MRI. Blood Oxygenation Level Dependent and Arterial Spin Labelling data were acquired simultaneously using a dual-echo arterial spin labelling sequence.

Results: SRC patients showed significant decreases in CBF0 spread across the grey-matter (P < 0.05, corrected), and these differences were also confounded by the effects of baseline end-tidal CO2 (P < 0.0001). Lower perfusion was co-localized with reductions in regional CMRO2|0 (P = 0.006) post-SRC, despite finding no group-differences in OEF0 (P = 0.800). Higher CVR within voxels showing differences in CBF0 was also observed in the SRC group (P = 0.001), compared to controls.

Conclusions: Reductions in metabolic demand despite no significant changes in OEF0 suggests that hypoperfusion post-SRC may reflect compromised metabolic function after the injury. These results provide novel insight about the possible pathophysiological mechanisms underlying concussion that may affect the clinical recovery of athletes after sport-related head injuries.

Study Supported By:

Disclosure: Dr. Champagne has nothing to disclose.
Heart rate variability interacts with recovery of resting-state connectivity in amygdala circuitry and the persistence of symptoms after sport-related concussion

Authors:
Kevin Bickart, Christopher Sheridan, CSCS, Corey M. Thibeault, PhD, Robert Hamilton, PhD, James LeVangie, Christopher Giza, MD, FAAN, Meeryo Choe, MD, FAAN

Objective: We investigated longitudinal trajectories of resting-state fMRI (rsfMRI), autonomic function, and graded symptoms after sport-related concussion (SRC).

Background: Limbic circuitry may be particularly vulnerable to traumatic brain injury, which could explain the affective and autonomic dysfunction that some patients develop. Relatively few studies have performed longitudinal rsfMRI analyses in concussion and fewer have combined imaging with autonomic and symptom data. We leveraged published limbic rsfMRI networks centered on the amygdala that include core affective and autonomic structures to test whether athletes with SRC would have altered connectivity, and that network recovery would be related to measures of autonomic function and symptom persistence.

Design/Methods: We compared rsfMRI connectivity of amygdala networks in college athletes with SRC (N=31, female=14) at three time points after concussion (T1=4 days, T2=10-14 days, T3=2-3 months) and matched controls with no concussion (in-sport control [ISC] N=36, female=17).

Results: SRCs show greater amygdala network connectivity as compared to ISCs (T1 p=0.003, T2 p=0.014) that normalizes over time (T3 p=0.182). However, SRCs with higher versus lower heart rate variability (HRV), as measured by pNN50 at T1, have opposing trajectories of connectivity. That is, SRCs with higher HRV have connectivity that starts high and normalizes over time (T1 p=0.001, T2 p=0.055, T3 p=0.576) whereas SRCs with lower HRV have connectivity that increases over time (T1 p=0.429, T2 p=0.050, T3 p=0.002). Furthermore, SRCs with greatest connectivity at T3, presumably the least recovered, have the most symptoms on the Graded Symptom Checklist at ~3 months (r=0.635, p=0.001).

Conclusions: Heightened connectivity of amygdala circuitry acutely after a concussion and its normalization over time may be protective, and with HRV, may be a biomarker of symptom persistence.

Study Supported By:

Disclosure:
Dr. Bickart has nothing to disclose. Dr. Sheridan has nothing to disclose. Dr. Thibeault has nothing to disclose. Dr. Hamilton has nothing to disclose. Dr. LeVangie has nothing to disclose. Dr. Giza has nothing to disclose. Dr. Choe has nothing to disclose.
Concussion Causing Transient Global Amnesia: Further Insights Into Pathophysiology?

Authors:
Mohammed Wasif Hussain, MD

Objective: To review a rare presentation of Transient Global Amnesia (TGA) in context of concussion with reversible imaging findings.

Background: TGA is characterized by sudden temporary loss of anterograde memory accompanied by repetitive questioning without focal neurologic deficits. While risk factors of age above 50 and migraines remain constant, a clear cause is unknown. The association between TGA and concussion is not well defined beyond 2 case reports in the literature. We review the existing literature and examine a case of TGA in temporal relationship to mild traumatic brain injury (mTBI) or concussion.

Design/Methods: Case Report

Results: A healthy 38-year-old male with no prior concussions or headaches, sustained a concussion after falling backward on pavement. He presented to the emergency room with retrograde amnesia of events 1 hour prior to his injury with subsequent anterograde amnesia. His exam demonstrated normal language and speech and no other focal neurological deficits. He was diagnosed with TGA with symptoms lasting for 16 hours before fully resolving. Approximately 24 hours after his injury, he developed a migraine headache and tinnitus that was worse with exertion, lasting for roughly 12 hours. His initial CT head while symptomatic demonstrated an area of hypodensity within the left anterior temporal lobe. 2 days after his presentation, he had an MRI with DWI/SWI as well as an EEG, all of which were completely normal, with complete resolution of the finding on CT. He had no further symptoms after his headache resolved and no recurrence of TGA after 12 months follow-up.

Conclusions: TGA presenting after a concussion has rarely been reported. We report such a case with imaging findings present during the acute phase that were not present on subsequent MRI suggesting possible reversible vasogenic edema. This may provide insights into the pathophysiology of TGA in this population.

Study Supported By:

Disclosure:
Dr. Hussain has nothing to disclose.
Incidence and Patterns of Menstrual Irregularities in Pediatric Patients After Concussion

Authors:
Emily Bateman, Mohammad Mortazavi, MD

Objective: Determine the incidence and patterns of menstrual irregularities in pediatric patients after a concussion and whether this is associated with prolonged recovery time.

Background: Abnormal menstrual patterns have been observed in women following a traumatic brain injury, which may be the result of disruption in the hypothalamic-pituitary-ovarian axis. The incidence and clinical significance of menstrual irregularities (MI) in pediatric patients after concussion is not well understood.

Design/Methods: A retrospective cohort chart review of female pediatric (11-20 years of age) concussion patients (n=97). Questionnaire survey provided at each visit. The survey asked for number of years since first menses, hormonal contraceptive use, if any MI since the concussion, and type of MI if applicable. Data collected from 11/1/2018 to 5/30/2019. Patients with menarche less than 2 years and/or had experienced irregularities prior to concussion were excluded from study.

Results: MI was reported in 26.8% of pediatric patients. The majority of pediatric cases with MI were between the ages of 16 and 20 (73.1%). 84.6% of pediatric patients with reported MI had prolonged post concussive symptoms (PPCS). Other self-reported irregularities included painful dysmenorrhea, more frequent cycles in a short amount of time, or menstruation after prolonged period of amenorrhea due to hormonal contraceptive use.

Recovered pediatric patients with reported MI had an average recovery time of 142 days, while recovered pediatric patients without reported MI had an average of 133 days of recovery time, which was not statistically significant (p = 0.825).

Conclusions: Menstrual irregularities are common after pediatric concussions and most common in the PPCS population with the highest rates in the older adolescent (16-20) age group. MI may be an important predictor of PPCS and should be reviewed by clinicians in the setting of head trauma. Recovery time after pediatric concussion was longer in the recovered menstrual irregularity group but was not statistically significant.

Study Supported By:

Disclosure:
Dr. Bateman has nothing to disclose. Dr. Mortazavi has nothing to disclose.
Do Learning Disorders Impact Clinical Measures Following Concussion?

Authors:
Mathew Stokes, MD, Munro Cullum, PhD

Objective: Evaluate differences in clinical testing following concussion between adolescents with no history of learning disorder (LD) and those with a history of dyslexia and/or ADD/ADHD.

Background: Learning disorders, such as ADHD, can affect ImPACT® baseline neurocognitive testing. The effect that ADHD has on other clinical measures is less well understood. Additionally, limited data exists on the effect of dyslexia on these measures.

Design/Methods: Data were prospectively collected from participants enrolled in the North Texas Concussion Registry (ConTex). Participants ages 10-18 years old, diagnosed with a concussion sustained within 30 days of enrollment were included and assessed for self-reported history of LD type (dyslexia and/or ADD/ADHD). Clinical findings examined included symptom scores (derived from SCAT5™), ImPACT®, King-Devick (KD) test, patient health questionnaire 8(PHQ-8) scores, and generalized anxiety disorder 7(GAD-7) scores. Mann-Whitney tests were used to compare groups.

Results: In total, 1298 participants were included: 58 with dyslexia, 158 with ADD/ADHD, 35 with both (dyslexia and ADD/ADHD), and 1047 with no LD. There was no difference in age, sex, time since injury, or history of concussion apart from the ADD/ADHD group, which had more males(P<.001).

The dyslexia group had slower mean KD time (P=.011) and increased error scores (P=.028). In those with ADD/ADHD, impulse control scores on ImPACT® were significantly higher (P=.007), but no other ImPACT® score differences reached significance. PHQ-8 and GAD-7 scores were significantly higher in those with ADD/ADHD (P<.001). Participants with both dyslexia and ADHD demonstrated slower KD times (P=0.009) and had higher PHQ-8 (P<.001) and GAD-7 (P=.001) scores.

Conclusions: Participants with dyslexia and/or ADD/ADHD had worse scores on commonly used concussion clinical measures including ImPACT® impulse control, KD testing, and depression and anxiety screenings. Understanding the differences in these groups will aid providers in their evaluation and assist in counseling families regarding the injury.

Study Supported By:

Disclosure:
Dr. Stokes has nothing to disclose. Dr. Cullum has nothing to disclose.
Age of First Concussion and Cognitive, Psychological, and Physical Outcomes

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Objective: This study examined the association between age of first concussion (AFC) and neurocognitive performance, psychological distress, postural stability, and concussion symptoms in healthy collegiate student athletes.

Background: Concussions are common among youth athletes, yet the long-term clinical consequences are largely unknown. We hypothesized that earlier AFC (younger age at first injury) would be associated with worse clinical outcomes.

Design/Methods: Participants included 4,267 collegiate athletes with a positive concussion history from various contact, limited-contact, and non-contact sports (1,818 women and 2,449 men) who completed baseline assessments as part of the Concussion Assessment, Research and Education (CARE) Consortium. Self-reported AFC included both sport- and non-sport-related concussions. Participants completed the Brief Symptom Inventory-18 (assessing psychological distress), the Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT, assessing neurocognitive performance and symptoms), the Sport Concussion Assessment Tool symptom evaluation, and the Balance Error Scoring System (assessing postural stability). Generalized linear models were implemented for men and women separately to examine the effects of AFC on clinical outcomes.

Results: Median time from AFC to assessment was four years. After correcting for multiple comparisons, earlier AFC was associated with greater somatic (Exp(B)=0.96, P=0.001) and global (Exp(B)=0.96, P<0.001) psychological distress on the Brief Symptom Inventory-18, and slower ImPACT reaction time (B=-0.003, P=0.001) in women. After correcting for multiple comparisons, AFC was not associated with any clinical outcomes in men.

Conclusions: Earlier AFC appears to have some long-term clinical consequences in women but not men, which is consistent with work suggesting that women report greater overall symptoms than men following concussion. These results underscore the importance of minimizing the risk of and properly managing concussions in youth sports, as they may have lasting effects. Future work should examine mechanisms of the AFC sex effects as well as longer-term clinical outcomes in middle and older adulthood.

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