Persistent Symptoms after Concussion: A Neuropsychiatric Perspective

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Disclosure

• The faculty have been informed of their responsibility to disclose to the audience if they will be discussing off-label or investigational use(s) of drugs, products, and/or devices (any use not approved by the US Food and Drug Administration).

• Applicable CME staff have no relationships to disclose relating to the subject matter of this activity.

• This activity has been independently reviewed for balance.
Disclosure

I’m risk adverse
Never played contact sports
Neither of my 2 sons played contact sports
Never had a concussion
Stopped biking
Additional Learning Points

• Learn the essential elements of the physical evaluation of concussion
• Objectively evaluate the concerns of CTE and dementia after TBI

CTE = chronic traumatic encephalopathy; TBI = traumatic brain injury.
Steve, a 30-year-old American, has been described by a former neighbor as follows: “Steve is very shy and withdrawn, invariably helpful, but with little real interest in people or the social world. A neat and tidy soul, he has a need for order and structure and a passion for detail.”

Which occupation is Steve more likely to have?

A. Salesman

B. Librarian

The Problem

• Concussion (mTBI) is common
• Vast majority fully recover after a single event
  – (This does not mean the brain has returned to “normal”)
• “Miserable minority” have prolonged symptoms
• Why?

mTBI = mild TBI.
<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Traumatically induced* physiologic disruption of brain function, as manifested by at least one of the following:</td>
<td>An occurrence of injury to the head that is documented in a medical record, with one or more of the following conditions attributed to head injury:</td>
<td>Traumatically induced structural injury and/or physiological disruption of brain function as a result of an external force† that is indicated by new onset or worsening of at least one of the following clinical signs, immediately following the event:</td>
<td>An alteration in brain function, or other evidence of brain pathology*, caused by an external force*. Alteration in brain function is defined as one of the following clinical signs:</td>
</tr>
<tr>
<td>Any period of loss of consciousness</td>
<td>Observed or self-reported (partial or complete) decreased level of consciousness</td>
<td>Any period of loss or a decreased level of consciousness</td>
<td>Any period of loss of or decreased level of consciousness</td>
</tr>
<tr>
<td>Any loss of memory for events immediately before or after the accident</td>
<td>Amnesia (i.e., loss of memory for events immediately preceding the injury, for the injury event itself, and for events subsequent to the injury)</td>
<td>Any loss of memory for events immediately before or after the injury (posttraumatic amnesia)</td>
<td>Any loss of memory for events immediately before (retrograde amnesia) or after the injury (posttraumatic amnesia)</td>
</tr>
<tr>
<td>Any alteration in mental state at the time of the accident (e.g., feeling dazed, disoriented, or confused)</td>
<td>Objective neuropsychological abnormality*</td>
<td>Any alteration in mental state at the time of the injury (confusion, disorientation, slowed thinking, etc.) (Alteration of consciousness/mental state)</td>
<td>Any alteration in mental state at the time of the injury (confusion, disorientation, slowed thinking, etc.)</td>
</tr>
<tr>
<td>Focal neurologic deficit(s) that may or may not be transient</td>
<td>Objective neurological abnormality</td>
<td>Neurologic deficits (weakness, loss of balance, change in vision, praxis, paresis/plegia, sensory loss, aphasia, etc.) that may or may not be transient</td>
<td>Neurologic deficits (weakness, loss of balance, change in vision, dyspraxia, paresis/plegia [paralysis], sensory loss, aphasia, etc.)</td>
</tr>
<tr>
<td></td>
<td>Diagnosed intracranial lesion†</td>
<td>Intracranial lesion</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Skull fracture</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

CDE = common data elements; PH = psychological health.  
Severity of Injury

- Glasgow Coma Scale
- Duration of LOC
- PTA
- Retrograde Amnesia

LOC = loss of consciousness; PTA = post-traumatic amnesia.
### Definitions of Severity

<table>
<thead>
<tr>
<th></th>
<th>Mild</th>
<th>Severe</th>
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<tbody>
<tr>
<td><strong>LOC</strong></td>
<td>&lt; 30 minutes</td>
<td>&gt; 1 week</td>
</tr>
<tr>
<td><strong>GCS</strong></td>
<td>13–15</td>
<td>&lt; 10</td>
</tr>
<tr>
<td><strong>PTA</strong></td>
<td>&lt; 24 hours</td>
<td></td>
</tr>
<tr>
<td><strong>Hospitalization</strong></td>
<td>None or brief</td>
<td>Weeks–Months</td>
</tr>
<tr>
<td><strong>Residual def</strong></td>
<td>None or few</td>
<td>Prominent</td>
</tr>
<tr>
<td><strong>Imaging</strong></td>
<td>“Complicated mild”</td>
<td></td>
</tr>
</tbody>
</table>

*GCS = Glasgow Coma Scale.*
Animal Research Described the Metabolic Cascade and Physiologic Changes

The Best of All Possible Worlds
(and why did we start to study sports concussions, anyway?)

Figure. Symptom, Cognitive, and Postural Stability Recovery in Concussion and Control Participants

Higher scores on the Graded Symptom Checklist (GSC) indicate more severe symptoms; lower scores on the Standardized Assessment of Concussion (SAC) indicate poorer cognitive performance; and higher scores on the Balance Error Scoring System (BESS) indicate poorer postural stability. Error bars indicate 95% confidence intervals. CC indicates time of concussion; PG, postgame/postpractice. On the BESS, multiple imputation was used to estimate means and 95% confidence intervals for control participants for the CC and PG assessments.

TRACK-TBI Study Data

- High percentage of symptom distress
- At both 6 and 12 months ...

<table>
<thead>
<tr>
<th>Outcome and time</th>
<th>Mean (SD)</th>
<th>% with clinically poorer outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>GOSE at 3 months</td>
<td>6.9 (1.1)</td>
<td>33.2</td>
</tr>
<tr>
<td>GOSE at 6 months</td>
<td>6.9 (1.0)</td>
<td>33.8</td>
</tr>
<tr>
<td>GOSE at 12 months</td>
<td>7.1 (1.0)</td>
<td>22.4</td>
</tr>
<tr>
<td>BSI-18 at 6 months</td>
<td>55.6 (10.7)</td>
<td>29.6</td>
</tr>
<tr>
<td>BSI-18 at 12 months</td>
<td>51.8 (11.1)</td>
<td>21.1</td>
</tr>
<tr>
<td>SWLS at 6 months</td>
<td>20.3 (8.0)</td>
<td>44.5</td>
</tr>
<tr>
<td>SWLS at 12 months</td>
<td>22.0 (8.2)</td>
<td>40.3</td>
</tr>
<tr>
<td>RPQ-13 at 6 months</td>
<td>14.6 (12.2)</td>
<td>n/a</td>
</tr>
<tr>
<td>RPQ-13 at 12 months</td>
<td>11.7 (11.3)</td>
<td>n/a</td>
</tr>
</tbody>
</table>

Mean (SD) scores reflect only those patients with data available for all applicable follow-up times. Percent scores include the total number of patients at each follow-up time. TRACK-TBI = Transforming Research and Clinical Knowledge in Traumatic Brain Injury; GOSE = Glasgow Outcome Scale-Extended; BSI = Brief Symptom Inventory; SWLS = Satisfaction With Life Scale; RPQ = Rivermead Post-Concussion Questionnaire; SD = standard deviation; n/a = not available.

Self-Reported Prognosis

- Symptoms are not specific
- Poor recovery associated with poorer premorbid mental and physical health, and more injury-related stress
- Persistent symptoms more likely in those with more acute symptoms and more emotional distress
Persistent Symptoms after Trauma
• Was there a TBI?
• What are the symptoms?
• What is causing the symptoms?
• Physical examination
• Treatment
• Role of imaging
Case 1

- A 25-year-old man complains of having been in a car accident 3 months before and now has problems with concentration, energy, and sleep.
- He says that he stopped short at a light and was told that a large truck ran into him. He does not remember the collision and the first memory he has is of waking up in the ER 1 hour later.
  - Was there a TBI?
  - How long was LOC or PTA?
  - What was the severity?

ER = emergency room.
Case 2

• 20-year-old female college student hit the right side of her head on the side of the door in the morning. She experienced severe pain on the right side of her head. She has full recall, and denies being stunned, dazed, or confused.

• Activities the remainder of the day: Went to class, was busy went to dinner, and went dancing that night.

• The next morning she woke up groggy and felt like crying without reason.

  – Was there a TBI?
What is causing the symptoms?

- Psychiatric
- Physical
- Psychological
- Legal, insurance
- Effort
Case 3

• 40-year-old woman driving a car with her 1-year-old daughter in a car seat in the back. In a “very serious car accident.” Her car was rear-ended while stopped. She went into oncoming traffic and spun around and crashed into “something hard and powerful”

• She thought, “Oh my god, my head.” She called her husband on the telephone. No recall of getting out of the car, but relates moment to moment details of events

• Complains of dizziness, trouble focusing, tired, sensitive to noise and light, poor sleep, poor memory, irritable, tearful, flashbacks, replaying accident
TBI and Psychiatric Diagnosis

- Common occurrence in multiple samples
- Do psychiatric disorders increase the risk of a TBI?
- Do psychiatric disorders affect TBI symptoms and outcome?

Case 4

- 19-year-old female college student, hit the left side of her face on a door
- Recalls hitting the door, but felt dazed for a couple of minutes
- Back of her head kept hurting, sensitive to light, “off balance”
- Uncomfortable with upgaze, neck several tender spots
Persistent Symptoms after Concussion
Are they physical?

- Headaches/migraine
- Neck/proprioception
- Vision
- Dizziness
- Insomnia
- Pain
- Seizures
- Hormonal

Multidisciplinary Assessment and Treatment

There are **Signs** as well as **Symptoms**
Concussion Produces Alterations in the ANS

- Dysregulation of CBF
  - Decreased at rest
  - Increased during exercise
- Higher resting HR at rest
- Decreased HRV at rest
- Decreased HR during exercise
  - Sympathetic at rest (difficulty attaining a parasympathetic state)
  - Parasympathetic influence during exercise

ANS = autonomic nervous system; CBF = cerebral blood flow; HR = heart rate; HRV = heart rate variability.
Cardiovascular Dysfunction during Exercise in Adolescents

For both HR and RPE, time and group were significant ($P<.05$) and a group-time interaction effect was significant for RPE ($P<.05$)

5 days after SRC (Acute) and at 14 days (Recovered), N=27. SRC = sports-related concussion; RPE = rating of perceived exertion. Hinds A, et al. *J Neurol Neurophysiol*. 2016;7(4).
Brain or Strain? Symptoms Alone Do Not Distinguish Physiologic Concussion From Cervical/Vestibular Injury


Objective: To compare symptoms in patients with physiologic postconcussion disorder (PCD) versus cervicogenic/vestibular PCD. We hypothesized that most symptoms would not be equivalent. In particular, we hypothesized that cognitive symptoms would be more often associated with physiologic PCD.

Design: Retrospective review of symptom reports from patients who completed a 22-item symptom questionnaire.

Setting: University-based concussion clinic.

Patients: Convenience sample of 128 patients who had symptoms after head injury for more than 3 weeks and who had provocative treadmill exercise testing.

Independent Variables: Subjects were classified as either physiologic PCD (abnormal treadmill performance and a normal cervical/vestibular physical examination) or cervicogenic/vestibular PCD (CGV, normal treadmill performance, and an abnormal cervical/vestibular physical examination).

Main Outcome Measures: Self-reported symptoms. Univariate and multivariate methods, including t tests, tests of equivalence, a logistic regression model, k-nearest neighbor analysis, multidimensional scaling, and principle components analysis were used to see whether symptoms could distinguish PCD from CGV.

Results: None of the statistical methods used to analyze self-reported symptoms was able to adequately distinguish patients with PCD from patients with CGV.

Conclusions: Symptoms after head injury, including cognitive symptoms, have traditionally been ascribed to brain injury, but they do not reliably distinguish between physiologic PCD and cervicogenic/vestibular PCD. Clinicians should consider specific testing of exercise tolerance and perform a physical examination of the cervical spine and the vestibular/ocular systems to determine the etiology of post-concussion symptoms.

Clinical Relevance: Symptoms after head injury, including cognitive symptoms, do not discriminate between concussion and cervical/vestibular injury.

Key Words: concussion, cervical, symptoms, vestibular, strain

INTRODUCTION

Sport-related concussion (SRC) is defined by the 2012 Zurich Consensus Statement on Concussion in Sport as "a complex pathophysiologic process affecting the brain, induced by biomechanical forces... which may be caused either by a direct blow to the head, face, neck, or elsewhere on the body with an "impulsive" force transmitted to the head." Rather than constituting a single entity, however, concussion is a heterogenous disorder that can be modified by factors such as genetics, age, gender, premorbid illness, and symptom burden. Because there is no gold standard diagnostic test, concussion is a clinical diagnosis based on a combination of physical signs and subjective, cognitive, and neurobehavioral symptoms that typically diminish over a matter of several days to weeks. Approximately 10% of concussed athletes, however, experience prolonged signs and symptoms of concussion for more than 2 weeks.

Symptoms after head injury may not be specific to the brain. Leslie and Cranton recently hypothesized that concussion is really a syndrome that does not require brain involvement in all cases and that concussion symptoms can emanate from the cervical spine. Concomitant injury to the cervical spine resembling whiplash may occur as a result of the acceleration-deceleration forces sustained in concussive trauma. Structural and functional injury to the cervical spine can be associated with prolonged symptoms such as headache, dizziness, blurred vision, and vertigo. Cognitive complaints, including poor concentration and memory deficits, have also been reported after whiplash injury. Symptoms such as headache, dizziness, poor memory, and vertigo may therefore result either from a brain injury, from injury to the cervical spine, or from injury to both. As a brain injury, however, it would be unreasonable to hypothesize that cognitive symptoms would reliably identify concussion from other potential symptom generators.
Cannot Use Symptoms to Diagnose Concussion

- P-PCD (n=36)
  - Headache
  - Dizziness
  - Foggy
  - Can’t concentrate

- Cervical/vestibular injury (n=92)
  - Headache
  - Dizziness
  - Foggy
  - Can’t concentrate

N=128.
P-PCD = physiologic postconcussion disorder.

No significant separation of symptoms
Important Aspects of the Physical Examination in Concussed Patients

A Practical Concussion Physical Examination Toolbox: Evidence-Based Physical Examination for Concussion

Jason M. Matuszak, MD†, Jennifer McVige, MD‡, Jacob McPherson, DPT§, Barry Willer, PhD¶, and John Leddy, MD‖
## Brief Buffalo Concussion PE

### Vital Signs

<table>
<thead>
<tr>
<th></th>
<th>0 minutes</th>
<th>1 minute</th>
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<tbody>
<tr>
<td><strong>Position</strong></td>
<td>Supine</td>
<td>Standing</td>
</tr>
<tr>
<td>Blood Pressure</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td>Heart Rate</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td>Symptoms?</td>
<td>Yes or No</td>
<td>Yes or No</td>
</tr>
</tbody>
</table>

Test results positive if: SBP drops 20 or DBP 10 mmHg (and Symptoms) + or -  or -

### Optic/Ophthalmologic Evaluation

<table>
<thead>
<tr>
<th></th>
<th>Nml</th>
<th>Abn</th>
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<tbody>
<tr>
<td>Pupil Reactivity</td>
<td>Nml</td>
<td>Abn</td>
</tr>
<tr>
<td>Visual tracking (CN III, IV, VI)</td>
<td>Nml</td>
<td>Abn</td>
</tr>
<tr>
<td>*Nystagmus (sustained)</td>
<td>Nml</td>
<td>Abn</td>
</tr>
<tr>
<td>*Smooth Pursuits</td>
<td>Nml</td>
<td>Abn</td>
</tr>
<tr>
<td>*Saccades (H&amp;V)</td>
<td>Nml</td>
<td>Abn</td>
</tr>
<tr>
<td>*VOR (CN VIII)</td>
<td>Nml</td>
<td>Abn</td>
</tr>
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</table>

### Cervical ROM

<table>
<thead>
<tr>
<th></th>
<th>Nml</th>
<th>Abn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexion (50°)</td>
<td>Nml</td>
<td>Abn</td>
</tr>
<tr>
<td>Extension (60°)</td>
<td>Nml</td>
<td>Abn</td>
</tr>
<tr>
<td>Rt lateral flexion (45°)</td>
<td>Nml</td>
<td>Abn</td>
</tr>
<tr>
<td>Lt lateral flexion (45°)</td>
<td>Nml</td>
<td>Abn</td>
</tr>
<tr>
<td>Rt rotation (80°)</td>
<td>Nml</td>
<td>Abn</td>
</tr>
<tr>
<td>Lt rotation (80°)</td>
<td>Nml</td>
<td>Abn</td>
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</table>

### Postural Control/Motor Coordination

<table>
<thead>
<tr>
<th></th>
<th>Nml</th>
<th>Abn</th>
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</thead>
<tbody>
<tr>
<td>Finger-Nose-Finger</td>
<td>Nml</td>
<td>Abn</td>
</tr>
<tr>
<td>Tandem Gait (F&amp;B)</td>
<td>Nml</td>
<td>Abn</td>
</tr>
<tr>
<td>*Romberg with VOR</td>
<td>Nml</td>
<td>Abn</td>
</tr>
</tbody>
</table>

### Cranial Nerves

<table>
<thead>
<tr>
<th>CN</th>
<th>Suggested Test</th>
<th>Nml</th>
<th>Abn</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Smell coffee grounds</td>
<td>Nml</td>
<td>Abn</td>
</tr>
<tr>
<td>V</td>
<td>Open mouth, Facial sensation</td>
<td>Nml</td>
<td>Abn</td>
</tr>
<tr>
<td>VII</td>
<td>Smile, puff cheeks, wrinkle</td>
<td>Nml</td>
<td>Abn</td>
</tr>
<tr>
<td>IX</td>
<td>Palatal elevation</td>
<td>Nml</td>
<td>Abn</td>
</tr>
<tr>
<td>X</td>
<td>Swallow</td>
<td>Nml</td>
<td>Abn</td>
</tr>
<tr>
<td>XI</td>
<td>Shoulder Shrug</td>
<td>Nml</td>
<td>Abn</td>
</tr>
<tr>
<td>XII</td>
<td>Tongue Strength</td>
<td>Nml</td>
<td>Abn</td>
</tr>
</tbody>
</table>

### Neck and/or Suboccipital Region

<table>
<thead>
<tr>
<th></th>
<th>Nml</th>
<th>Abn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spasm</td>
<td>Nml</td>
<td>Abn</td>
</tr>
<tr>
<td>Tenderness</td>
<td>Nml</td>
<td>Abn</td>
</tr>
</tbody>
</table>

### Total Abnormal Signs

*Abnormality = observable abnormal response and/or symptom provocation.

¶ Measured with an Astron ACR/21 Accommodation Rule.
COMMENTARY

Time to Change from a Symptom-based Concussion Assessment to a Structured Physical Examination
mTBI patient

Neurological Assessment (Sports Medicine or Rehab MD, Neurologist, Neurosurgeon)

Graded Treadmill Test (Exercise physiologist)

Autonomic/Physiological PCD

Sub-maximal Aerobic Exercise Prescription

Vestibulo-ocular dysfunction

Cervicogenic PTD

Targeted Vestibular Physiotherapy

Cervical Spine Physiotherapy

Post Traumatic Psychiatric Outcomes (Psychiatrist, Neuropsychologist)

Post Traumatic Migraine Headaches (Headache Neurologist)

Individualized Care

Individualized Care

• Clinical history
• Physical examination
• Rule out co-existing neurological conditions or spine injuries
• Determine need for brain or spine imaging
• Medical clearance for graded treadmill testing

Multidisciplinary Medical Clearance
Early Exercise Tolerance Testing and Early Physical Examination Findings are Useful for Prognosis after SRC

- Prospective randomized controlled trial (university and community sports medicine centers)
  - Degree of early exercise tolerance was strongest predictor of recovery: lower tolerance = longer recovery \((P=.0032)\)
  - When combined with a brief physical examination of the cervical, vestibular and oculomotor systems, good ability to predict who will recover within a week of injury

### Stepwise Percent Variation with Days to Recovery as the Outcome Variable

<table>
<thead>
<tr>
<th></th>
<th>BCTT within 4 days injury</th>
<th>Low HR Threshold (≤ 135 bpm)</th>
<th>High HR Threshold (&gt; 135 bpm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal Recovery ≤ 21 days</td>
<td></td>
<td>1</td>
<td>17</td>
</tr>
<tr>
<td>Prolonged Recovery &gt; 21 days</td>
<td></td>
<td>7</td>
<td>2</td>
</tr>
</tbody>
</table>

**BCTT** = Buffalo Concussion Treadmill Test; **bpm** = beats per minute.


Every 1 bpm increase in HR threshold resulted in a .82 day shorter recovery.
Imaging and Biomarkers for mTBI: Questions to Be Answered
You have had a concussion, and continue to have residual symptoms 3 months later. Routine CT and MRI have been normal. Your doctor orders a 3 Tesla MRI DTI, which shows several white matter abnormalities. **Do you feel:**

A. Better

OR

B. Worse
Which crowd is bigger?
Goals

• Abnormalities on routine (CT/MRI) day of injury for mTBI have prognostic significance: “Complicated mild”
• Detect neurotrauma-related brain abnormalities with high sensitivity and specificity (especially when routine imaging is unrevealing)
• Identify prognostic biomarkers (especially that predict adverse outcomes)
• Advance knowledge of task-associated brain function and dysfunction
• Effect treatment

CT = computed tomography; MRI = magnetic resonance imaging.
Issues to Be Answered

- Sensitivity and specificity
- Inconsistencies
- Uniformity of analysis
- Clinical variables
- Meaning of abnormality
  - NFL after anesthesia

Implications for Abnormal Imaging and Biomarkers

- Is not a substitute for complete physical evaluation
- Affect treatment?
  - Compare with aerobic testing
Summary

• Not ready for prime time
Treatment

- Rest?
- Exercise
- Slow breathing/HRV
- Meditation
- Treat the cause of the abnormal findings on physical examination
Benefits of Strict Rest After Acute Concussion: A Randomized Controlled Trial
darryl George McCrea, MD, MPH; Jennifer A. Rupp, PhD; Eugene J. Sills, PhD, MPH; Michael Mallek, PhD; Thomas Haines, PhD

ABSTRACT
Determine if recommending strict rest improved concussion recovery and outcome after discharge from the pediatric emergency department (ED).

METHODS Patients aged 11 to 22 years presenting to a pediatric ED within 24 hours of concussion were randomized. Participants underwent neurocognitive, balance, and symptoms assessment at the ED and were randomized to strict rest or usual care for 5 days versus usual care (1-2 days rest, followed by stepped return to activity). Participants completed a diary used to record physical and mental activity level, calculate energy expenditure, and record daily postconcussive symptoms. Neurocognitive and balance assessments were performed at 1 and 30 days postconcussion. Symptom calculation was performed to directly quantify meaningful differences in postconcussive symptoms, neurocognitive, and balance scores between treatment groups. Linear mixed modeling was used to detect contributions of group assignment to individual recovery trajectory.

RESULTS Ninety-nine patients were enrolled. CR completed all study procedures (64 intervention, 35 control). Postdischarge, both groups reported an 80% decrease in energy expenditure and activity level. As expected, the intervention group reported less school and after-school attendance for days 2 to 5 postconcussion (p = 0.07 and 6.7 hours total, p < 0.05). There was no statistically significant difference in symptoms or recovery between groups. Recovery was not significantly different in the intervention group compared to reported daily postconcussive symptoms (total symptom score over 10 days, 18.7 vs. 13.5, p > 0.05) and slower symptom resolution was noted. The finding that recommending strict rest for adolescents immediately after concussion offered no added benefit over the usual care. Adolescents’ symptoms reporting was influenced by recommending strict rest.

CONCLUSIONS Recommending strict rest for adolescents immediately after concussion offered no added benefit over the usual care. Adolescents’ symptoms reporting was influenced by recommending strict rest.

Department of Neurology, University of California, San Francisco, California, USA.

WHAT’S KNOWN ON THIS SUBJECT: Expert consensus recommends rest after concussion with separative return to activity journal and retrospective human data suggest that early rest promotes recovery in adults. However, pediatric data is limited.

WHAT’S NEW IN THIS STUDY: Recommendations regarding strict rest postconcussion are not supported by evidence. The efficacy of a bonding and regulatory schedule for pediatric mild traumatic brain injury concussion.

WHAT’S NEXT IN THIS FIELD: Future research should focus on evidence-based therapeutic interventions for pediatric concussion.

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When patients don’t get better

What are we missing?
References

Neuropsychiatry of Persistent Symptoms After Concussion

Jonathan M Silver, PhD

KEYWORDS

Concussion • Brain injury • Neuropsychiatric • Chronic symptoms

INTRODUCTION

Acute postconcussive symptoms are fairly consistent in their presentation, and by definition are time limited. At the initial presentation, the individual complaining of feeling fuzzy or slowed down, and one of the results is unexpected. It is outside the expected range of values. It can be an abnormal result for glucose, thyroid hormone, and dopamine, a finding on school CT scans, or a visual field deficit. Recent consensus statements comprehensively address the initial evaluation of concussion and return to play recommendations. Although most individuals who have been diagnosed with concussion return to baseline functioning within several months, there is a subset of individuals who

Invalid symptom reporting may be indicative of:What are we missing?

Jonathan M Silver, PhD

New York University School of Medicine, New York, NY, USA

Abstract

BACKGROUND: In the evaluation of neurorehabilitation patients involved in compensation or litigation, it is often assumed that poor performance or exaggerated symptoms reflect an intentional attempt to game the system. PURPOSE: The purpose of this article is to review multiple issues that can contribute to invalid symptom reporting and performance. CONCLUSIONS: Multiple factors relevant to normal behavior, including observations from social psychology and behavioral economics, are important in the context of invalid symptom reporting and performance. These factors, which include pre-injury traits and beliefs (e.g., beliefs about progress and symptoms after TBI), factors at the time of initial treatment (e.g., expectations of recovery, mood effects, stereotype threat), and thoughts and feelings during evaluations (e.g., anger, retraction, irritation), may be important explanations. To best serve our patients, further research is needed to illustrate these relative effects on performance compared to "true" reporting.

Keywords: Concussion, validity, effort, stereotype threat, irritation, malingering

1. Introduction

A common scenario in medicine: You are evaluating a patient for a complex problem. A number of tests are administered, and one of the results is unexpected. It is outside the expected range of values. It can be an abnormal result for glucose, thyroid hormone, and dopamine, a finding on school CT scans, or a visual field deficit. Recent consensus statements comprehensively address the initial evaluation of concussion and return to play recommendations. Although most individuals who have been diagnosed with concussion return to baseline functioning within several months, there is a subset of individuals who...
What predicts recovery?

A. Expectation
B. Depression
C. Litigation
D. Personality
What’s going on?

• Veterans with TBI, PTSD, or both screened for inclusion in study
• Insufficient effort (defined as score < 82.5% on 1 primary measure of the WMT)
  – 1/26 in TBI only group
  – 0/16 in PTSD only group
  – 15/34 of TBI/PTSD group

PTSD = posttraumatic stress disorder; WMT = Word Memory Test.
Stereotype Threat
APOE Allele and Effect on Test Results

- Of participants with risk allele (ε4+), those who knew that they had it judged memory capacity as worse and performed worse on verbal memory tests for immediate and delayed recall.
- Of those without risk allele (ε4-), those who knew status rated as having lower frequency of forgetting, less forgetting when reading, and better memory functioning than those who did not know, but performance was the same.

Pre-Injury Factors

Traumatic Brain Injury

Expectations

Stress

Stereotype Threat

Anxiety

Revenge

Cheating

Depression

Loss Aversion

PTSD

SYMPTOMS
Litigation/Compensation

What is the cost of the adversarial legal and insurance/compensation process?
Effect of Compensation Process

- 616 participants, followed for 6 years; 2/3 made compensation claims
- Stressful aspects: Understanding what was needed for claim, time it took, number of assessments, amount received, perceived fairness
- Associated with greater disability, anxiety, depression, lower quality of life

It’s Your Fault

• Blaming others: Poorer physical and emotional well-being
• Motor vehicle accident: Someone else responsible—more depression, less likely to return to work

It’s Not Fair

• Perceived injustice
  – Greater depression, poor rehabilitation outcome, prolonged disability
  – Mediated by anger

I’m Sorry
Medical Liability Reform

• Communication and Resolution Programs
  – Open discussion of adverse outcomes with patients and proactively seek resolution
    • Offer apology, explanation, and compensation if standard of care not met
• University of Michigan: Compensation decreased 59%, new claims decreased 36%
• Stanford: Claim frequency decreased 36%, insurance premiums 32%

Pre-Injury Factors

Traumatic Brain Injury

Expectations

Stress
Stereotype Threat

Anger
Revenge

Loss Aversion

Cheating

Depression
Anxiety
PTSD

SYMPTOMS
Loss Aversion
Pre-Injury Factors

- Traumatic Brain Injury

Expectations

- Stress
- Stereotype Threat

Depression Anxiety PTSD

Anger Revenge

Loss Aversion

Cheating

Symptoms
Cheating (alternative facts)

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Are we creating a problem?
Case 5: “I got concussed again”

- 20-year-old man suffers a concussion. Symptoms resolve over 2 weeks.
- Every time he hits his head, no matter how mild, he complains of headaches, dizziness, and fatigue.
Chronic Traumatic Encephalopathy
What about Chronic Traumatic Encephalopathy?
**The science and questions surrounding chronic traumatic encephalopathy**

**Vin Shen Ban, MBChir, MRCS, Christopher J. Madden, MD, Julian E. Bailes, MD, H. Hunt Batjer, MD, and Russell R. Lonser, MD**

*Department of Neurological Surgery, University of Texas, Southwestern Medical Center, Dallas, Texas; Department of Neurological Surgery, Northwestern University Feinberg School of Medicine, Chicago, Illinois; Department of Neurological Surgery, The Ohio State University Wexner Medical Center, Columbus, Ohio*

Concussion occurs most frequently during the routine activities of daily life, such as cycling, but it is the most common form of sports-related traumatic brain injury (TBI). Acute signs and symptoms related to concussion resolve within 10 days of injury to 90%–95% of adult athletes but may linger longer in concussed children and adolescents, and therapy is often required for persistent symptoms.

Recently, media attention has surrounded the potential long-term effects of sports-related concussion (and subconcussive impacts), including chronic traumatic encephalopathy (CTE). Specifically, high-profile cases of athletes or former athletes who thought to have suffered or died of chronic traumatic encephalopathy (CTE) have highlighted the problem in the media.

Consensus Statement from the International Conference on Concussion in Sport, which was held in Zurich in 2012, published the following concern: ...the interpretation of causation in the modern CTE case should proceed cautiously. It was also recognized that it is important to address the issue of how parents/athletes from media pressure related to the possibility of CTE.

To better assess our scientific understanding of CTE, we reviewed the scientific literature on the long-term effects of sports-related TBI and CTE. We use this information to assess the experiences and discuss the research opportunities to address the questions that remain unanswered.

**CTE-Related Science and Questions**

Does the Presence of Cerebral Tau Protein Equal a Diagnosis of CTE?

A common misconception is that the presence of tau protein in the brain leads to a diagnosis of CTE.

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Chronic Traumatic Encephalopathy

Pathological Features (n=48):
- Neuronal loss, gliosis
- Tau deposition (NFTs) perivascular, sulcal depths (frontal, mesio-temporal, entorhinal cortical distribution)

The spectrum of disease in chronic traumatic encephalopathy

Chronic Traumatic Encephalopathy in Athletes: Progressive Tauopathy After Repetitive Head Injury
Ann C. McKee, MD, Robert C. Cantu, MD, Christopher J. Nowinski, AB, Tessa Hedley-Whyte, MD, Brandon E. Gavett, PhD, Andrew E. Budset, MD, Veronica E. Santini, MD, Hyo-Soon Lee, MD, Caroline A. Kubilus, and Robert A. Stern, PhD

RESEARCH ARTICLE

Chronic Traumatic Encephalopathy in Blast-Exposed Military Veterans and a Blast Neurotrauma Mouse Model
Lee E. Goldstein,1,3,4,9 Andrew M. Fisher,1,4 Chad A. Tagge,1,4 Xiao-Lei Zhang,8 Libor Velisek,7 John A. Sullivan,7 Chirag Upadhyay,7 Jonathan M. Kracht,7 Marla Ericsson,6 Mark W. Wojnarowski,7 Cesar J. Goliett,7 Giorgi M. Maglakelidze,7 Noel Casey,1,5 Juliet A. Moncaster,1,5 Olga Mineva,1,5,9 Robert D. Mair,1 Christopher J. Nowinski,8 Robert A. Stern,1,4 Robert C. Cantu,1,4 James Gelinas,1,7 Jan K. Blustajn,7 Benjamin L. Wolkach,7 Tsuneya Ikeda,7,12 Thor D. Hein,8,12 Andrew E. Budson,8 Neil W. Kowall,1,5 David Chargin,13 Andre Sharon,14 Sudat Saman,14 Garth F. Hall,8 William C. Moss,14 Robin O. Cleveland,14 Rudolph E. Tanzi,15 Patrick R. Stanton,1 Ann C. McKee,4,5,15
Contact Sports and Chronic Traumatic Encephalopathy

1. Convenience sample; brain donations
2. Selection bias: Deceased, exposure to repetitive brain trauma; all subjects had symptoms
3. Lack of specificity for CTE: Non-specific symptoms
4. Recall bias: Retrospective clinical evaluation
5. No control group: Other studies show tau+ sz
6. Largest clinicopathological study of CTE: Half of cases previously published

What did this study add to our understanding?

CTE = chronic traumatic encephalopathy.
High School Football

• Cohort Study: n=2692; 834 played football; 1858 no football
• Primary outcomes: Depression and composite cognitive score
• Matched for demographics, IQ, education
• No difference in cognition, lower depression scores
• Football was different in 1950s
• Unable to control for prior mTBI; subgroups

Chronic Traumatic Encephalopathy-Like Abnormalities in a Routine Neuropathology Service

*Pearson’s Chi square $P=0.0098$.
Hypothetical Model

MCI = mild cognitive impairment; AD = Alzheimer’s disease; FTD = frontotemporal dementia; LBD = Lewy body dementia.
Chronic Traumatic Encephalopathy

- Too early to know
- Who is vulnerable
- What are the predisposing factors (environment, subconcussive hits, substance use, genetics)
- IT IS NOT A CONSEQUENCE OF A SINGLE CONCUSSION
Interventions

- Optimize expectations
- Diagnose and treat physical conditions
- Treat depression and anxiety
- Pharmacologic treatment of residual cognitive problems
- Exercise
- Slow breathing
- Minimize stereotype threat during testing
- Address feelings of anger and revenge: I’m sorry you got hurt
- Address loss aversion
- Money affects behavior