Mild Traumatic Brain Injury in Sports, Daily Life, and Military Service

Grant L. Iverson, Ph.D.
Professor, Department of Physical Medicine and Rehabilitation, Harvard Medical School; Director, MassGeneral Hospital for Children Sport Concussion Program; & Associate Director of Traumatic Brain Injury, Red Sox Foundation and Massachusetts General Hospital Home Base Program

January 30, 2015

The materials contained in this presentation are not authorized to be reproduced, transmitted, distributed, or displayed without expressed consent and permission.
Funding Disclosure

- Canadian Institute of Health Research
- Lundbeck Canada
- AstraZeneca Canada
- ImPACT Applications, Inc.
- CNS Vital Signs
- Psychological Assessment Resources, Inc.
- Tampere University Hospital
- Alcohol Beverage Medical Research Council
- Rehabilitation Research and Development (RR&D) Service of the US Department of Veterans Affairs
- Defense and Veterans Brain Injury Center
- Mooney-Reed Charitable Foundation
- INTRuST Posttraumatic Stress Disorder and Traumatic Brain Injury Clinical Consortium funded by the Department of Defense Psychological Health/Traumatic Brain Injury Research Program (X81XWH-07-CC-CSDoD)
Traumatic brain injuries occur on a broad continuum of severity, from very mild injuries to catastrophic injuries resulting in death or severe disability.
Continuum of TBI Severity

Approximately 90% of all injuries

Very mild/transient  Uncomplicated mild  Complicated mild  Moderate  Severe  Catastrophic
Moderate-Severe TBI

• Can result in:
  – widespread damage to the structure and function of the brain
  – permanent changes in physical functioning, cognition, emotional functioning, behavior, and personality
  – permanent disability from work

• Outcome is variable, however, ranging from very good to very poor.
Numbers for
Mild Traumatic Brain Injury (MTBI)

- Vast majority of injuries in civilians (and military)
- Common comorbidities (in civilians presenting to the ED)
  - Neurological – up to 25%
  - Psychiatric (incl. alcohol and substance abuse) – up to 30%
- Intracranial lesion on conventional neuroimaging – 0-40%
- Neurosurgical intervention – 1%
- Mortality – 0.1%
- Majority (70-80%) recover within days or weeks
Mild Traumatic Brain Injuries are Not Created Equally
Spectrum of MTBI

Extremely Mild (Transient)  Structural Damage (Permanent)
Continuum of Pathophysiology

Minor Neurometabolic

Major Neurometabolic & Pathoanatomical (e.g., Contusion)
Rate of Day-of-Injury CT Abnormalities

• Incidence of intracranial abnormalities in MTBI in Emergency Department studies
  – 5% to 40% across studies
  – It increases with lowering of GCS: 15, 14, 13

• MRI reveals a greater rate
Continuum of Biological & Psychological Vulnerability

Extremely Hardy
Extremely Vulnerable
There is no *simple*, reasonably explanatory model for good or poor outcome
PTSD and Mild Traumatic Brain Injury

EDITED BY
Jennifer J. Vasterling
Richard A. Bryant
Terence M. Keane

CHAPTER 3

A Biopsychosocial Conceptualization of Poor Outcome from Mild Traumatic Brain Injury

Grant L. Iverson
Biopsychosocial Model for Poor Outcome

**Traumatic Axonal Injury**
- Cognitive Diminishment
- Mental Health Problems

**Altered neurotransmitter Systems**
- Social Psychological Factors
- Insomnia

**Post-Concussion -Like Symptoms**
- Chronic Headaches or Bodily Pain
- Depression
- Anxiety/Stress/Worry
- PTSD

**Pre-Injury Factors**
- Personality Characteristics or Disorders
- Biopsychosocial Resilience/Hardiness
- Biopsychosocial Vulnerability
- Pre-Existing Mental Health Problems

**Previous Brain Injuries**
- Narcissistic
- Dependent
- Histrionic
- Passive-Aggressive
- ADHD
- Learning Disability
- Genetics Relating to Injury Vulnerability
- Depression
- Anxiety
- Genetic Vulnerability

Copyright © 2010, Grant Iverson, Ph.D
Recovery from Concussion in Sports
By definition, a sport-related concussion is a mild traumatic brain injury.
Is sport-related concussion a benign injury?

Results from meta-analyses
Adverse Effects of Sport Concussion on Cognition

- Concussion Hours < 24: -0.97
- Concussion Days: -0.22
- > 7 Mod: -0.22
- Severe > 2 Years: -0.84
- TBI: -1.03
- MCI-Early Dementia: -1.03
Pathophysiology

- Complex interwoven cellular and vascular changes

- **Multilayered Neurometabolic Cascade**

- Under certain circumstances, cells degenerate and die
Primary Mechanisms

• Ionic shifts
• Abnormal energy metabolism
• Diminished cerebral blood flow
• Impaired neurotransmission
Fortunately, the brain undergoes dynamic restoration
Assessment Timeline

Sideline
Post-Game
24 Hours
First Week
Second Week
Third Week
At Risk!
Rest Following Injury

How much and for how long?
What is the rationale for rest?

• The injured brain might be in a state of neurometabolic crisis.

• Assuming that neurometabolic crisis involves an “energy crisis,” then vigorous activity might compound or magnify the energy crisis.

• Passing another mechanical force through the injured brain, while it is in a state of neurometabolic crisis, might result in magnified pathophysiology.
Critical Questions

- How do we define “rest”?
- How long should an athlete rest?
- How do we define gradual resumption of activities?
- How much rest is too much rest?
- When should we begin active rehabilitation?
Is Rest After Concussion “The Best Medicine?”: Recommendations for Activity Resumption Following Concussion in Athletes, Civilians, and Military Service Members

Noah D. Silverberg, PhD; Grant L. Iverson, PhD
- Silverberg and Iverson (2012) concluded that bed rest exceeding three days is not recommended and gradual resumption of pre-injury activities should begin as soon as tolerated.
Is rest in the initial days following concussion a good idea?

In my opinion, yes.
Can prolonged bed rest be harmful?

Yes.
What does the Sport Concussion Group 2012 Zurich Consensus Statement say?

• “In the absence of evidence-based recommendations, a sensible approach involves the gradual return to school and social activities (prior to contact sports) in a manner that does not result in a significant exacerbation of symptoms”

(McCrory et al., 2013)
Gradual Return to Sports Following Injury
Consensus statement on concussion in sport: the 4th International Conference on Concussion in Sport held in Zurich, November 2012

Paul McCrory, 1 Willem H Meeuwisse, 2, 3 Mark Aubry, 4, 5, 6 Bob Cantu, 7, 8 Jiří Dvořák, 9, 10, 11 Ruben J Echemendia, 12, 13 Lars Engebretsen, 14, 15, 16 Karen Johnston, 17, 18 Jeffrey S Kutcher, 19 Martin Raftery, 20 Allen Sills, 21 Brian W Benson, 22, 23, 24 Gavin A Davis, 25 Richard G Ellenbogen, 26, 27 Kevin Guskiewicz, 28 Stanley A Herring, 29, 30 Grant L Iverson, 31 Barry D Jordan, 32, 33, 34 James Kissick, 6, 35, 36, 37 Michael McCrea, 38 Andrew S McIntosh, 39, 40, 41 David Maddocks, 42 Michael Makdissi, 43, 44 Laura Purcell, 45, 46 Margot Putukian, 47, 48 Kathryn Schneider, 49 Charles H Tator, 50, 51, 52, 53 Michael Turner 54

Consensus Statement on Concussion in Sport: the 3rd International Conference on Concussion in Sport held in Zurich, November 2008

P McCrory, W Meeuwisse, K Johnston, J Dvorak, M Aubry, M Molloy and R Cantu

doi:10.1136/bjsm.2009.058248
Management Protocol: Stepwise

- No activity / Rest
- Light aerobic exercise
- Sport-specific exercise
- Non-contact training drills
- Full contact practice
- Return to play
Progressive Return to Activity
Guidelines for Military Service Members

Defense and Veterans Brain Injury Center
Handouts, Guidelines, Slides can be downloaded
Progressive Activity Process

- Six stage approach from ‘Rest’ to ‘Unrestricted Activity’
- Progression is measured across physical, cognitive, and vestibular domains
- Utilizes the Neurobehavioral Symptom Inventory (NSI) for symptom tracking
- Resting heart rate (HR) and blood pressure (BP) are used as physiological measures to evaluate activity tolerance
## Stages of Progressive Activity

<table>
<thead>
<tr>
<th>Rehabilitation Stages</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage 1</td>
<td>Rest</td>
</tr>
<tr>
<td>Stage 2</td>
<td>Light Routine Activity</td>
</tr>
<tr>
<td>Stage 3</td>
<td>Light Occupation-oriented Activity</td>
</tr>
<tr>
<td>Stage 4</td>
<td>Moderate Activity</td>
</tr>
<tr>
<td>Stage 5</td>
<td>Intensive Activity</td>
</tr>
<tr>
<td>Stage 6</td>
<td>Unrestricted Activity</td>
</tr>
</tbody>
</table>
Recovery Time in Athletes
NCAA Football Cohort

- 1,631 players
- 94 concussions
- Balance problems resolved in 3-5 days
- Symptoms gradually resolved by 7 days
- Cognition resolved by 5-7 days
- 91% appeared recovered by 7 days

McCrea et al. (2003)
Pennsylvania High School Football Cohort

- 2,141 players
- 3-year prospective cohort study
- 134 concussions
- Players followed until recovered

Recovery Curves (N = 134)

Days Post Injury

- No Previous Concussions
- 1 or More Previous Concussions

94% at 40 days
84% at 28 days
Multiple Concussions
Multiple Concussions

• Literature is mixed.

• Overall, group studies suggest possible lowered threshold, worse initial presentation, and slower recovery in some athletes with multiple injuries.

• Tremendous individual differences, however.
Recovery from Mild Traumatic Brain Injury in Civilians
Most people recover functionally within 3 months following injury.
Sport Concussion Assessment Tool 2 in a Civilian Trauma Sample with Mild Traumatic Brain Injury

Teemu M. Luoto,1 Noah D. Silverberg,2 Anneli Kataja,3 Antti Brander,3 Olli Tenovuo,4 Juha Öhman,1 and Grant L. Iverson5–7
Subjects

- Tampere University Hospital, ED, Finland
- 49 patients with MTBIs
- No history of mental health or substance abuse problems
- All underwent MRI for clinical or research purposes: 24.5% Abnormal
- First Research Visit, SCAT2; M = 30.4 hours (SD = 27.3) and all within 5 days
One Month Outcome

- ICD-10 Postconcussional Syndrome, Mild in Severity =

  23% of the MTBI sample

  12% of the Community Control sample with remote ankle injuries
Acute Predictors of One-Month Postconcussional Syndrome

- Loss of Consciousness: No
- Retrograde Amnesia: No
- Post-Traumatic Amnesia: No
- Abnormal MRI: No
- High Symptom Reporting in first few days: Yes
- Acute Psychological Distress: Yes (strongest predictor)
Most people return to work within 3 months.

Return to work rates are highly variable across studies and are likely influenced by many factors separate from the injury to the brain.
Factors Affecting Recovery Time

- General health
- Previous concussions / neurological problems
- Pre-injury mental health problems
- Mechanism of Injury: MVA vs. Sports
- *Acute Psychological Distress* in the first few days
- *Severity of concussion symptoms in the first week*
- Post-Acute co-occurring conditions (depression, PTSD, chronic pain)
- Personality Characteristics
- Motivation
- Litigation
Introduction to the Post-Concussion Syndrome

• What is it?
• How long does it last?
• Can it be misdiagnosed?
ICD-10 Criteria for Postconcussional Syndrome

• Must endorse symptoms in at least 3 domains
  – Physical
  – Emotional
  – Cognitive
  – Insomnia
  – Excessive worry over symptoms
  – Intolerance for alcohol
• Physical Symptoms (headache, dizziness, balance problem, noise sensitive, light sensitive, and/or fatigue)

• Emotional Symptoms (irritability, sadness, nervousness, and/or feeling more emotional),

• Cognitive Symptoms (poor concentration, poor memory); and

• Insomnia (trouble falling asleep and/or sleeping less than usual).
Post-Concussion Syndrome

- More common in women than men.
- Pre-injury mental health problems are a major risk factor.
- It is associated with or influenced by traumatic stress in service members, veterans, and civilians.
- Persistent symptoms at 1 or 3 months are a risk factor for persistent symptoms at 1 year.
- Easy to misdiagnose in people with depression, anxiety, PTSD, and chronic pain.
The symptoms of mild TBI can be mimicked or magnified by traumatic stress, anxiety, pain, depression, sleep disturbance, and social psychological factors at any point during recovery.
The Nonspecificity Conundrum

Symptoms of the post-concussion syndrome are common in people with other health problems.
“Postconcussion-Like” Symptoms are Common in:

- University students
- Mental health outpatients
- General medical patients
- Chronic pain patients
- Personal injury litigants
Examination of “Postconcussion-Like” Symptoms in a Healthy Sample

Grant L. Iverson
University of British Columbia & Riverview Hospital, Vancouver, British Columbia, Canada

Rael T. Lange
University of British Columbia, Vancouver, British Columbia, Canada
PCS-Like Symptoms in Community Volunteers

• 104 community control subjects from the greater Vancouver area

• Exclusion criteria: (a) previous mental health problem, (b) brain injury, (c) neurological disorder, (d) substance abuse.

• All completed a PCS checklist patterned after the ICD-10 Criteria.

Iverson & Lange (2003)
PCS-Like Symptoms in Community Controls (Blue = Mild; Red = Mod-Severe)
ICD 10 Diagnostic Criteria

Mild PCS = 72.1%

Moderate – Severe Symptom Endorsement

12.5%
Misdiagnosis of the persistent postconcussion syndrome in patients with depression

Grant L. Iverson*

Department of Psychiatry, University of British Columbia & Riverview Hospital, 2255 Wesbrook Mall, Vancouver, BC V6T 2A1, Canada
Accepted 14 December 2005
Misdiagnosis of PCS in Depression

• 64 patients with depression

• Diagnosed and referred by family physician or psychiatrist

• Independently confirmed diagnosis with SCID-I

Iverson (2006)
PCS-Like Symptoms in Patients with Depression  
(Blue = Mild; Red = Mod-Severe)
ICD 10 Diagnostic Criteria

Mild PCS = 89.1%

Moderate – Severe Symptom Endorsement

57.8%
Treatment & Rehabilitation
Basic Principles: Initial Months Following Injury

• Focused, Evidence-Based Treatment for Specific Symptoms and Problems
  – Medications
  – Physical Therapy
  – Vestibular Rehabilitation
  – Exercise
  – Psychological Treatment
Psychological Treatment for People with Chronic Problems
Psychological Treatment

- Cognitive Behavior Therapy
- Self-Management
- Behavioral Activation
- Stress Management
- Acceptance & Commitment Therapy
Conclusions

• Mild TBIs are heterogeneous.

• An initial period of rest is helpful but too much rest can be harmful for some people.

• Most athletes appear to recover within one month and most civilians appear to recover within three months.
• Patients with depression or chronic pain, in the absence of head trauma, report very high levels of concussion-like symptoms

• A substantial minority of healthy control subjects also endorse high levels of symptoms

• Poor outcome cannot be explained by purely neurological, psychological, contextual, or motivational factors

• The only reasonable approach to understanding poor outcome following Mild TBI is a biopsychosocial perspective
Vestibular Injury
Brain Injury
Exaggeration/Secondary Gain
Chronic Bodily Pain or Headaches
Depression
Post-Traumatic Stress
Anxiety/Stress/Somatic Preoccupation
Life Stress
Insomnia/Sleep Disturbance
PCS-Like Symptom Reporting
Careful and Comprehensive Assessment = Targets for Treatment and Rehabilitation
Reduce Symptoms; Improve Function

- Sleep Disturbance
- Stress & Anxiety
- Depression
- Deconditioning
- Headaches
- Bodily Pain
Treat what you can treat

- Many of the treatment and rehabilitation approaches that are effective for traumatic stress, depression, and chronic pain can be adapted for use with individuals who have symptoms and problems that are believed to be partially or largely related to an MTBI.