Neurocognitive Testing for Postconcussion Syndrome

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Professor of Neurosurgery and Neurology
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Member, NFL Head, Neck and Spine Committee
Neuropsychology Consultant, Green Bay Packers
The Role of *Neuropsychological Consultation* in *Multi-Dimensional Assessment and Management of Athletes with Prolonged Recovery after Sport-Related Concussion*

Michael McCrea, PhD, ABPP

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mTBI Recovery & Outcome:  
*It Starts at the Beginning*

“mTBI is about what happened to the patient at the time of the injury event…and defined by the characteristics and course of clinical signs and symptoms during the acute period”

James P. Kelly, MD
Director, National Intrepid Center for TBI

(Or, even *before* the beginning!)
Acute Effects and Recovery Time Following Concussion in Collegiate Football Players
The NCAA Concussion Study

Over 25,000 Athlete Seasons, 1,500 Concussions Studied

Michael McCrea, PhD
Kevin M. Guskiewicz, PhD, ATC
Stephen W. Marshall, PhD
William Barr, PhD
Christopher Randolph, PhD
Robert C. Cantu, MD
James A. Onate, PhD, ATC
Jingzhen Yang, MPH
James P. Kelly, MD

Context  Lack of empirical data on recovery time following sport-related concussion hampers clinical decision making about return to play after injury.

Objective  To prospectively measure immediate effects and natural recovery course relating to symptoms, cognitive functioning, and postural stability following sport-related concussion.

Design, Setting, and Participants  Prospective cohort study of 1631 football players from 15 US colleges. All players underwent preseason baseline testing on concussion assessment measures in 1999, 2000, and 2001. Ninety-four players with concussion (based on American Academy of Neurology criteria) and 56 noninjured controls underwent assessment of symptoms, cognitive functioning, and postural stability immediately, 3 hours, and 1, 2, 3, 5, 7, and 90 days after injury.
## SRC: How Long Does it Take to Recover?

<table>
<thead>
<tr>
<th>Rate of Postinjury Recovery in HS and College Athletes (n=790)</th>
<th>Total (%)</th>
<th>Cumulative Total (%)</th>
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<tbody>
<tr>
<td>Rapid (&lt; 1 day)</td>
<td>21.1</td>
<td>21.1</td>
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<tr>
<td>Gradual (&gt; 1 day, &lt; 7 days)</td>
<td>64.3</td>
<td>85.4</td>
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<tr>
<td>Prolonged (1 week – 1 month)</td>
<td>11.9</td>
<td>97.3</td>
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<tr>
<td>Persistent (&gt; 1 month)</td>
<td>2.7</td>
<td>100.0</td>
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</tbody>
</table>

Is Symptom Recovery Really Recovery?
Effect Sizes: 0.2 Small, 0.5 Medium, 0.8 Large

< 0.3 Difficult to detect in individual patients; large overlap b/n patients and control group

Meta-Analytic Studies and Reviews:
Frencham, 2004; Belanger et al., 2005; Schretlin & Shapiro, 2005; Broglio et al 2008; Iverson, 2011; Rohling et al 2011

Adapted from Iverson, 2011
Then Who Are All These People in my Clinic?

Small Fraction of Athletes

Biggest Clinical Challenge

Highest Resource Utilization
10% take > 7 days to recover

Acute severity predicts subacute recovery (LOC, PTA, 24 hr GSC)

2.5% symptomatic > 45 days

No impairment on objective measures at Day 45 relative to BL

3.8M SRC: 95,000 > 45 days
Risks of Persistent Symptoms After SRC

Self-Report Symptom Recovery

- > 7 Days: 36.6%
- > 10 Days: 25.7%
- > 15 Days: 15.8%
- > 30 Days: 6.9%
- > 45 Days: 2.5%

Predictors of Persistent Symptoms >45 Days:

- Pre-injury Baseline BSI-18 Somatization Index Score (p=.004)
- Faintness or dizziness
- Pains in heart or chest
- Nausea or upset stomach
- Trouble getting your breath
- Numbness or tingling in parts of your body
- Feeling weak in parts of your body

After Controlling for BL BSI-18 (SOM) Acute Injury Characteristics, Symptom Severity, NCAT Results NOT Predictive of Persistent Symptoms

McCrea 2014 Unpublished
Neurobiopsychosocial Recovery Model

ACUTE
- Neuro-biological dysfunction
- Significant clinical symptoms, impairments

POST-ACUTE
- Full clinical recovery typical
- Modestly prolonged clinical recovery in more severe injuries
- Increasing influence of non-injury factors over time

CHRONIC
- Small fraction with persistent or worsening symptoms
- Multi-factorial risk model
- Outcome most strongly associated with non-injury factors

Implications for Treatment, Intervention

Longitudinal Time Course
- Days 0-10
- Days 10-30
- > Day 30
Neurobiopsychosocial Model of mTBI

Multi-Domain Predictor Variables

Neurobiological
- Pre-Injury Factors
  - Genetics
  - Neurologic Vulnerabilities
- Trauma Burden
  - Injury Severity
  - Repetitive Exposure
  - Polytrauma
- Biomarkers
  - Structural/Functional Imaging
  - Blood Biomarkers

Psychosocial
- Psychological Function
  - Premorbid Comorbidities
- Environmental Factors
  - Social Support
  - Life Stressors
  - Iatrogenesis
- Motivational Factors
  - Expectation
  - Secondary Gain

Multi-Dimensional Outcome
- Neurologic Health
- Neurocognitive Function
- Neurobehavioral Function
- Psychological Health and Wellness
- Life Function & Quality

Implications for Inter-Disciplinary Clinical Model

McCrea, McAllister & Morey, 2012
Role of Neuropsychological Evaluation

Not a One Size Fits All Solution

ACUTE INJURY
Field (ED) Deployable Cognitive Screening

SUBACUTE RECOVERY
Brief or Computerized Neurocognitive Testing

CHRONIC / COMPLEX
Comprehensive Neuropsychological Assessment

Right Tool for the Right Job!
Assessment as Intervention!
WHO Collaborating Centre
Task Force on Mild Traumatic Brain Injury

- Results of survey of non-surgical interventions and cost for mTBI (J Rehabil Med 2004)
- Recommendations for intervention based on the evidence
  - “Evidence that early intervention can reduce long-term complaints, and that this intervention need not be intensive.”

...Role of Education in Treating AND Preventing PCS
Borrowing from Lessons Learned

ARTICLES

Brief Cognitive Behavioral Interventions in Mild Traumatic Brain Injury
Lori Jean Miller
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Wiley Mittenberg
Center for Psychological Studies, Nova Southeastern University, Fort Lauderdale, Florida, USA

Postconcussion syndrome is a common and persisting consequence of mild traumatic brain injury. The development of treatments for the syndrome has been hampered by a lack of consensus in diagnostic criteria, confusion about the relative contribution of psychological and neurologic etiological factors, and a paucity of controlled treatment outcome studies. In this article, we review the literature relevant to prevention and treatment of persisting postconcussive symptoms. Studies in adults and children suggest that although symptoms may initially have a neurologically based, the syndrome persists because of psychological factors. Brief psychological treatment appears to significantly reduce the severity and duration of symptoms following mild head trauma. The attribution of persisting symptoms to organic factors conversely appears to be heterogeneous. Potentially useful diagnostic and treatment protocols are outlined.

Keywords: traumatic brain injury, neuropsychology, outcome research

Impact of early intervention on outcome following mild head injury in adults
J Ponsford, C Willmott, A Rothwell, P Cameron, A-M Kelly, R Nelms, C Curran

Background: The impact of mild head injury is variable and determinants of outcome remain poorly understood. Results of previous intervention studies have been mixed. Objectives: To evaluate the impact on outcome of the provision, in terms of reported symptoms, cognitive function and psychological adjustment across three post-injury time periods. Methods: 202 adults with mild head injury were studied. 79 were assigned to an intervention group and were seen at three weeks and three months after injury; 123 were assigned to a non-intervention control group and were seen at three months only. Participants completed measures of post concussion psychological adjustment, concussive symptoms, and tests of attention, speed of information processing, and memory. Subjects seen at one were given an information booklet outlining the symptoms associated with mild head injury and suggested coping strategies. Those seen only at three months after injury did not receive this booklet. Results: Participants in the intervention group who were seen at one week and given the information booklet reported fewer concussive symptoms overall and were significantly less stressed at three months after injury. Conclusions: The provision of an information booklet reduces anxiety and reporting of ongoing problems.

METHODS
Participants
Participants were recruited from consecutive presentations to the emergency departments of two hospitals over a 30 month period. Ethical approval was obtained. Participants were aged 18 years or over, English speaking, and had a history of trauma to the head resulting in loss of consciousness for less than 30 minutes, post-concussion symptoms for less than 24 hours, and a Glasgow coma scale (GCS) score of 13-15 on presentation to the emergency department. Participants were recruited only if they had ongoing symptoms at 3 months post-injury. Participants were allocated to one of two groups. Those assigned to the intervention group were contacted within 48 hours and seen five to seven days after the injury. A detailed history was taken and neuropsychological assessment performed. Intervention group participants were given an information booklet outlining common symptoms associated with mild head injury, their likely time course, and suggested coping strategies. No specific feedback was given to the controls. These participants were assessed three months after the injury. Intervention group participants received standard emergency department treatment and were not given the information booklet. They were assessed only at three months after injury. Measures:

Intervention group participants completed the measures outlined below at one week and three months post-injury. Control group participants completed the measures at three months only.

A longitudinal, controlled study of patient complaints following treated mild traumatic brain injury
Shauna Kashluba a, Chris Paniak b, Treena Blake b, Shawn Reynolds a, Geraldine Toller-Lobe a, Julianna Naszy a

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University of Alberta, Edmonton, Alta., Canada
Accepted 30 September 2003

Abstract
This study provided 3-month follow-up data to a previous paper that compared symptom complaints of patients with mild traumatic brain injury (MTBI) with those of non-injured control participants within 1 month of injury. The 110 MTBI patients and 115 control participants were group-matched on age, gender, education level, and socioeconomic status. As a group, MTBI patients no longer endorsed significantly more symptoms (M = 14.09, S.D. = 10.77) than did the control group (M = 12.56, S.D. = 8.46, P = .232). Only 3 of the 43 queried symptoms were endorsed by significantly more (Bonferroni-corrected P < .0016) MTBI patients than controls. Using the same Bonferroni-corrected criteria, 10 of the 43 symptoms were endorsed at a significantly higher severity level by MTBI patients. Overall, the treated MTBI group’s symptom complaints diminished from baseline to 3 months post-injury, with relatively few differences remaining between the two groups.

Keywords: Mild traumatic brain injury; Longitudinal

Mild traumatic brain injury (MTBI) is one of the most common neurologic disorders representing up to 90% of all brain injuries sustained (Kraus & Nourjah, 1989; Sattz et al., 1999; Thonhill et al., 2000). Numerous studies have investigated symptoms associated with MTBI at varying times following injury. Most of these studies indicate that MTBI symptoms are largely resolved within 3 months of injury, with the majority of people generally reporting a full recovery (Alexander, 1995; Binder, Rohlting, & Lumbeck, 1997; Dikmen, Mischuler, * Corresponding author. Tel.: +1-780-471-7369; fax: +1-780-471-7969. E-mail address: paniak@ualberta.ca (C. Paniak).
Beyond “He Needs Neuropsych Testing”

- Detailed history:
  - pre-injury, peri-injury, post-injury factors
- Multi-dimensional assessment
  - Cognitive, Psychological
- Intervention
  - Athlete/parent education
- Progression Planning
  - Restoring function
  - RTP, RTL
- Outcomes-based research
  - Shared with athletes

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**The Concussion Clinic: A Practical, Evidence-Based Model for Assessment and Management of Sport-Related Concussion**

Michael McCrea
Medical College of Wisconsin

Matthew R. Powell
Marshfield Clinic

This article reviews the essential components of a practical, evidenced-based approach to the management of sport-related concussion in an ambulatory care setting. The model presented is based on the core philosophy that concussion assessment and management be approached from the biopsychosocial perspective, which recognizes the medical/physiological, psychological, and sociological factors that influence recovery and outcome following concussion. Based on the biopsychosocial paradigm, we outline a care delivery model that emphasizes an interdisciplinary approach in which the clinical neuropsychologist is a key participant. We discuss the importance of nonmedical, psychoeducational interventions introduced during the acute phase to facilitate recovery after sport-related concussion. Finally, using the local experience of our “Concussion Clinic” as a backdrop, we offer two separate case studies that demonstrate the value of this model in evaluating and managing athletes after sport-related concussion. The overall objective of this paper is to provide an adaptable template that neuropsychologists and other healthcare providers can use to improve the overall care of athletes with sport-related concussion and civilians with mild traumatic brain injury.

**Keywords:** brain injury, concussion, neuropsychological tests, sport injuries
Rehabilitation from postconcussion syndrome: nonpharmacological treatment. A. Nelson Sheese AL, Hammeke TA.

Core treatment strategies emphasize:
(1) education about mTBI, PCS, natural recovery course
(2) reassurance of a good outcome
(3) reduction in activity level and refrain from hazardous behaviors during the acute phase
(4) gradual return to lifestyle activities as symptoms permit
(5) careful monitoring and early intervention for adverse emotional responses
(6) symptom-specific treatment when needed
(7) ready access to providers during acute and subacute recovery periods.
Interdisciplinary Clinic Model

- Dedicated Triage line
  - ATC screens referrals
- Inter-disciplinary Visits
  - Sports Medicine
  - Neuropsychology
  - ATC
- Team Specialists
  - Psychology/CBT
  - Vestibular Rehab/PT
  - Other (Optho, Pain, etc.)
- Systematic RTS, RTP
- Efficient care delivery
- Systematic Follow-up

Key Roles of Neuropsychologist:
- Flexible, hybrid assessment
- Consult with MD on RTP
- Patient/parent education
- Residency, Fellowship training
- Direct the research program
- Outreach, Education, Prevention
An Ounce of Prevention...

LIGHT LIFTING:
Early Education to Facilitate Recovery & Outcome

HEAVY LIFTING:
Resource Intensive Intervention with Unpredictable Outcome
Thank You

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Factors Influencing Recovery and Outcome After mTBI

Adapted from Iverson, Zasler, Lange, 2008
Many Hits, Rather Than A Big One, Pose Greatest Concussion Risk?

At a Crossroads

Concussion news worries parents

OTL survey finds 57 percent of parents less likely to allow kids to play football

Outside the Lines' survey finds that a majority of parents are concerned enough about news reports of concussions from playing football to keep their children away from the sport.

Looking to Science for Answers
What About the “Miserable Minority”?

“This gripping educational film explores the connection between concussion and suicidal depression - a little known medical condition called Post Concussion Syndrome (PCS). PCS is possibly the most under-diagnosed, yet widespread condition affecting young people today. PCS masks itself by appearing as many other symptoms including the inability to learn, abuse of drugs and alcohol and the loss of motivation or joy.”

“A Must See for Concussion Victims and Their Families” – William Brown, film-maker
Beyond “He Needs Neuropsych Testing”
SRC & mTBI: Natural History of Recovery
Emotional response to sport concussion compared to ACL injury

2010, Vol. 24, No. 4, Pages 589-597  
Lynda M. Mainwaring1*, Michael Hutchison1 Sean M. Bisschop2, Paul Comper2, Doug W. Richards1.

Primary objectives: To ascertain and compare the nature of emotional response of athletes to concussion and to anterior cruciate ligament (ACL) injury.

Research design: Pre-injury, post-injury and longitudinal emotional functioning of athletes with concussion \((n = 16)\), athletes with ACL injuries \((n = 7)\) and uninjured athletes \((n = 28)\) were compared in a prospective repeated-measures design.

Methods and procedures: Participants completed the short version of the Profile of Mood States (POMS). ANOVAs and trend analysis were used to examine between and within group differences across time on two sub-scales, Total Mood Disturbance and Depression.

Main outcomes and results: Athletes with ACL injury reported higher levels of depression for a longer duration than athletes with concussion. Relative to un-injured controls, athletes with concussion reported significant changes in Total Mood Disturbance and Depression post-injury, whereas athletes with ACL injuries reported significant changes in Depression scores only. Different patterns of post-injury emotional disturbance for the injured groups were observed by trend analyses.

Conclusions: Concussed athletes do not report as much emotional disturbance as athletes with ACL injuries. Differential patterns of emotional disturbance were detected between injured groups. The authors recommended that clinical protocols and educational programmes address emotional sequelae associated with sport concussion and ACL injury.

Importance of a Neurobiopsychosocial Approach to Injury Management to Improve Recovery and Outcome
### Performance-Based, Functional Recovery after SRC

#### Table I. Characteristics of the 39 studies included in the meta-analysis

<table>
<thead>
<tr>
<th>Study</th>
<th>Sample size; study design</th>
<th>Immediate post-injury assessment</th>
<th>Immediate post-injury neurocognitive assessment</th>
<th>Immediate post-injury time from injury (days)</th>
<th>Immediate post-injury effect size</th>
<th>Immediate post-injury 95% CI</th>
<th>14 Days post-injury assessment</th>
<th>14 Days post-injury effect size</th>
<th>14 Days post-injury 95% CI</th>
<th>Mean study quality score</th>
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</thead>
<tbody>
<tr>
<td>Barr and McCrea[49]</td>
<td>118; control</td>
<td>NC</td>
<td>SAC</td>
<td>0.003</td>
<td>-2.52</td>
<td>-2.82, -2.22</td>
<td>NC</td>
<td>-0.52</td>
<td>-1.13, 0.10</td>
<td>8.75</td>
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<td>Bruce and Echemendia[50]</td>
<td>38; control</td>
<td>NC</td>
<td>P&amp;P</td>
<td>0.08</td>
<td>-0.69</td>
<td>-1.30, -0.08</td>
<td>NC</td>
<td>-0.52</td>
<td>-1.13, 0.10</td>
<td>9.00</td>
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<td>Collie et al.[18]</td>
<td>109; control</td>
<td>NC</td>
<td>P&amp;P</td>
<td>2.2</td>
<td>-0.11</td>
<td>-0.56, 0.33</td>
<td>NC</td>
<td>-0.52</td>
<td>-1.13, 0.10</td>
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<td>Field et al.[44]</td>
<td>92; control</td>
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<td>Guskiewicz et al.[88]</td>
<td>20; control</td>
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<td>30; baseline–post–concussion</td>
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**ACUTE (24 HR) COGNITIVE EFFECT SIZES:** 
-0.81 (LARGE)

**SYMPTOMS:** -3.31
**BALANCE:** -2.56

Broglio et al., 2008
SUBACUTE (14 DAYS) COGNITIVE EFFECT SIZES: -0.26 (SMALL)

SYMPTOMS: -1.09
BALANCE: -1.16
Multi-Tiered Cognitive Assessment: Right Tool for the Right Job

NO ONE SIZE FITS ALL SOLUTION
Thank You

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Evidence-based mTBI Care

• Early intervention at point of entry (ED)
• Patients with acute/subacute TBI or concussion
  – Before point of contamination
• Inter-disciplinary
  – PM&R, Sports Medicine
  – Neuropsychology
  – Nurse Practitioner
• Systematic Follow-up
• Focus on restoring function, maximizing outcome
Multi-Disciplinary Care Model

- Early intervention model
- Patients with acute/subacute TBI or concussion
  - Before influence of comorbidities
- Inter-disciplinary
  - Sports Medicine
  - Neuropsychology
  - Athletic Trainer
- Systematic Follow-up
- Focus on restoring function, maximizing outcome
What’s the true incidence of “PCS”?

• Epidemiology?
  – Frequent citation of influential Alexander (1995 *Neurology*) review article: “at one year after injury approximately 15% of [mild TBI] patients still have disabling symptoms”
  – Articles referenced for this figure are Rutherford et al., 1978; McLean et al., 1983.
    • This figure and these citations echoed in multiple publications, but…..
Original citations for the “15%” at 1 year

• Rutherford et al., 1979 (actually mis-cited in the Alexander article)
  – 145 consecutive mild TBI cases admitted to hospital in Belfast.
  – 131 followed up at one year, 19 still reporting symptoms (14.5%)
  – 8/19 involved in lawsuits, 6/19 suspected of malingering at 6 weeks post-injury (overlap of 5)
  – 10/19 pts reporting at least one new symptom not endorsed 6 weeks post-injury
  – Age not related to duration of symptoms, but gender was (women more likely to be symptomatic)
  – No controls (e.g., ortho injuries)
Original citations for the “15%” at 1 year

• McLean et al., 1983
  – 11 pts with mild TBI (GCS 13-15)
  – 8 pts with mod TBI (GCS 9-12)
  – 1 pt with severe TBI (GCS=8)
• Controls N=52, friends of pts (non-injured)
• Groups compared on neurocognitive scores and symptom checklist at 3 days & 1 month post-injury.
• No difference in neurocognitive scores, but more symptoms in pt group at 1 month.

The moral of the story: Check original sources!
What is “PCS”?  

• DSM-IV- proposed new category:
  – A. History of a head trauma that has caused significant concussion (loc, pta, sz)
  – B. Evidence from neuropsychological testing of impaired attention or memory
  – C. Three or more occur shortly post-injury and persist for at least 3 months:  
    • Headache  
    • Dizziness  
    • Irritability  
    • Fatigue  
    • Anxiety, depression, or emotional lability  
    • Sleep disturbance  
    • Personality change  
    • Apathy

PCS:
Largely a Symptom-based Diagnosis
“Translational Research?”

How Do the Findings Apply to Other Populations at Risk of mTBI?

Sports  Civilian  Military
Predictors of Postconcussive Symptoms 3 Months After Mild Traumatic Brain Injury

Jennie Ponsford
Monash University; Monash-Epworth Rehabilitation Research Centre, Epworth Hospital; and National Trauma Research Institute, Melbourne, Australia

Peter Cameron and Mark Fitzgerald
Monash University; Alfred Hospital; and National Trauma Research Institute, Melbourne, Australia

Michele Grant
Monash University; Monash-Epworth Rehabilitation Research Centre, Epworth Hospital; and National Trauma Research Institute, Melbourne, Australia

Antonina Mikocka-Walus
Monash University, National Trauma Research Institute and University of South Australia

Michael Schönberger
Monash University; Monash-Epworth Rehabilitation Research Centre, Epworth Hospital; and University of Freiburg

Objective: There is continuing controversy regarding predictors of poor outcome following mild traumatic brain injury (mTBI). This study aimed to prospectively examine the influence of preinjury factors, injury-related factors, and postinjury factors on outcome following mTBI. Method: Participants were 123 patients with mTBI and 100 trauma patient controls recruited and assessed in the emergency department and followed up 1 week and 3 months postinjury. Outcome was measured in terms of reported postconcussional symptoms. Measures included the InsPACT Post-Concussional Symptom Scale and cognitive concussion battery, including Attention, Verbal and Visual memory, Processing Speed and Reaction Time modules, pre- and postinjury SF-36 and MINI Psychiatric status ratings, VAS Pain Inventory, Hospital Anxiety and Depression Scale, PTSD Checklist-Specific, and Revised Social Readjustment Scale. Results: Presence of mTBI predicted postconcussional symptoms 1 week postinjury, along with being female and premorbid psychiatric history, with elevated HADS anxiety a concurrent indicator. However, at 3 months, preinjury physical or psychiatric problems but not mTBI most strongly predicted continuing symptoms, with concurrent indicators including HADS anxiety, PTSD symptoms, other life stressors and pain. HADS anxiety and age predicted 3-month PCS in the mTBI group, whereas PTSD symptoms and other life stressors were most significant for the controls. Cognitive measures were not predictive of PCS at 1 week or 3 months. Conclusions: Given the evident influence of both premorbid and concurrent psychiatric problems, especially anxiety, on postinjury symptoms, managing the anxiety response in vulnerable individuals with mTBI may be important to minimize ongoing sequelae.

- Prospective study of 123 mTBI patients, 100 TC’s
- Evaluated in ED, follow-up at 7 days, 3 mos
- PCS scale and cognitive testing, SF-36, MINI Psychiatric screening, HADS, PTSD CL
- Elevated PCS scores in mTBI group at Day 7, not different from TCs at 3 mos
- PCS at 3 mos predicted by preinjury physical problems and concurrent psychosocial factors, not by mTBI
- Cognitive measures not predictive of PCS at 7 days or 3 mos
Symptoms after Military mTBI

- 298 blast, 92 non-blast mTBI patients
- NSI and PCL administered
- PCS not predicted by mechanism or acute characteristics of mTBI
- Symptoms higher in mTBI < 1 mo ago vs. > 1 mo ago, and with higher PTSD sx’s
- Symptom reporting most strongly associated with emotional distress

Patients with a reported history of mild traumatic brain injury (mTBI) due to blast (n = 298) or non-blast (n = 92) mechanisms were asked to complete the Neurobehavioral Symptom Inventory (NSI) and the Post-traumatic Stress Disorder Checklist (PCL). Mechanism of injury did not account for a significant amount of variance in post-concussion symptom reporting overall, nor did severity of mTBI (i.e., brief loss of consciousness versus only an alteration of consciousness). Symptoms reporting was greater in those injured more than 1 month ago compared to those injured less than 1 month ago and in those reporting higher levels versus lower levels of PTSD symptoms. When examining specific symptoms, the only symptom that significantly varied between groups was hearing difficulty (with the blast-injured group reporting more severe difficulty with hearing). Findings suggest that greater symptom reporting is most strongly related to emotional distress.
Risk Factors for Postconcussion Symptom Reporting after Traumatic Brain Injury in U.S. Military Service Members

Rael T. Lange, Tracey Brickell, Louis M. French, Brian Ivins, Aditya Bhagwat, Sonal Pancholi, and Grant L. Iverson

Abstract

The purpose of this study was to identify factors that are predictive of, or associated with, postconcussion symptom reporting after traumatic brain injury (TBI) in the U.S. military. Participants were 125 U.S. military service members (age: M = 29.6 years, standard deviation [SD] = 8.9, range = 18–56 years) who sustained a TBI, divided into two groups based on symptom criteria for postconcussional disorder (PCD): PCD-Present (n = 65) and PCD-Absent (n = 60). Participants completed a neuropsychological evaluation at Walter Reed Army Medical Center (M = 9.4 months after injury, SD = 9.9; range: 1.1 to 44.8). Factors examined included demographic characteristics, injury-related variables, psychological testing, and effort testing. There were no significant group differences for age, sex, education, race, estimated premorbid intelligence, number of deployments, combat versus non-combat related injury, or mechanism of injury (p > 0.098 for all). There were significant main effects for severity of body injury, duration of loss of consciousness, duration of post-traumatic amnesia, intracranial abnormality, time tested post-injury, possible symptom exaggeration, poor effort, depression, and traumatic stress (p < 0.044 for all). PCD symptom reporting was most strongly associated with possible symptom exaggeration, poor effort, depression, and traumatic stress. PCD rarely occurred in the absence of depression, traumatic stress, possible symptom exaggeration, or poor effort (n = 7, 5.6%). Many factors unrelated to brain injury were influential in self-reported postconcussion symptoms in this sample. Clinicians cannot assume uncritically that endorsement of items on a postconcussion symptom checklist is indicative of residual effects from a brain injury.
Need More Convincing about a Neurobiopsychosocial Model of mTBI?
**Challenge: Non-specificity of PCS symptoms**

<table>
<thead>
<tr>
<th></th>
<th>Headache</th>
<th>Dizziness</th>
<th>Irritability</th>
<th>Memory problems</th>
<th>Conc. problems</th>
</tr>
</thead>
<tbody>
<tr>
<td>College students(^1)</td>
<td>36%</td>
<td>18%</td>
<td>36%</td>
<td>17%</td>
<td>42%</td>
</tr>
<tr>
<td>Chronic pain(^2)</td>
<td>80%</td>
<td>67%</td>
<td>49%</td>
<td>33%</td>
<td>63%</td>
</tr>
<tr>
<td>Depressed(^3)</td>
<td>37%</td>
<td>20%</td>
<td>52%</td>
<td>25%</td>
<td>54%</td>
</tr>
<tr>
<td>PI claimants (non tbi)(^4)</td>
<td>77%</td>
<td>41%</td>
<td>63%</td>
<td>46%</td>
<td>71%</td>
</tr>
<tr>
<td>mTBI(^5)</td>
<td>42%</td>
<td>26%</td>
<td>28%</td>
<td>36%</td>
<td>25%</td>
</tr>
</tbody>
</table>

**PCS Criteria are Neither Diagnostic nor Prognostic**

The neuropsychological impact of sports-related concussion: A meta-analysis

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Abstract
There is increasing interest in the potential neuropsychological impact of sports-related concussion. A meta-analysis of the relevant literature was conducted to determine the impact of sports-related concussion across six cognitive domains. The analysis was based on 21 studies involving 790 cases of concussion and 2014 control cases. The overall effect of concussion (d = 0.49) was comparable to the effect found in the non-sports-related mild traumatic brain injury population (d = 0.54; Belanger et al., 2005). Using sports-concussed participants with a history of prior head injury appears to inflate the effect sizes associated with the current sports-related concussion. Acute effects (within 72 hr of injury) were greatest for delayed memory, memory acquisition, and global cognitive functioning (d = 1.00, 1.03, and 1.42, respectively). However, no residual neuropsychological impairments were found when testing was completed beyond 7 days postinjury. These findings were moderated by cognitive domain and comparison group (control group versus preinjury self-control). Specifically, delayed memory in studies utilizing a control group remained problematic at 7 days. The implications and limitations of these findings are discussed. (JNNS, 2005; 11: 345–357.)

Keywords: Brain concussion, Head injury, Mild concussion, Sequelae, Traumatic brain injury, Football, Soccer

INTRODUCTION
Sports-related concussion occurs with some frequency. Among high school athletes, for instance, 5.5% of all injuries are concussions with an estimated 62,816 new cases of concussion annually (Powell & Barber-Foss, 1999). Football accounts for 63% of these injuries. The rate of concussion is similarly high in professional sports with an estimated 41 concussions per National Football League game (Pellman et al., 2004).

Sports-related concussion has gained increasing attention in the neuropsychology literature. Early work by Barth and colleagues (Barth et al., 1983; Riem et al., 1981) in the 1980s set the stage for a plethora of empirical investigation into the neuropsychological impact of concussion in sports and the resolution of cognitive sequelae over time. In addition, other researchers have suggested the possibility that repeated exposure to sports-related activities such as heading a soccer ball may cause a more subtle concussion (e.g., headaches, dizziness, feeling “dazed,” etc.) with an associated dose–response effect (Webbe & Ochs, 2003; Witol & Wehbe, 2003).

Although it is clear that most patients suffer at least some acute cognitive difficulties associated with concussion or mild traumatic brain injury (MTBI) more generally, the nature and course of postacute cognitive recovery remains an area of intense controversy. In non-sports-related MTBI, most cases recover completely within the first 3 months (Dikmen et al., 1996, 1995; Gentili et al., 1985; Gronwall & Wrightson, 1974; Levin et al., 1987), however, a significant minority continue to manifest cognitive deficits beyond that point, with prevalence estimates varying across study from 7–8% (Blinder et al., 1997) to 33% (Riem et al., 1981). In addition, a number of individuals continue to report dis...
mTBI Outcome

• Neurophysiological basis for sx’s & dysfunction acutely after MTBI

• Maximal sx’s first 72 hrs, rapid improvement over 1st week

• Lower true incidence of PCS

• Persistent symptoms (e.g., PCS) often largely related to comorbidities or non-injury factors

• PCS symptoms highly nonspecific

• Multi-factorial model of PCS

“Clearly, the estimate of 10-20% of patients with MTBIs not recovering by 6-12 months is much too high”