Mild TBI: Sports Concussions to Combat Injuries

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University of Virginia TBI Study

Glasgow Coma Scale: All Head Injury Admissions
(n = 1248)

<table>
<thead>
<tr>
<th>Glasgow Coma Scale</th>
<th>No. Patients</th>
<th>% of Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 - 8</td>
<td>260</td>
<td>21%</td>
</tr>
<tr>
<td>9 - 12</td>
<td>304</td>
<td>24%</td>
</tr>
<tr>
<td>13 - 15</td>
<td>684</td>
<td>55%</td>
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</tbody>
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University of Virginia TBI Study (1981)

3 months post injury – 34% of mild head injured patients who were previously employed had not returned to work (n=310)
UVA MILD HEAD INJURY: RESEARCH CRITERIA

• Glasgow Coma Scale > 12

• Loss of Consciousness < 20 minutes

• Length of Hospitalization (No Collateral Injuries) < 48 hours

• No Neuroimaging Evidence of Structural Impairment (Levin)
Percentages of Mild Head Injured Patients Across the Halstead Impairment Indexes

Rimel et al 1981, Barth et al 1983)
Mild Head Injury: The Silent Epidemic

Wall Street Journal, 1982
Mild Acceleration-Deceleration Brain Injury

“Acceleration induced head injury in the monkey: I. The model, its mechanical and physiological correlates.”

(Gennarelli et al, 1981)
Axonal degeneration induced by experimental noninvasive minor head injury

John A. Jane, M.D., Ph.D., F.R.C.S.(C), Oswald Steward, Ph.D., and Thomas Gennarelli, M.D.
Neurochemical Model of Concussion in Fluid Percussion

David Hovda, Ph.D., UCLA Dept. of Neurosurgery

- Increase in extracellular potassium and sodium, and intracellular calcium
- Initial hypermetabolism and hyperglycolysis to restore homeostasis
- Subsequent hypometabolism:
  - Uncoupling of cerebral blood flow and glucose utilization creates relative ischemia in regard to metabolic demands of tissue
University of Virginia Study of Mild Head Injury in Football

SLAM

Sports as a Laboratory Assessment Model
• Focus on Sports Concussion as a Laboratory for Clinical Research
  • Application to MTBI in the general population

• Focus on Sports Concussion as a Sports Medicine Issue
  • Improving sports safety/reducing risk
University of Virginia Football Study

TOTAL (10 Universities)  2350 Players

Post-injury Protocol:

Concussions 195
Orthopedic Injuries 59
Student Controls 48
TRAIL MAKING B
Pre-Season and Post-Injury Performances
(Timed in Seconds)
Percentage of Players Reporting Symptoms Following Mild Concussion

<table>
<thead>
<tr>
<th></th>
<th>Pre-season</th>
<th>24-Hours</th>
<th>5 Days</th>
<th>10 Days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Headaches</td>
<td>27.0</td>
<td>70.6</td>
<td>54.3</td>
<td>27.2</td>
</tr>
<tr>
<td>Memory</td>
<td>2.3</td>
<td>33.9</td>
<td>26.7</td>
<td>8.8</td>
</tr>
<tr>
<td>Dizziness</td>
<td>2.3</td>
<td>34.8</td>
<td>21.6</td>
<td>9.4</td>
</tr>
</tbody>
</table>
UVA Mild Head Injury in Football
(Barth, et al., 1989)

- 10 University Prospective Study (n=2350)
- 195 Concussions
- 107 Student/Red Shirt Athlete Controls
- Single Concussion:
  - Attention and Complex Problem Solving Deficits
  - Inability to Take Advantage of Practice Effect
  - 5 to 10 Day Recovery Curve

Virtually every college, high school, and professional study since the UVA study has found similar recovery curves following mild concussion [3 to 10 day recoveries]
Acceleration-Deceleration Mild Head Injury and Concussion Assessment

Standardized Assessment of Concussions (SAC)

(McCrea, Kelly, Kluge, Ackley, and Randolph, 1997)
Computerized Assessment in Acceleration Deceleration Concussion

- ANAM: Automated Neuropsychological Assessment Metric – Bleiberg (DoD)
- ImPACT: Immediate Post Concussion Assessment and Cognitive Testing - Lovell (U of Pittsburgh)
- CRI: Concussion Resolution Index – Erlanger (HeadMinder)
The light is "red"

Followup
Report Date: 11/28/1999 18:10:37
Baseline Test Date: 11/03/1999 00:22:49
Trauma Test Date: 11/25/1999 13:23:32

Protocol Validity

This is a valid protocol.

Findings

The light is "RED"

On one test, John Doe’s current score was significantly lower than his baseline score stored in our files. These findings are consistent with lowered cognitive functioning due to the concussion of 11/23/1999 00:00:00.

Experts guidelines recommend that players not be allowed to return to competition until all post-concussive symptoms have resolved.
Critical Issues in Sports Mild Head Injury

• When is it safe for a player to return to play?

• What are the effects of multiple concussions? Timing of concussions? Latency effects?
In this era of evidence based medicine, those who must make critical return-to-play decisions are left in the unenviable position:

Do we ignore a potential problem because we have little scientific data, or do we over-react to sensational headlines based upon single case observations?
The Dangers of Charlatanism or Scientism: Striking a Balance

To avoid decisional paralysis and harm to the athlete, we must strike a balance between what we know with reasonable certainty and what we observe and hope to better understand.
The Importance of Return-To-Play Decisions: Striking Another Balance

• Avoid potential negative outcomes
  – Protect the health of the athlete and avoid:
    • Second Impact Syndrome
    • Acute and Chronic Cognitive Deficits
    • Severe Emotional Problems
    • Chronic Traumatic Encephalopathy

• Carry out the mission/goal
  – Return to game and play well
  – Avoid being lost for future games
Potential Negative Medical Outcomes Associated With Return-To-Play Decisions:

SECOND IMPACT SYNDROME

- Occurs in athletes with prior concussion following relatively minor second impact (controversial and based upon single case studies)
- Catastrophic increase in intracranial pressure due to dysfunction of autoregulation of cerebral circulation
- Most often occurs in athletes < 24 years old

LOW INCIDENCE – HIGH POTENTIAL ACUTE IMPACT

Schneider, 1973; Saunders; 1984; Cantu, 1998. Evidence Level 4
Potential Negative Medical Outcomes Associated With Return-To-Play Decisions:

ACUTE AND CHRONIC COGNITIVE DEFICITS

Acute cognitive deficits 3 to 10 days post single concussion.

HIGH INCIDENCE – HIGH ACUTE LOW-CHRONIC POTENTIAL IMPACT
Barth, 1989; Lovell, 2003. Evidence Level 1 & 2

Possible chronic cognitive deficits with multiple concussions.

LOW-MOD INCIDENCE – HIGH CHRONIC POTENTIAL IMPACT
Potential Negative Medical Outcomes Associated With Return-To-Play Decisions:

SEVERE EMOTIONAL PROBLEMS

DEPRESSION

LOW INCIDENCE – HIGH POTENTIAL CHRONIC IMPACT

Evidence Level 2 & 3
Potential Negative Medical Outcomes Associated With Return-To-Play Decisions:

CHRONIC TRAUMATIC ENCEPHALOPATHY

- Progressive degenerative neurological process found in some athletes who sustain multiple concussions and sub-concussive blows. This early degenerative process is characterized by cerebral atrophy and increased levels of tau protein, as well as cognitive impairment (dementia) and, in some cases, depression.

LOW-MOD INCIDENCE – HIGH POTENTIAL CHRONIC IMPACT

McKee /Cantu, 2009; Omalu,/DeKosky 2005. Evidence Level 3 & 4
CHRONIC TRAUMATIC ENCEPHALOPATHY

Tau Protein: Amygdala (McKee et al. 2009)

Healthy Brain  Football Player  Boxer
Early evidence of CTE in a recently deceased 18-year-old boy who suffered multiple concussions in high school football.
Return to Play and Practice

What Do We Know With Reasonable Certainty?

• Single uncomplicated concussion often results in acute neurocognitive and balance deficits and a rapid (3 to 10 day) recovery curve.
• Once an athlete has sustained a concussion, the risk for subsequent concussion increases 3 to 6 fold.
• Multiple concussions may increase the severity and duration of cognitive symptoms (multiple concussions may result in CTE).
• Children are likely at greater risk for slower recovery.
Return to Play: Consensus Statements
Evidence Level 5 [Expert Opinion]

- American Academy of Neurology Practice Parameters (1997)
  - Severity grading; no symptom return to play (presently being revised)
  - Importance of neurocognitive assessment
  - Simple vs. complex concussion
- Zurich Conference on Sports Concussion (2009)
  - Neurocognitive assessment important (verify athlete self report)
  - Individually based decisions (one size does not fit all)
  - Diagnosis of concussion = remove from game no matter how fast symptoms clear
Conservative Approach to Return to Play and Practice

- Every player is different and decisions should be made by the medical/athletic training staff (and the player), taking individual history into account.

- If concussion is diagnosed, the player should be removed from play for that game/practice and until symptom free with exertion. Rest is recommended.

- When symptom free, neurocognitive retesting should be implemented to check against baseline test scores to mitigate inaccurate player symptom report.
Conservative Approach to Return to Play and Practice

• Since there is no scientific evidence to support a cut-off for too many concussions in a season or in a lifetime, decisions should be made by the medical/athletic training staff (and the player), taking individual history into account.

• Consideration should be given to a full neurological and neurocognitive examination when considered necessary by the team physician following multiple concussions. Any significant neurologic symptoms should trigger such an evaluation.
PREVENTION AND REDUCTION OF RISK IN SPORTS

- Education of the athlete and public
- Rules to protect the brain
- Equipment to protect the brain
- Reduction of contact in practice
Flexible bonnet
Serves as an anchoring point for the 18 shock absorbers, drawstring and strap. The drawstring and straps ensure a snug fit.

- Shock absorbers
- Drawstring
- Faceguard
- Strap
- Chin piece
Improvised Explosive Device Blast Injuries

- **Primary Blast Injury**: Wave induced changes in atmospheric pressure: Over pressure - Vacume [hollow organs most effected].

- **Secondary Blast Injury**: Objects placed in motion by the blast and hitting soldiers.

- **Tertiary Blast Injury**: Soldiers being put in motion by the blast and hitting other objects.

- **Quaternary Blast Injury**: Burns, toxic fumes, crush injuries, hypertension.
Blast Injuries: Comparison to Sports Concussions

- Blast injuries are more complicated than sports concussions, yet have some similarities, particularly in the tertiary phase of acceleration-deceleration.

- Complications include:
  - Primary over pressure dynamics
  - Secondary and quaternary injuries
  - PTSD
Clinical Mild TBI Outcome

- Most mild head injured patients recover fully and quickly (within 3 months).
- Many mild head injury patients experience significant neurocognitive deficits which can last several weeks or months.
- Longer periods of disability are related to post concussion syndrome, individual recovery curves, and individual vulnerability.
Lessons Learned From Clinical Experience
Outside of Sports: Individual Vulnerability
Factors and Outcome

- More severe concussion
- Multiple concussions
- Age
- Pain
- Premorbid health/conditioning
- Premorbid intellectual/cognitive functioning/LD/ADD
Lessons Learned From Clinical Experience Outside of Sports: Individual Vulnerability Factors and Outcome

- Alcohol/substance use/abuse
- Depression
- Sleep disturbance
- Genetics?
- Support systems to allow rest and recovery
- Information provision and positive expectations