The Sports Concussion Crisis

www.sportslegacy.org

Center for the Study of Traumatic Encephalopathy

Dr. Robert Cantu and Mr. Chris Nowinski

EATA January 2010
Where I was in 2003

- I had a big future (in wrestling)
- Named “2002 Newcomer of the Year” by RAW Magazine
- Youngest male Hardcore Champion in WWE History
- Things were going well....
When Wrestling Goes Wrong
My “First” Concussion

- I received a concussion against the Dudley Boyz in June 2003

- Aftermath
  - Headaches
  - Memory impairment
  - Depression
  - Sleep activity
My True Concussion History

- Dr. Robert Cantu helped me remember 5 prior concussions

- After my symptoms persist and 8 doctors can’t help me, I visit Dr. Robert Cantu

- 2 undiagnosed concussions in football

- 4 undiagnosed concussions, in wrestling
My Concussors
An Education Comes Too Late

- I didn’t have the right information to protect myself from concussions

• Retired in 2003 at age 24  
  - Symptoms persist to this day

Shockingly, he is the first to tell me that:

1. Concussions are cumulative and can have long-term effects
2. “Resting concussions” helps them heal

I wrote *Head Games* to warn others because studies show athletes are not informed of the risks. If the damage is partially preventable, how can we not tell athletes how to protect themselves?
**Sports Legacy Institute**

- Dr. Robert Cantu and I founded SLI in 2007 to solve the sports concussion crisis

> “(This) **groundbreaking research** may be providing the most significant concussion discoveries and the most startling and potentially devastating findings (in sports medicine).” August 5, 2007

- Bob Ley, ESPN

- Incorporated June 14th, 2007

- The Institute will initially **focus its efforts on the study of degenerative brain conditions including Chronic Traumatic Encephalopathy**, or CTE, a condition caused by repetitive concussive and sub-concussive brain injuries.
Sports Legacy Institute Team

**Founding Members**

CHRISTOPHER NOWINSKI - President
Consultant, Trinity Partners LLC, Waltham, MA
Author, *Head Games: Football’s Concussion Crisis*
Former WWE professional wrestler

ROBERT CANTU, MD
Chief of Neurosurgery Service and Director of Sports Medicine, Emerson Hospital, Concord, MA
Co-Director, Neurologic Sports Injury Center Brigham and Women’s Hospital, Boston, MA

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Center for the Study of Traumatic Encephalopathy

• September 2008 SLI and BU founded the first ever research center dedicated to CTE

A Collaboration Between Sports Legacy Institute and Boston University School of Medicine

Goals

1. Establishment of Brain Donation Registry
   • Current or retired athletes, with and without history of concussion, to agree to donate brain tissue following death.

2. Conduct Clinical Research
   • Examinations of retired athletes, including cognitive, mood, and neurological assessments, as well as brain MRI and spinal taps (to measure proteins in cerebrospinal fluid). Study longitudinally and examine brains following death.

3. Expansion of Brain Bank
   • Brain tissue repository for the examination of the underlying neuropathology associated with repetitive concussion in athletes.
The CSTE Brain Bank Registry

- Living athletes are lining up to be part of this groundbreaking research

- **National Football League (43)**
  - Ted Johnson
  - Joe DeLamielleure
  - Isaiah Kacyvenski
  - Ben Lynch
  - Bernie Parrish
  - Ralph Wenzel
  - Frank Wycheck
  - Bruce Laird
  - Brent Boyd
  - Mel Owens
  - Dan Pastorini
  - Billy Ray Smith
  - Ken Gray
  - Barry “J.B.” Brown
  - James Houston
  - Chad Levitt
  - David Long
  - Harry Jacobs

- **National Hockey League (5)**
  - Keith Primeau
  - Noah Welch
  - Steve Heinze
  - Ryan Vandenbussche

- **Pro Wrestling (15)**
  - Rob Van Dam
  - Lance Storm
  - Chris Nowinski
  - Tom Materas

- **Boxing**
  - Termite Watkins

- **Soccer**
  - Cindy Parlow

- **Swimming**
  - Jenny Thompson

- **National Basketball Association**
  - Paul Grant
  - Malcolm Huckaby

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**Level** | **Donors**
--- | ---
Pro | 78
Amateur | 48
Total | 126

*As of May 2009*
3 active NFL players promise their brains for concussion research: 'The culture has to change'

Sean Morey  
Arizona Cardinals

Lofa Tatupu  
Seattle Seahawks

Matt Birk  
Minnesota Vikings
Sept. 2009 - NFL Sponsored Study Finds Risk

• Former NFL players risk of “dementia, Alzheimer’s disease, or other memory-related disease”
  • Age 30-49: 19x normal population
  • Age 50+: 5x normal population

"I read that story about dementia in former NFL players. Maybe we should reconsider this."
Teammates Pretty Sure Ben Roethlisberger Can No Longer Remember Their Names

PITTSBURGH— After Ben Roethlisberger repeatedly addressed his Pittsburgh teammates as "dude," "Mac," and "you there" for an entire practice session last Monday, the quarterback's fellow Steelers concluded that the oft-concussed Pro Bowler is unable to remember their names. "I walked up to him in the locker room and said, 'Hey Ben,' and he responded, 'Hey...brother,'" said a teammate who spoke on the condition of continued anonymity. "He only used a first name once, and that was when he was talking to Troy Polamalu. And he kept calling him Randy." When asked if he would be ready for Sunday's game, Roethlisberger said that as the third-string goalie, there is only so much he could do.
Congressional Hearings - Wed. October 28, 2009

• House Judiciary Committee calls hearings with the full committee. NFL Commissioner, NFLPA ED, 8 doctors testify
NFL Commissioner Goodell Denies Risk at Hearing

• (AP) NFL Commissioner Roger Goodell didn't acknowledge a connection between head injuries on the football field and later brain diseases Wednesday. "I just asked you a simple question. What is the answer?" Conyers persisted. Goodell replied by saying a medical expert could give a better answer than he could.
Preventing Negative Outcomes for Athletes

A strategy to improve neurological outcomes for athletes must address both concussions and overall brain trauma.

Risk Management

Concussions
- Reporting
- Diagnosis
- Management

Overall Brain Trauma
- Reduce overall trauma to the brain through:
  - Rule changes
  - Practice style changes

PCS

CTE
Incidence of Concussion in Football - Trainer Data

- According to medical professionals, concussion is rare in football

- When athletic trainers are surveyed on how many concussions they see each season, they consistently find that between 2% and 6% of football players suffer concussions each season.*

<table>
<thead>
<tr>
<th>Source</th>
<th>Level</th>
<th>Incidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Powell et al (1999)</td>
<td>High School</td>
<td>3.6 %</td>
</tr>
<tr>
<td>Guskiewicz et al (2000)</td>
<td>HS/College</td>
<td>5.6 %</td>
</tr>
<tr>
<td>Guskiewicz et al (2003)</td>
<td>NCAA</td>
<td>6.3 %</td>
</tr>
<tr>
<td>McCrea et al (2002)</td>
<td>HS/College</td>
<td>3.8 %</td>
</tr>
<tr>
<td>Zemper (2003)</td>
<td>HS/College</td>
<td>4.1 %</td>
</tr>
<tr>
<td>Gerberich et al (1983)</td>
<td>High School</td>
<td>2.4 %</td>
</tr>
</tbody>
</table>

* Football will be used as the primary example because it has been studied more extensively than other sports. However, concussion data for ice hockey, lacrosse, soccer, and other sports is similar.
Incidence of Concussion in Football - Player Data

- Players simply do not report concussions, so they don’t exist in medical records.
- When players are surveyed directly, anonymously, after the season, and the word “concussion” is removed from the questions (instead, they ask about symptoms), players appear to be suffering 10 to 50 times more concussions than they tell athletic trainers (or coaches).

<table>
<thead>
<tr>
<th>Source</th>
<th>Level</th>
<th>Incidence</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Langburt et al (2001)</td>
<td>High School</td>
<td>47.2 %</td>
<td>3</td>
</tr>
<tr>
<td>Delaney et al (2002)</td>
<td>College</td>
<td>70.2 %</td>
<td>4</td>
</tr>
<tr>
<td>Delaney et al (2000)</td>
<td>CFL</td>
<td>47.8 %</td>
<td></td>
</tr>
<tr>
<td>Woronzoff (2001)</td>
<td>College</td>
<td>61.2 %</td>
<td></td>
</tr>
<tr>
<td>McCrea et al (2004)</td>
<td>High School</td>
<td>15.3 %</td>
<td></td>
</tr>
<tr>
<td>Moreau (2005)</td>
<td>High School</td>
<td>65.2 %</td>
<td></td>
</tr>
</tbody>
</table>

- This high concussion incidence is supported by other studies, including one that found that 21% of high school football players suffered a headache in the last game, yet only one in five told a coach or athletic trainer.
You Can’t See a Concussion

THAT’S GOTTA HURT...
Pittsburgh Steelers running back Destry Wight lies injured on the field Sunday night after he dislocated his right ankle and broke his right leg.
Head Impact Data

Head Impacts During High School Football: A Biomechanical Assessment

<table>
<thead>
<tr>
<th>Position</th>
<th>Impacts</th>
<th>Per Session</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lineman</td>
<td>736</td>
<td></td>
</tr>
<tr>
<td>Skill</td>
<td>431</td>
<td>16 hits</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Level</th>
<th>Mean Linear Acc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>HS</td>
<td>~ 24 g</td>
</tr>
<tr>
<td>College</td>
<td>~ 22 g</td>
</tr>
</tbody>
</table>

- 271 hits (1.4%) exceeded 70 g’s, one proposed concussion threshold

- HS athletes sustain greater more trauma to the brain than college athletes. Theories include:
  - Poor training on proper technique
  - Weaker body requires reliance on using head as battering ram
  - Weaker necks

Steven P. Broglio, PhD
Why Players Don’t Report Concussions

• Historically, the general consensus had been that athletes didn’t report symptoms because they didn’t want to be held out of the game. Research shows that is not true.

• The top reason high school athletes don’t report concussions is that they do not believe a concussion is a serious injury!

Why Concussion Was Not Reported

- Did not think it was serious enough: 66%
- Did not want to leave the game: 41%
- Did not know it was a concussion: 36%
- Did not want to let down teammates: 22%

• This groundbreaking study revealed that athletes are poorly educated on concussions.
  - Another recent study found that fewer than half of college athletes were aware that concussions can have negative consequences.

Other Reasons Athletes Don’t Report Concussions

- **Decision Tree** - Experience shows that athletes are often able to play through a concussion if they choose to ignore their symptoms. Those who live by a “if you can walk you can play” mantra are less inclined to report symptoms.

- **Fear** - Athletes also list the following reasons for withholding information.
  - Fear of losing starting position or playing time
  - Fear of being perceived as “not tough”
  - Fear of punishment from - or being mocked by - their coaches

- **Injury Culture** - Coaches need to recognize how the injury culture they create will affect athlete reporting.
  - Coaches who have “must practice to play” should consider creating a separate and unique rule for concussions.

**Concussion Education is No Longer Optional**
Concussion Grading - Historical

- Historically, concussions have been “graded” based on the symptoms present during and after the time of injury.

<table>
<thead>
<tr>
<th>Severity</th>
<th>Symptoms</th>
</tr>
</thead>
</table>
| Grade 1  | No loss of consciousness  
           | Post-traumatic amnesia lasts <30 minutes  
           | Post-concussion signs/symptoms last <30 minutes |
| Grade 2  | Loss of consciousness less than one minute  
           | Post-traumatic amnesia >30 minutes and <24 hours  
           | Post-concussion signs/symptoms last >30 min and <7 days |
| Grade 3  | Loss of consciousness greater than one minute  
           | Post-traumatic amnesia >24 hours  
           | Post-concussion signs/symptoms last >7 days |

Cantu RC. Post-traumatic (retrograde and anterograde) amnesia: pathophysiology and implications in grading and safe return to play. J of Athletic Training 36(3)244-248, 2001
Concussion Grading – Zurich Guidelines

• However, the latest consensus statement (Zurich 2008) advises that concussions should not be graded at the time of injury, as there is little evidence to support that immediate symptoms (LOC, amnesia, balance deficits) correlate with recovery time.

• Instead, concussion severity is best measured by how long signs and symptoms of a concussion remain.

• Additional updates.
Return-to-Play Guidelines Update

- After an athlete suffers a concussion, only a medical professional (athletic trainer, doctor, etc.) should clear them to return to play.

- Coaches SHOULD NOT make return-to-play decisions.

- For educational purposes, the following is a background on methods medical professionals use to determine when it is safe for an athlete to return-to play.

<table>
<thead>
<tr>
<th>Severity</th>
<th>1st Concussion</th>
<th>2nd Concussion</th>
<th>3rd Concussion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade 1</td>
<td>May return-to-play if asymptomatic for &gt; 1 week</td>
<td>Return to play in 2 weeks when asymptomatic for 1 week</td>
<td>Terminate season; may return to play next season if asymptomatic</td>
</tr>
<tr>
<td>Grade 2</td>
<td>May return-to-play if asymptomatic for &gt; 1 week</td>
<td>Minimum of 1 month; may then return-to-play if asymptomatic for &gt; 1 week</td>
<td>Terminate season; may return to play next season if asymptomatic</td>
</tr>
<tr>
<td>Grade 3</td>
<td>Minimum of 1 month; may then return-to-play if asymptomatic for &gt; 1 week</td>
<td>Terminate season; may return to play next season if asymptomatic</td>
<td></td>
</tr>
</tbody>
</table>
When to Return to the Same Game

• Historically, some experts have advocated allowing athletes to return to the same game if symptoms clear within 15 minutes.

• However, recent research indicates it may never be safe to return high school aged athletes and below to the same game.

• SLI and the 2008 “Zurich Guidelines” recommend never returning youth athletes to the same game.
  - The younger the athlete, the longer he or she should be held out for the same concussion.

When in doubt, sit them out!
Differential Response to Concussion - Age

- Even though you often see professional athletes return to the same game after a concussion, do not think the same rules apply to your youth athletes.

- Medical research indicates that the younger the brain:
  - The longer it takes for the athlete to recover
  - The greater the risk of Second Impact Syndrome
  - The more damage the concussion can cause

- Among the potential reasons -
  - The immature brain is approximately 60 times more sensitive to glutamate-mediated N-methyl-D-aspartate excitotoxic brain injury.
Concussion Management

- Proper concussion management is complicated and involves many pieces that fit together like a puzzle.
The period between the concussion and recovery is often referred to as a "window of vulnerability", as return-to-play during this time could cause more severe or even catastrophic brain injury.

Figure 9-1. Neurometabolic cascade following experimental brain injury in the rat.

* Giza and Hovda (2000)
Post-concussion syndrome

• Every athlete has post-concussion symptoms – post-concussion syndrome (PCS) is name given to the varied constellation of prolonged symptoms that around 5-10% of athletes seem to suffer.
  – An athlete usually isn’t considered as having PCS until his symptoms have persisted for over 4 weeks

• As of 2008, there is no way to predict which athletes will recover more quickly and which will suffer PCS.

• Athletes who suffer from PCS sometimes need to take time away from school, and often suffer from headaches, anxiety, depression, and fatigue.
Second-Impact Syndrome

- **Second Impact Syndrome** occurs when an athlete, who has already sustained a head injury, sustains a second head injury before symptoms have cleared from the first injury.

- This second blow to the head, sometimes minor, can result in a loss of auto regulation of the brain's blood supply. Loss of autoregulation leads to brain swelling. This results in increased intracranial pressure and leads to hemorrhage of the brain.

- The average time from second impact to brainstem failure is quite rapid, taking two to five minutes. 50% of SIS sufferers die, and the survivors rarely recover fully.

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**Young Players, Serious Injuries**

- **The New York Times**
  - September 16, 2007 - At least 50 high school or younger football players in more than 20 states since 1997 have been killed or have sustained serious head injuries on the field, according to research by The New York Times.

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Second Impact Syndrome - Case Study

The Event

- 5-foot-1-inch high school freshman fullback Jake S. had just finished a play on the field. He was able to return to the huddle but then collapsed as he was leaving the huddle and slipped into a coma.
- He died a few days later.

A Concussion the Week Before?

- **Prior Game** - "He went out for a halfback pass. As soon as he caught the ball, he got hit. It caught him more in the face mask than in the head. It tweaked his neck a little bit. He came out for a few plays. He went back in and finished the game."

- **Friends Knew** - Friends told authorities that Jake complained of headaches the week before the tragedy. His father said it didn't appear as if he had any symptoms of a concussion after the last game.
Duration of “Window of Vulnerability”

- The duration of the “window of vulnerability” is unknown and varies from athlete to athlete.

- Some computerized neuropsych testing shows that by measuring cognitive function, it may be unsafe for about half of high school athletes to return for at least a week. Some athletes may take weeks or months.

<table>
<thead>
<tr>
<th>Time since concussion</th>
<th>Percent of athletes who have not returned to normal cognitive function*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 week</td>
<td>More than 50%</td>
</tr>
<tr>
<td>2 weeks</td>
<td>~25%</td>
</tr>
<tr>
<td>3 weeks</td>
<td>10 to 20%</td>
</tr>
</tbody>
</table>

Concussions are like snowflakes - 
No two are the same

*Estimates based on multiple sources
Gender and Concussions

**The Facts**

- Females tend to suffer more reported concussions than males that play the same sport.
  - High school basketball – Females are diagnosed with 3x more concussions
  - High school soccer - Females are diagnosed with 68% more concussions
- Females tend to have longer recoveries than males in the same sport.

**The Theories**

- **Honesty** - females are more likely to report concussion symptoms than males.
- **Physiologic** - hormone differences between males and females may account for a differing concussion experience.
- **Biomechanical** - males tend to have stronger necks, which may absorb some of the force of a blow.
Stepwise Return-to-Play

- Once the player is out, the simplest return to play guideline involves step-wise RTP

- When returning athletes to play, they should follow a stepwise symptom-limited program, with stages of progression. For example:
  - rest until asymptomatic (physical and mental rest)
  - light aerobic exercise (e.g. stationary cycle)
  - sport-specific exercise
  - non-contact training drills (start light resistance training)
  - full contact training after medical clearance
  - return to competition (game play)

- There should be approximately 24 hours (or longer) for each stage and the athlete should return to stage 1 if symptoms recur. Resistance training should only be added in the later stages. **Medical clearance should be given before return to play.**

* Summary and Agreement Statement of the Second International Symposium on Concussion in Sport, Prague 2004
Key Guidelines

• The only established way to recover from a concussion more quickly is through **physical and mental rest**.

• The most important guideline to remember is that no athlete should return to participation while still symptomatic – first, at rest; and then at exertion.
  – This includes the presence of headache related to a concussive episode.

• Athlete cannot return to play until neuropsychological testing battery has returned to baseline score or higher (in applicable)
Special Considerations

Concussion History

- Athletes with a **history of concussion** tend to have prolonged symptoms and worse outcomes. Return-to-play with those athletes should be managed *even more* cautiously.

Recent Concussion

- Athletes who have had a **recent concussion** tend to have prolonged symptoms and worse outcomes. Return-to-play with those athletes should be managed *even more* cautiously.

Severity of Hit that Produces Concussion

- If a **minor impact** produces **severe or prolonged concussion symptoms**, it raises a red flag. Return-to-play with those athletes should be managed *even more* cautiously.
Role of Neck Strength in Concussion

Strong Neck = Lower Concussion Risk

• Studies indicate that a stronger neck can help absorb some of the force of a collision, thus reducing the force that reaches the brain
  − Head injury criterion (HIC), a force used to measure concussion risk, is proportional to
    \[
    \text{Change in Velocity}^4 / \text{Distance}^{1.5}
    \]

• Therefore a small change in velocity can lead to an enormous reduction (to the power of 4) in concussion risk

• SLI recommends strengthening the neck muscles, especially the ones that resist rotation, to lower the risk of concussion

• Do not bridge!
Helmets

• Protective headgear is designed and tested by the manufacturer to meet standards created by the National Operating Committee on Standards for Athletic Equipment (NOCSAE).
  – Helmets are tested at various impact forces at multiple temperatures and impact locations on the helmet.

• Due to the imperfect nature of the testing, it is difficult to claim one helmet is always better than another. There are, however, a few guidelines that can be issued with confidence.
  – New helmets test better than older helmets
  – Proper fitting are safer. Proper fit means:
    ▪ You cannot move the helmet without moving the head (no spin)
    ▪ The helmet cannot impair vision

• One football helmet manufacturer using new technology recently performed considerably better than their competitors on the NOCSAE tests. Helmets are expected to continue to improve.
Teach Athletes to Treat Head Injuries Differently

Injured vs. hurt

Always Injured
Teach Athletes to Report Each Other’s Concussions

- Coaches should have this conversation with their team each season!

- Dr. Edward Nichols,
  - Harvard Football Team Doctor 1905

  “In case any man in any game got hurt by a hit on the head so that he did not realize what he was doing, his teammate should at once insist that time be called and that a doctor come onto the field to see what is the trouble.”