New Frontiers in the Science of Concussion

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Statement of Disclosure

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ImPACT Applications, Inc.
Developer of ImPACT Test

Paid Consultant: (World Wrestling Entertainment (WWE)

Volunteer consultant (past or present)
  The National Football League (NFL)
  The National football League Players Association (NFLPA)
  The National Hockey League (NHL)
  Major League Baseball
  NASCAR
  Formula 1 Racing/Indianapolis Racing League
  US Olympic Team
  Major League Soccer
  US Ski and Snowboard Team
  Special Olympics
Why Focus on Youth Sports?

- Kids represent the largest and most vulnerable group when it comes to concussion
- Few services are available for children below High school
- Relatively few studies have been completed with young children
- But... the landscape is changing

- Odds of playing in college are 1 in 90
- 35 millions kids play organized sports
  - 66% of boys, 52% of girls
- 60 Percent of all kids play sports out of school
- Over 1 million boys play football
Why Worry about Concussions in Children?

- Children’s brains are more vulnerable to injury
- Most concussions occur in children, not adults
- Injury can seriously interfere with school
- Children often deny their symptoms
- Children’s are more likely to be seriously injured
  - Second Impact Syndrome (SIS)
Facts and Statistics

- At least 10% of all contact sport athletes sustain concussions yearly (probably low) up to 3.8 million injuries per year in US (CDC)

- 63% of all concussions occur in football

- An athlete who sustains concussion is 4-6 times more likely to sustain a second concussion

- Girls have a higher rate in some sports

- The best way to prevent problems with concussion is to manage them effectively when they occur
Second Impact Syndrome

**Occurs in athletes with prior concussion following relatively minor second impact**
- A number of recent cases (New Jersey, Pennsylvania, Washington)
- Second impact has been shown to occur up to 14 days post-injury
- Athlete returns to competition before resolution of symptoms

**Catastrophic increase in intracranial pressure**
- Vasomotor paralysis, edema, massive swelling, herniation, death

**Most often occurs in athletes <19 years old**
- Neuro-chemical processes appear to differ in developing brain
Concussion Management Legislation
Zach Lystedt returned to play by coach after two injuries in one game.

Second injury produced malignant brain swelling and permanent brain damage.

State of Washington passed law requiring evaluation prior to return to play.

At least 48 other states have Bill’s pending (including Pennsylvania)
Definition of Concussion

An Evolving Understanding
A concussion (or mild traumatic brain injury) is a complex pathophysiological process affecting the brain, induced by traumatic biomechanical forces secondary to direct or indirect forces to the head. Disturbance of brain function is related to neurometabolic dysfunction, rather than structural brain injury and is typically associated with normal structural imaging findings (CT Scan, MRI). Concussion may or may not involve a loss of consciousness. Concussion results in a constellation of physical, cognitive, emotional, and sleep-related symptoms. Recovery is a sequential process and symptoms may last from several minutes to days, weeks, months, or even longer in some cases.
<table>
<thead>
<tr>
<th>SYMPTOM</th>
<th>PERCENT</th>
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<tbody>
<tr>
<td># 1  Headache</td>
<td>75%</td>
</tr>
<tr>
<td># 2  Difficulty Concentrating</td>
<td>57%</td>
</tr>
<tr>
<td># 3  Fatigue</td>
<td>52%</td>
</tr>
<tr>
<td># 4  Drowsiness</td>
<td>51%</td>
</tr>
<tr>
<td># 5  Dizziness</td>
<td>49%</td>
</tr>
<tr>
<td># 6  Foggy</td>
<td>47%</td>
</tr>
<tr>
<td># 7  Feeling Slowed Down</td>
<td>46%</td>
</tr>
<tr>
<td># 8  Light Sensitivity</td>
<td>45%</td>
</tr>
<tr>
<td># 9  Balance Problems</td>
<td>39%</td>
</tr>
<tr>
<td># 10 Difficulty with Memory</td>
<td>38%</td>
</tr>
</tbody>
</table>
Recovery from Concussion: How Long Does it Take?

WEEK 1
- 40% RECOVERED

WEEK 2
- 60% RECOVERED

WEEK 3
- 80% RECOVERED

N=134 High School Male Football Athletes

Collins, Lovell et al.; Neurosurgery, 2006
Biomechanics of Concussion
Biomechanics of Injury

• Force Vectors
  – Newton’s 2nd Law (F=ma)

• Linear (translational)
  – Compression and possible stretching of neural tissue

• Rotational (angular)
  – An angular acceleration of the head around the midline axis
  – More likely to result in a concussion when the force is directed laterally
Linear Injury

Head stops suddenly, brain moves within skull
Hit from side causes rapid rotation of the head and rotation of the brain within the skull
Pathophysiology of Concussion
During injury, potassium ions (K⁺) rush out of the cell...
Neuron Following Concussion

After many days
New Technology

✅ New devices to measure force

- Helmet-based
- Mouth guards
- Ear piece
- Wearable technologies

Never a substitute for diagnosis by health care professional or other trained adult
The HITS-System Helmet
Gathering “Real Time” Telemetric Data
Measuring the Number of Hits
Management of Concussion

It makes a big difference....
A Very Brief History of Concussion Management

1980’s
Guidelines
“3 strikes and you're out”
Clinical Consensus

1990’s
More Guidelines (+20)
Cognitive Testing

2000
Computer based cognitive testing
“Corner Stone” Balance assessment
Explosion of research
Individual management

2010—
Media barrage
Cognitive testing is standard
Gizmo’s and gadgets
Evolution of more effective treatment approaches
The **Pittsburgh Steelers** Program

- First program to monitor professional athletes
- Resulted in league wide programs in NFL
- Resulted in adoption by other sports/leagues/Colleges
- Currently over **8 million kids have been tested**
Establishing a Clinical Service for the Management of Sports-Related Concussions

The clinical management of sports-related concussions is a specialized area of interest with a lack of empirical findings regarding best practice approaches. The University of Pittsburgh Medical Center Sports Concussion Program was the first of its kind; 13 years after its inception, it remains a leader in the clinical management and research of sports-related concussions. This article outlines the essential components of a successful clinical service for the management of sports-related concussions, using the University of Pittsburgh Medical Center Sports Concussion Program as a case example. Drawing on both empirical evidence and anecdotal conclusions from this high-volume clinical practice, this article provides a detailed account of the inner workings of a multidisciplinary concussion clinic with a comprehensive approach to the management of sports-related concussions. A detailed description of the evaluation process and an in-depth analysis of targeted clinical pathways and subtypes of sports-related concussions effectively set the stage for a comprehensive understanding of the assessment, treatment, and rehabilitation model used in Pittsburgh today.

KEY WORDS: Concussion, Mild traumatic brain injury, Ocular-motor, Rehabilitation, Vestibular

Neurosurgery 75:571–581, 2014
DOI: 10.1227/NEU.0000000000000471
www.neurosurgery-online.com
Multidisciplinary Concussion Management: A Clinical Model

- Pediatric Practices
- Emergency Departments
- Certified ATC’s/Primary Care Sports Med
- PM & R
- Vestibular / Physical Therapy
- Neuro Radiology
- Neurology NeuroSurg.
- Behavioral Optometry
- Primary Care Physicians
- UPMC Concussion Program
Concussion Continuum of Care

“Tools in the tool Box”

Pre-season

Baseline Testing
- Supervised at School
  Or clinic

Concussion
- Remove From Play
  - Sideline Testing
  - Balance

1-3 Days

First Follow-Up
- Evaluation
  - ImPACT
  - Balance
  - Vestibular

Follow-up Testing as needed
- Back to baseline?
- Normal
  Vest/Balance
- No symptoms/w
  exertion
Unique Contributions of Neurocognitive Assessment to Concussion Management

Testing reveals cognitive deficits in asymptomatic athletes within 4 days post-concussion.

N=215, MANOVA p<.000000

(Fazio, Lovell, Collins et al., Neurorehabilitation, 2007)
What About Younger Children?

✓ Currently limited of repeatable tests for kids 10 and under

✓ Widespread baseline testing makes computer based testing useful (in conjunction with more standard procedures)

We are currently testing new iPad based test in a number of settings:
✓ Over 1,000 kids tested nationally
✓ Special Olympics of New Jersey program
✓ Clinical availability in early 2015
## UPMC Typical Evaluation

<table>
<thead>
<tr>
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<tbody>
<tr>
<td><strong>✓</strong> Balance and Vestibular-Ocular Screening</td>
</tr>
<tr>
<td><strong>✓</strong> Computerized Neurocognitive Assessment (and other Tests)</td>
</tr>
</tbody>
</table>

### Same day patient feedback
- Severity of Injury?
- Prognosis for Recovery?
- Neuroimaging indicated?
- PMR/Vestibular/Optometry referral?
- Level/type of Physical Exertion Allowed?
- Level of Cognitive Exertion Allowed?
- Academic Accommodations?
- Return to Play?

### Communication to parents ATC, Doctors, Schools