

Concussion and Computerized Testing.



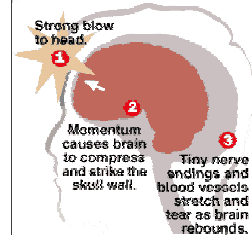
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What happens in a concussion?

- Head motion and intracranial contact leads to:
- Axonal shear and alterations in cerebral protein metabolism.
- Changes in EEG.
- Changes in cognitive function, information processing and short term memory.

Watch your head

Studies have shown that a teenager's thinking abilities can suffer from two or more significant blows to the head. Here's a look at how a concussion occurs.



Do we care about concussions? The "Good" old days.

- Diagnosis of exclusion.
- No LOC--no concussion.
- No brain damage.
- If no signs of increased intra-cranial pressure--no problem.
- Home with a head injury sheet
- Wake up every hour!!!!

Do we care about concussions? The current world view.

- Better research data. Impact, CogSport
- Media attention.
- Greater risk of further injury due to problems with information processing.
- Post-concussion syndrome.
- Long term cognitive difficulties
- Second Impact Syndrome.

- Neurosurgery. 2002 Nov;51(5):1175-9;
Cumulative effects of concussion in high school athletes. Collins MW, et al

METHODS: 163 athletes who experienced sports-related concussion composed the initial study group. Sixty athletes with no concussion history were compared with 28 athletes with a history of three or more concussions. The groups were compared in terms of the on-field presentation of symptoms after an in-study concussion.

- **CONCLUSION:** This study is the first to suggest a cumulative effect of concussion in high school athletes. A more severe on-field presentation of concussion markers is evidenced in high school athletes with a pronounced history of concussion. This study's findings highlight the need for more long-term outcome studies in high school athletes who sustain sports-related concussions.

Am J Sports Med. 2002 Mar-Apr;30(2):157-62.

No evidence of impaired neurocognitive performance in collegiate soccer players.

Guskiewicz et al

Despite an average of 15.3 seasons of soccer exposure and a higher prevalence of previous concussions, the soccer athletes did not demonstrate impaired neurocognitive function or scholastic aptitude when compared with the nonsoccer athletes or the student nonathletes. Additionally, there was no significant relationship between a history of soccer-related concussion and either neurocognitive performance or scholastic aptitude. Neither participation in soccer nor a history of soccer-related concussions was associated with impaired performance of neurocognitive function in high-level United States soccer players.

Grading of concussions.

- Were intended to help guide management
- Based on loss of consciousness and amnesia.
- Arbitrary and not reflective of pathology.
- Post-concussion syndrome.
- If you're out, you're out.
- If you can't remember, you can't return.
- Other key component is cognitive function.

Assessment of cognitive function

- Orientation in 3 spheres.
- Serial 7's: Timed 30 sec to 50
- Months of the year in reverse. 12 sec.
- Timing tests adds useful information.
- "Normal" information processing not known for most patients.

Assessment of cognitive function

- Maddocks et al Clin J of Sport Med 1995.
- Questions regarding newly acquired information more sensitive than orientation questions.
- Maddocks eight questions valid assessment of concussion.
- Who, who, who, who, who, where, what day is it, what date is it.

Non-computerized pre-season documentation of cognitive function.

- Documentation is possible.
- Digit symbol substitution test. DSST
- Documents speed of information processing in an objective fashion.

DSST

- Hinton et al. J. Clin Exp Neuropsych 1997.
- Scores improve with practice.
- Scores decline with mild head injury in rugby players.
- DSST is sensitive to decreases in speed of information processing.
- Untimed word recognition not sensitive.

Name: _____
Date: _____

Digit	1	2	3	4	5	6	7	8	9	Score														
Symbol	—		□	⊏	⊐	○	△	×	≡	□														
Samples	2	1	3	7	2	4	8	2	1	3	2	1	4	2	3	5	2	3	1	4	5	6	3	1
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	1	5	4	2	7	6	3	5	7	2	8	5	4	6	3	7	2	8	1	9	5	8	4	7
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	9	2	8	1	7	9	4	6	8	5	9	7	1	8	5	2	9	4	8	6	3	7	9	8

Standardized Assessment of Concussion (SAC)

- McCrea et al. J. of Head Trauma Rehab April 1998.
- Paper guided clinical evaluation
- 568 Normal football players.
- 33 concussed-Tested by AT on site.
- Score dropped after concussion compared with pre-season, and returned to normal after 48 hours.

SAC

- More useful for acute diagnosis of head injured patient than pre-season documentation.
- More cumbersome than DSST.
- More than just speed of information processing.
- Helpful organizer for clinic inventory or student PT/AT.

Serum myelin basic protein levels.

- Mau et al-chinese journal 1995
- Levels of MBP not elevated in concussed patients.
- Elevated with cerebral contusion and hematomas
- No difference between contusion and hematoma.

Protein S-100 Levels

- Protein S-100 is a calcium binding protein made in astroglial cells in all parts of the CNS.
- Its levels have been shown to be elevated in mild head injury.
- Waterloo et al. Acta Neurochir-Wien 1997.
- Elevated blood levels were predictive of neurocognitive anomalies after 12 months.
- Speed of information processing was key.

Computer based neuropsychological testing. The next frontier.



The Best Approach To Concussion Management

WHAT DOES COMPUTERIZED NEUROCOGNITIVE TESTING ENABLE US TO DO?




- Quantify the injury with a highly sensitive measure of brain function
- Protect the student athlete.
- Help determine safe return to play.
- Help prevent cumulative effects of multiple concussions
- Provides objective data to help determine athlete's injury status
- Prevent lingering effects of concussion and potential catastrophic injury



FACTS AND STATISTICS


- 10% of all contact sport athletes sustain concussions yearly
- 63% of all concussions occur in football (USA)
- Estimated that up to 20% of football players will sustain a concussion per season.
- An athlete who sustains concussion is 4-6 times more likely to sustain a second concussion
- "Bell ringers" or mild concussions account for 75% of all concussive injuries
- Effects of concussion are cumulative in athletes who return to play prior to complete recovery
- The best way to prevent problems with concussion is to manage them effectively when they occur



ON-FIELD SIGNS/SYMPTOMS OF CONCUSSION

<u>Concussion Signs</u>	<u>Concussion Symptoms</u>
<ul style="list-style-type: none"> • Appears dazed • Confused about play • Answers question slowly • Personality/behavior change • Forgets plays prior to hit • Retrograde amnesia • Forgets plays after hit • Anterograde amnesia 	<ul style="list-style-type: none"> • Headache • Nausea • Balance problems • Double vision • Photosensitivity • Feeling sluggish • Feeling foggy • Change in sleep pattern • Cognitive changes

• Loss of consciousness



SPORTS-RELATED CONCUSSION: Topics of Concern


Return to Play
- Current guidelines are not data driven.

CT and MRI insensitive to subtleties of injury.
- CAT scans & the standard MRI Scans do not indicate if there are physiological changes in the concussed brain - since these instruments study structure and not FUNCTION.

Self-report determines management directives. Is it reliable?

ImPACT: A TOOL FOR EVALUATING CONCUSSION
(Immediate Post-Concussion Assessment and Cognitive Testing)

- Computerized test developed by clinical researchers at the University of Pittsburgh Medical Center (UPMC)
- Developed to allow for a more objective assessment of concussion and recovery
- Accounts for individual differences in cognitive ability and symptom reporting through the use of baseline testing
- Provides a common metric which allows for effective collaboration between athletic trainers, coaches, physicians, and neuropsychologists in concussion management




WHAT DOES ImPACT MEASURE?

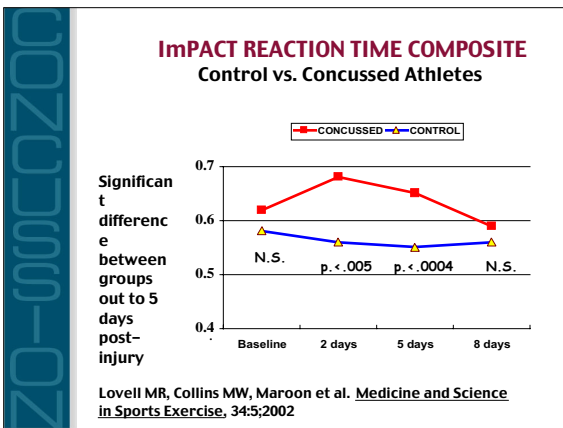
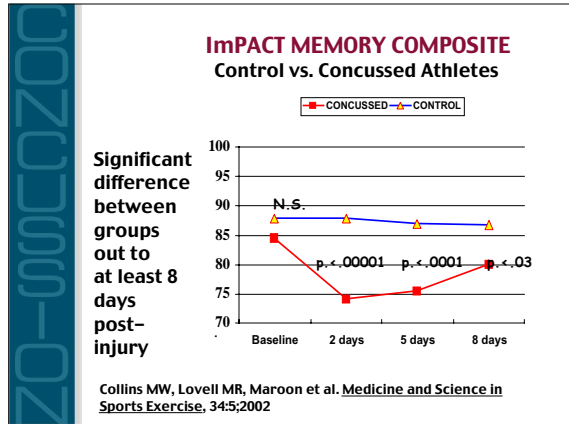
- **Demographic/Concussion History Questionnaire**
- **Concussion Symptom Scale**
- 21 Item Likert scale (e.g. headache, dizziness, nausea, etc)
- **Eight Neurocognitive Measures**
- Measures domains of Memory, Working Memory, Attention, Reaction Time, Mental Speed, Verbal Memory, Visual Memory, Reaction Time, Processing Speed - Summary Scores
- **Detailed Clinical Report**
- Automatically computer scored
- Outlines demographic, symptom, neurocognitive



ImPACT Overall Injury Sample 2000–2002



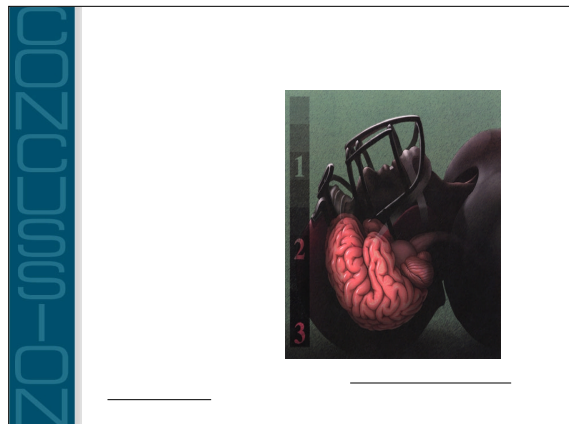
- Over 4,500 athletes in baseline sample
- 410 athletes suffered concussion during season
 - Evaluated within 2 days of injury
 - Re-evaluated at days 5 and 8 post-injury
 - 243 high school, 141 college, 26 other athletes
- 272 male concussions, 138 female concussions
- Compared to 100 HS and College controls

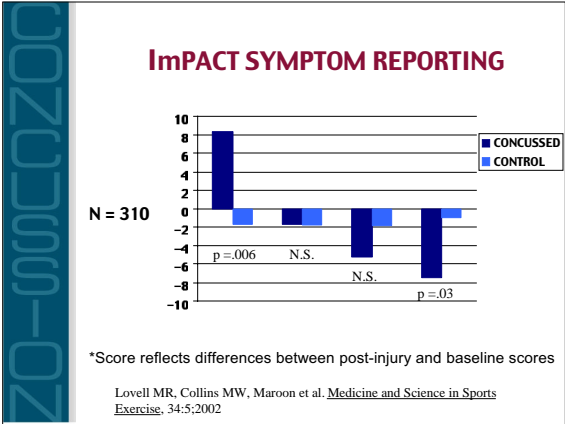


- Up to 8 days.

Concussion management: problem

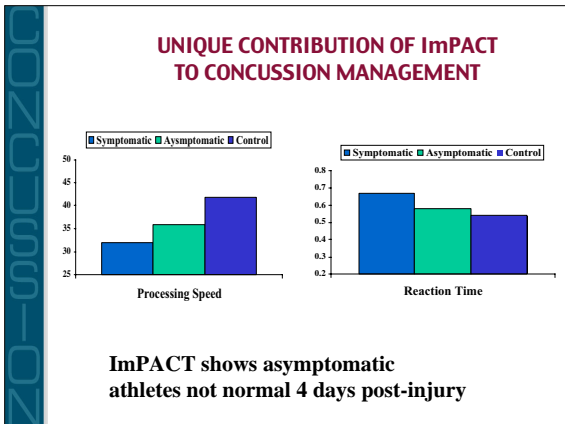
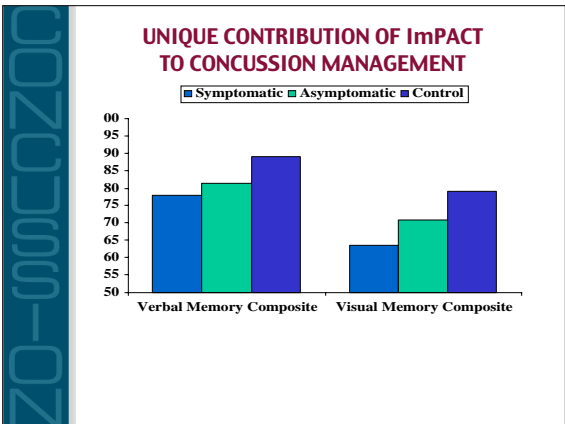
- Management is largely based on subjective report from concussed individual.
- Concussed patient may not give reliable history
- History may not uncover bona fide neurocognitive anomalies.





Take home point

- Concussed athlete may have no symptoms despite having a significant information processing deficit
- Concussed athletes may under-report their symptoms.



Take Home Point

- Symptoms used to guide concussion management have been proven to be unreliable.
- Physical examination and advanced imaging are not reliable.
- Only computerized neurocognitive or other neuropsychological testing has been proven reliable.

Lovell, Collins, Iverson, Field, Podell, Cantu, Fu; *J Neurosurgery*; 98:296-301,2003
 Lovell, Collins, Iverson, Johnston, Bradley; *Amer J Sports Med*; 32:47-54,2004

UPMC HEALTH SYSTEM
PITTSBURGH, PENNSYLVANIA
affiliated with the University of Pittsburgh schools of the health sciences

- Athletes with <5 min of signs/symptoms
- Athletes with 5- 15 min of signs/symptoms

>>

ImPACT SYMPTOM SCALE SCORES

Brief versus Prolonged On-field Mental Status Changes

Time Point	5-15 min	<5 min	P-value
Baseline	~10	~10	
DAY 2	~35	~20	P < .003
DAY 4	~25	~10	P < .061
DAY 7	~10	~5	NS

Lovell, Collins, Iverson, Field, Podell, Cantu, Fu; *J Neurosurgery*; Feb, 2003

ImPACT MEMORY COMPOSITE SCORES

Brief versus Prolonged On-field Mental Status Change

Time Point	5-15 min	<5 min	P-value
Baseline	~85	~85	
DAY 2	~78	~65	P < .02
DAY 4	~80	~68	P < .004
DAY 7	~85	~75	P < .03

N = 64 High School Athletes

Lovell, Collins, Iverson, Field, Podell, Cantu, Fu; *J Neurosurgery*; 98:296-301,2003
Lovell, Collins, Iverson, Johnston, Bradley; *Amer J Sports Med*; March

“BELL-RINGER” SUMMARY

First study to challenge assumption that Grade 1 or mild concussion in high school athletes is associated with rapid and complete recovery


- Findings contrary to most grading systems (AAN)
- Recovery from concussion may not be linear process
- Symptoms resolve earlier than neurocognitive deficits
- Should high school athletes diagnosed with concussion ever be allowed to return to

UPMC SPORTS CONCUSSION PROGRAM

Presence of headache at 7 days post-concussion is highly predictive of neurocognitive deficits on ImPACT (Collins, Field, Lovell et al; *American Journal of Sports Medicine*; May 2003)


- High school athletes with a history of ≥3 prior concussions are up to 9X more likely to have more severe on-field presentation following subsequent concussion (Collins et al., *Neurosurgery*, Nov, 2002).

- High school athletes with concussion demonstrate more protracted neurocognitive recovery when compared to college athletes (Field, Collins, Lovell et al., *Journal of Pediatrics* May, 2003).
- On-field Amnesia up to 10X more predictive than LOC in predicting outcome (Collins et al., *Clinical Journal of Sport Medicine*, July 2003)




UPMC SPORTS CONCUSSION PROGRAM

- No athlete should return to play with symptoms of concussion (caution with lack of symptoms)
- All athletes should be properly evaluated after concussion
- ImPACT is currently available as an effective clinical “tool” for all levels of contact sport participation

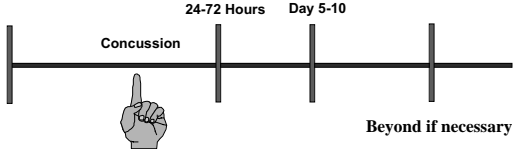


UPMC RETURN TO PLAY PROTOCOL Stage 2 - Follow-Up Evaluation


- ImPACT Assessment
 - Evaluation should occur during acute period of injury
 - Assessment includes Clinical Interview and ImPACT
 - Follow-up evaluations can occur approx every 5 days
- Return to Baseline (or estimated preinjury status)
 - Symptom data
 - Cognitive data
- Return to Exertion/Practice
- Return to Competition



Clinical Protocol ImPACT Testing




The diagram shows a horizontal timeline with four vertical tick marks. The first tick mark is labeled 'Concussion' with a hand icon pointing to it. The second tick mark is labeled '24-72 Hours'. The third tick mark is labeled 'Day 5-10'. The fourth tick mark is labeled 'Beyond if necessary'.




Why Schools Should Use ImPACT

- Concussions are one of the most serious medical problems at the High School level
- Proper management of concussion is the best form of prevention of serious injury
- An increasing number of schools are being sued each year for concussion mismanagement
- Parents appreciate the information provided by ImPACT about their injured child



If Used Correctly, ImPACT will...

- Help determine severity of concussion
- Provide valuable information to the athlete, parents, athletic trainers, physicians
- Provide information on academic deficits associated with concussion
- Identify cognitive deficits in athletes with no symptoms



ImPACT will NOT.....

- Prevent a concussion from occurring
- Eliminate the risk of concussion

Post-Concussion Syndrome

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- Headache
- Dizziness
- Nausea
- Fatigue
- Tinnitus
- Whiplash??

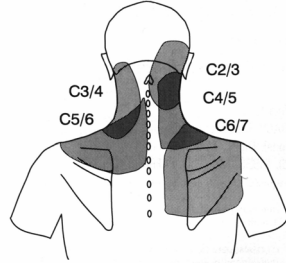


Figure 1. Maps showing the typical distribution of pain referred from each of the cervical zygapophysial joints when stimulated in normal volunteers (modified from Dwyer et al²⁹).

What about return to play?

- No return with loss of consciousness.
- No return with any post-traumatic amnesia.
- No return with post-concussive symptoms, tested with intense exertion.
- No return with neuro-psychological anomalies.
- Err on the side of caution as symptoms and signs are not reliable

Canadian Academy of Sport Medicine Guidelines

- Never return to sport while symptomatic.
- Grading not emphasized.
- Progress to next level when asymptomatic.
- Light exercise.
- Sport specific activity.
- On field practice without body contact.
- On field practice with body contact.
- Game play. *Clin. J. of Sport Med.* July 2000



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