Update: 4th International Consensus Conference on Concussions in Sports

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Sports and Recreation Concussions

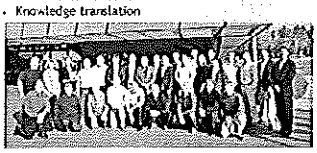
- CDC estimates that there may be as many as 3.8 million sports and recreation concussions annually in the United States
- Good news/bad news situation
  - In sports, tragedies due to concussions are often preventable

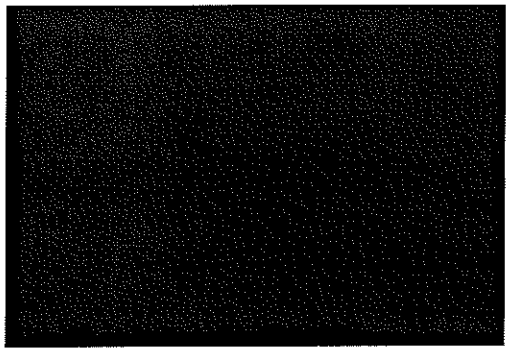
Disclosures

NFL Head, Neck and Spine Committee
Football and Wellness Committee USA Football
Medical Advisory Board Pop Warner Football
NCAA Task Force on concussion
Medical Advisory Board X2IMPACT

4th International Conference on Concussion in Sports

- 1st Vienna 2001, 2nd Prague 2004, 3rd Zurich 2008
- 4th meeting in Zurich 2012
  - NIH consensus development conference format
    - Pre-defined group of questions
    - Body of literature identified
    - Presentation by experts in open session day 1 and day 2
    - Discussion/debate closed session with consensus panel on day 3
    - Document drafted by authors and circulated to panel
    - Knowledge translation





Sports Concussion Definition

- *"Concussion is a brain injury and is defined as a complex pathophysiological process affecting the brain, induced by biomechanical forces. Several common features that incorporate clinical, pathologic and biomechanical injury constructs that may be utilized in defining the nature of a concussive head injury include..."*

McCrory P et al Consensus statement on concussion in sport the 4th International Conference on Concussion in Sport held in Zurich, November 2012 Br J Sports Med 2013;47:250–258

Definition

1. *Concussion may be caused either by a direct blow to the head, face, neck or elsewhere on the body with an "impulsive" force transmitted to the head.*
2. *Concussion typically results in the rapid onset of short-lived impairment of neurologic function that resolves spontaneously. However in some cases symptoms and signs may evolve over a number of minutes to hours.*
3. *Concussion may result in neuropathological changes but the acute clinical symptoms largely reflect a functional disturbance rather than a structural injury and as such, no abnormality is seen on standard structural neuroimaging studies.*
4. *Concussion results in a graded set of clinical symptoms that may or may not involve loss of consciousness. Resolution of the clinical and cognitive symptoms typically follows a sequential course. However it is important to note that in some cases, post-concussive symptoms may be prolonged.*

McCrory P et al. Consensus statement on concussion in sport-the 4th International Conference on Concussion in Sport held in Zurich, November 2012. Br J Sports Med 2013;47:250–258

Pathophysiology

- Metabolic changes that occur in the animal model, and thought to occur in humans include:
  - Alterations in intracellular/extracellular glutamate, potassium and calcium.
  - A relative decrease in cerebral blood flow in the setting of an increased requirement for glucose (i.e. increased glycolysis).
- This mismatch in the supply and demand of metabolism may potentially result in cell dysfunction and increase the vulnerability of the cell to a second insult.

Harmon K et al.: "American Medicine Society for Sports Medicine position statement: concussion in sport." Br J Sports Medicine, 47:15-26, 2013

Advanced Imaging

- Functional MRI (fMRI)
- Diffusion Tensor Imaging (DTI)
- MR-Spectroscopy (MRS)

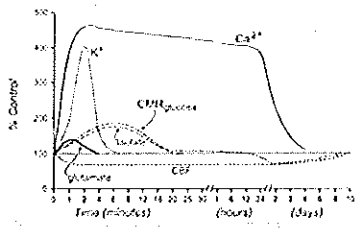


Figure 1. Neurometabolic cascade following concussion. K^+, potassium; $CMR_{glucose}$, cerebral metabolic rate of glucose utilization; Ca^{2+}, calcium; CBF, cerebral blood flow. With permission (adapted from Hovda et al[20]).

Advanced Imaging

- fMRI, DTI and MRS represent new neuroimaging techniques
- Evaluate brain injury & function;
  - Blood oxygenation
  - White matter axonal / structural integrity
  - Neurometabolites
- Research Tools
- Not yet ready for clearance/management decisions

Pathophysiology

- Brain injury evolves- not static
- Neuronal tissue vulnerability
- Hyperglycolysis and reduced CBF (regional)
- Brain needs time to recover

SELECTED ACUTE SIGNS AND SYMPTOMS SUGGESTIVE OF CONCUSSION

COGNITIVE	SOMATIC	AFFECTIVE
Confusion	Headache	Emotional lability
Post-traumatic amnesia (PTA)	Fatigue	Irritability
Retrograde amnesia (RGA)	Disequilibrium, dizziness	
Loss of consciousness (LOC)	Nausea/vomiting	
Disorientation	Visual disturbances (photophobia, blurry/double vision)	
Feeling "in a fog," "zoned out"	Phonophobia	
Vacant stare		
Inability to focus		
Delayed verbal and motor responses		
Slurred/incoherent speech		
Excessive drowsiness		

Herring SA (chair), et al.: "Concussion (Mild Traumatic Brain Injury) and the Team Physician: A Consensus Statement-2011 Update" Medicine and Science in Sports and Exercise. 2011; 43:2412-2422

Gender Comparable Sports

- Girls had a higher rate of concussions than boys
- Concussions represented a greater proportion of all injuries in girls' sports
- Girls had a greater proportion of concussions due to player-playing surface contact and player-equipment contact
- Except for track and field and swimming, girls had a higher proportion of recurrent concussion

Marar,M et al. AJSM 2012;40:747-755

SELECTED SIGNS AND SYMPTOMS SUGGESTIVE OF CONCUSSION

COGNITIVE	SOMATIC	AFFECTIVE	SLEEP
Confusion	Headache	Emotional lability Irritability	Drowsiness
Post-traumatic amnesia (PTA)	Fatigue		Sleeping less
Retrograde amnesia (RGA)	Disequilibrium, dizziness		Sleeping more
Loss of consciousness (LOC)	Nausea/vomiting		Trouble falling asleep
Disorientation	Visual disturbances (photophobia, blurry/double vision)		
Feeling "in a fog," "zoned out"	Phonophobia		
Vacant stare			
Inability to focus			
Delayed verbal and motor responses			
Slurred/inco-herent speech			

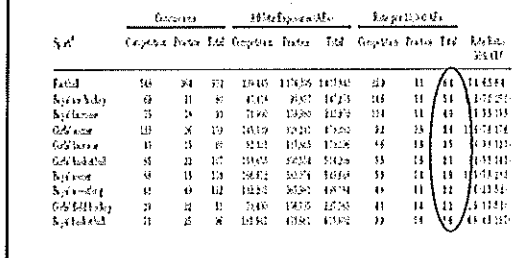
Herring SA (chair), et al.: "Concussion (Mild Traumatic Brain Injury) and the Team Physician: A Consensus Statement-2011 Update" Medicine and Science in Sports and Exercise. 2011; 43:2412-2422

Gender and Sports Concussions

- The role of female gender as a possible modifier in the management of concussion was discussed at length by the panel. There was no unanimous agreement that the current published research evidence is conclusive enough for this to be included as a modifying factor, although it was accepted that gender may be a risk factor for injury and/or influence injury severity

McCrory P et al. Consensus statement on concussion in sport the 4th International Conference on Concussion in Sport held in Zurich, November 2012 Br J Sports Med 2013;47:250–258

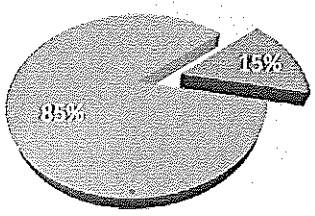
Epidemiology: Concussion Rates in High School Sports



Marar M et al. Epidemiology of Concussions Among United States High School Athletes in 20 Sports AJSM 2012;40:747-755

Symptom Duration

Multicenter, prospective, 5 year study
16,624 college and high school athletes
637 concussions



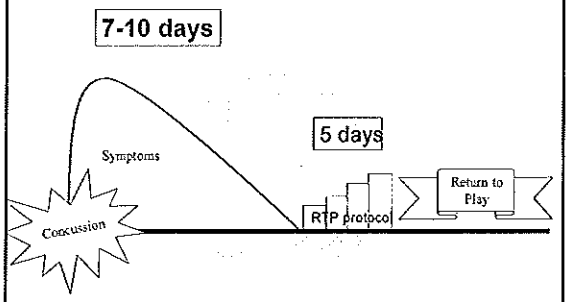
Morea M et al. Neurosurgery 2009,65:876-82

Sports Concussion Recovery

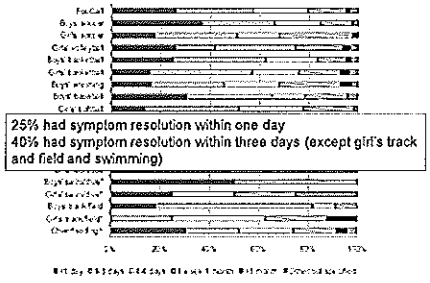
- Majority (80-90%) resolve in short (7-10 day) period
- May take longer in children and adolescents

McCrory P et al. Consensus statement on concussion in sport: the 4th International Conference on Concussion in Sport held in Zurich, November 2012 Br J Sports Med 2013;47:250–258.

The Basic Youth Sports Concussion Map



Concussion Symptom Resolution



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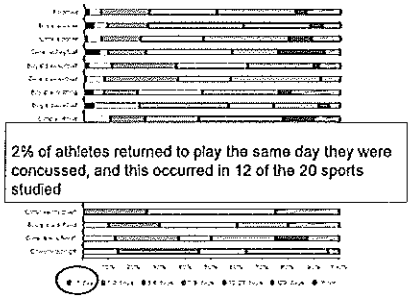
Length of Time For RTP After Concussion

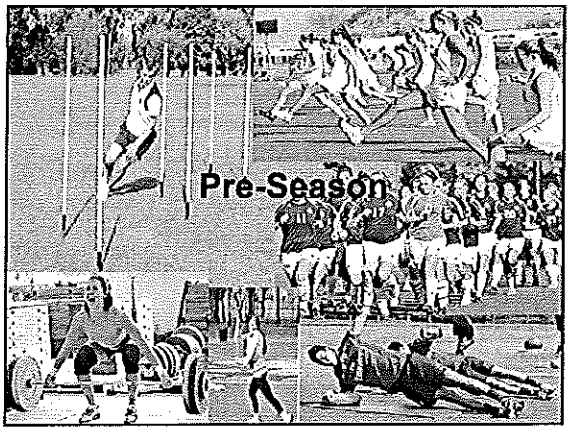


Marar M et al. Epidemiology of Concussions Among United States High School Athletes in 20 Sports AJSM 2012;40:747-755

Epidemiology of Severe Injuries Among United States High School Athletes

sport	Concussion (% >21 days)
Boy's football	5.9%
Boy's soccer	11.8%
Girl's soccer	7.7%
Girl's volleyball	8.9%
Boy's basketball	1.2%
Girl's basketball	6.6%
Boy's wrestling	3.3%
Boy's baseball	1.4%
Girl's softball	1.2%

Darrow, CJ et al. Am J Sports Medicine 2009 Sep;37(9) 1798-805



Pre-Season Planning

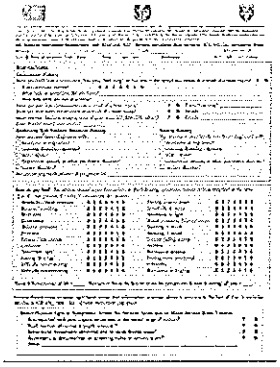
- Develop an emergency medical action plan, including guidelines specific to concussion management
- Incorporate a standardized baseline assessment tool for concussion that includes prior concussion history, risk factors for prolonged or complicated recovery, symptom checklist and neurological examination emphasizing cognitive function and balance (NFL, SCAT 3, Child-SCAT 3)
- Consider baseline neuropsychological testing
- Coordinate a team for concussion management (*e.g.*, physicians, certified athletic trainers and other health care providers, neuropsychologists, school officials) that is compliant with state laws and rules and regulations of governing bodies
- Educate athletes, parents/guardians, coaches, school officials and others

SCAT3™

Child-SCAT3™

Pocket CONCUSSION RECOGNITION TOOL™

Br J Sports Med 2013 47: 259 -262 , Br J Sports Med 2013 47:263-266, Br J Sports Med 2013 47: 267



Baseline

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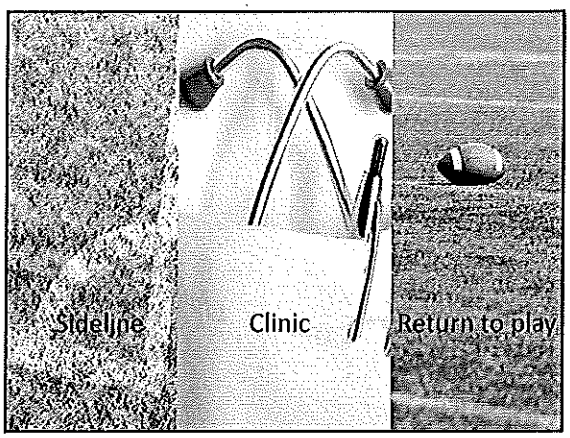

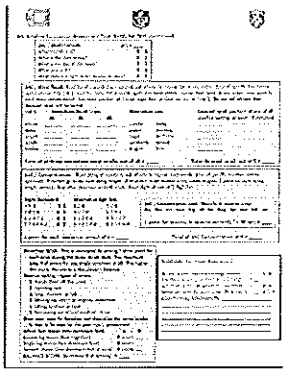

Baseline
Page 2

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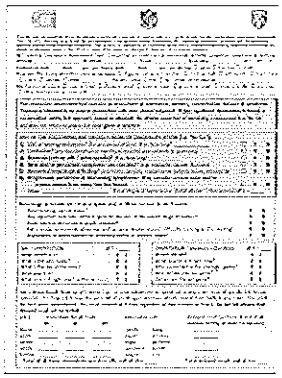
Sideline evaluation

Game-Day Evaluation & Treatment *Pre-Game*
It is *essential* to:

- Implement the game-day medical action plan specific to concussion.
- Understand the indications for cervical spine immobilization and emergency transport.

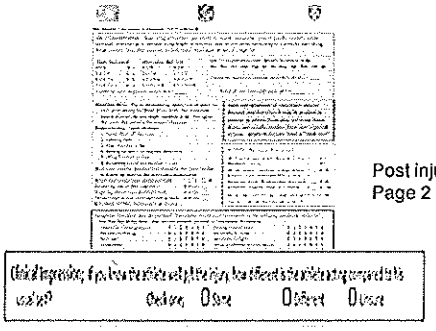



Post injury

www.uwmedicine.org/sportsconcussion

Game-Day Evaluation & Treatment
It is *essential* to:

- Evaluate the injured athlete on-the-field in a systematic fashion:
  - Assess for adequate airway, breathing, and circulation (ABC's).
  - Followed by focused neurological assessment emphasizing mental status, neurological deficit, and cervical spine status.
  - Determine initial disposition (emergency transport vs. sideline evaluation).



Post injury
Page 2

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Game-Day Evaluation & Treatment
Sideline/Dugout/Locker Room
It is *essential* to:

- Obtain a more detailed history and perform a more detailed physical examination (NFL, SCAT 3, Child-SCAT 3) and compare to baseline data if available
  - –Assess for cognitive, somatic, and affective signs and symptoms of acute concussion with particular attention paid to the number and severity of symptoms because of their prognostic significance

Game-Day Evaluation & Treatment *Sideline/Dugout*
continued It is *essential* to:

- Not leave the player unsupervised.
- Perform serial neurological assessments.
- Determine disposition for symptomatic and non-symptomatic players, including post-injury follow-up (options include home with observation or transport to hospital).
- Provide post-event instructions to the athlete and others (e.g., regarding alcohol, medications, physical exertion and medical follow-up).

Catastrophic Head Injuries in High School and College Football

- National Center for Catastrophic Sports Injury Research data from 1989-2002
- 94 cases
  - 75 subdural hematomas, 10 subdural with diffuse brain swelling, 5 diffuse brain swelling, 4 AVM or aneurysm
- 92 cases were in high school players
  - Boden et al. AJSM 2007; 35: 1075 - 1081

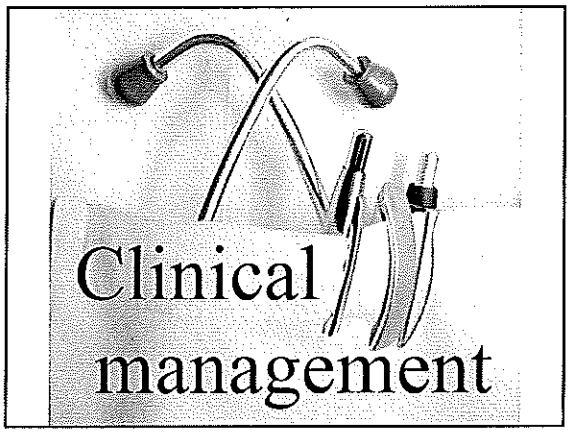
Return To Play

- It was unanimously agreed that no return to play on the day of concussive injury should occur.
- There are data demonstrating that at the collegiate and high school level, athletes allowed to RTP on the same day may demonstrate NP deficits post-injury that may not be evident on the sidelines and are more likely to have delayed onset of symptoms.

McCrory P et al. Consensus statement on concussion in sport: the 4th International Conference on Concussion in Sport held in Zurich, November 2012 Br J Sports Med 2013;47:250–258.

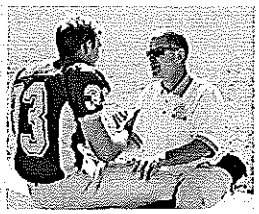
Catastrophic Head Injuries in High School and College Football

- 59% of athletes had a previous history of concussion(s):
  - 71% of those injuries occurred in the same season as the catastrophic injury
- 39% (21 of 54) of athletes at time of catastrophic injury were playing with residual symptoms from a previous concussion
  - Boden et al. AJSM 2007; 35: 1075 - 1081



Return-To-Play *Same-Day*
It is *essential* to understand:

- It is the safest course of action to hold an athlete out.
- When in doubt, sit them out.

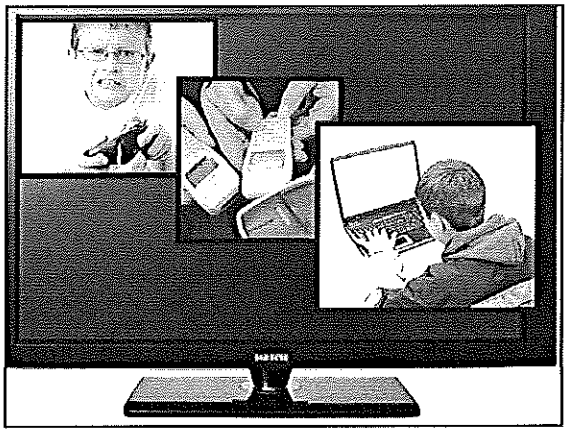


Management Principles

- All return to play guidelines are empiric
- Originally designed to prevent Second Impact Syndrome
- None were developed specifically for the young athlete

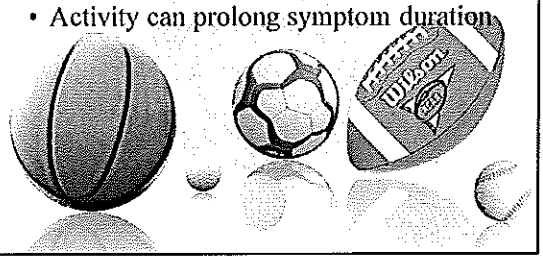
Post Game-Day Evaluation & Treatment It is *essential* to:

- Obtain a comprehensive history of the current concussion and of any previous concussion
  - Perform a physical examination, including a detailed neurological/cognitive evaluation. (NFL, SCAT 3, child-SCAT 3 as a component)
  - Determine the need for further evaluation and consultation.
  - Determine return-to-play status.



Physical Rest

- Activity can exacerbate symptoms
- Activity can prolong symptom duration

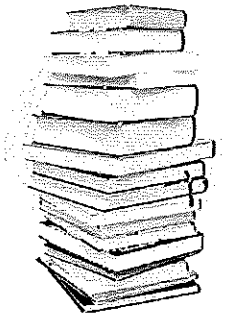


Rest

- The cornerstone of concussion management is physical and cognitive rest until the acute symptoms resolve and then a graded programme of exertion prior to medical clearance and RTP.

McCrory P et al. Consensus statement on concussion in sport, the 4th International Conference on Concussion in Sport held in Zurich, November 2012 Br J Sports Med 2013;47:250–258

(Relative) Mental Rest



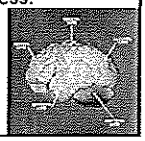
Rest

- The cornerstone of concussion management is physical and cognitive rest until the acute symptoms resolve and then a graded programme of exertion prior to medical clearance and RTP.
- The current published evidence evaluating the effect of rest following a sports-related concussion is sparse
- Low-level exercise for those who are slow to recover may be of benefit, although the optimal timing following injury for initiation of this treatment is currently unknown

McCrory P et al. Consensus statement on concussion in sport, the 4th International Conference on Concussion in Sport held in Zurich, November 2012 Br J Sports Med 2013;47:250–258

Post Game-Day Evaluation Neuropsychological Testing

- Understand the indications and limitations of neuropsychological testing.
  - Type and content of test data
  - Player age
  - One component of the evaluation process.



Management Principles

It is *essential* to

- Understand:
  - Brief LOC (seconds, not minutes) is associated with specific early deficits, but does not predict the severity of injury; therefore classification systems or RTP guidelines based solely on brief LOC are not accurate.
  - The number and duration of additional signs and symptoms (and neuropsychological data) are more accurate in predicting severity and outcome. RTP guidelines which address these issues are more useful.
  - Duration of symptoms is a major factor in determining severity, therefore severity of injury should not be determined until all signs and symptoms have cleared.
  - Initial treatment is rest-physical and cognitive
  - The treatment of and the RTP decision for the athlete with concussion must be individualized.

Herring SA (chair), et al : "Concussion (Mild Traumatic Brain Injury) and the Team Physician: A Consensus Statement-2011 Update" Medicine and Science in Sports and Exercise 2011; 43:2412-2422

Neuropsychological Testing

- NP testing may be used to assist RTP decisions and is typically performed when an athlete is clinically asymptomatic; however, NP assessment may add important information in the early stages following injury.
- There may be particular situations where testing is performed early to assist in determining aspects of management, for example, return to school in a paediatric athlete. This will normally be best determined in consultation with a trained neuropsychologist.

McCrory P et al. Consensus statement on concussion in sport: the 4th International Conference on Concussion in Sport held in Zurich, November 2012 Br J Sports Med 2013;47:250–258.

Management Modifiers

Post-Game Day

It is *essential* to:

- Consider modifiers which may affect RTP, including:
  - Severity of the current injury
  - Previous concussions (number, severity, proximity)
  - Significant injury in response to a minor blow
  - Age (developing brain may react differently to trauma than mature brain)
  - Sport
  - Learning disabilities
  - ADD/ADHD
  - Anxiety/Depression
  - Migraine Headache
- Understand controversy exists for post-game RTP decisions.

Herring SA (chair), et al : "Concussion (Mild Traumatic Brain Injury) and the Team Physician: A Consensus Statement -2011 Update" Medicine and Science in Sports and Exercise 2011; 43:2412-2422

Neuropsychological Testing

- Neuropsychological Tests
  - Baseline NP testing was considered by the panel and was not considered to be required as a mandatory aspect of every assessment however may be helpful or add useful information to the overall interpretation of these tests. It also provides an additional educative opportunity for the physician to discuss the significance of this injury with the athlete.

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FACTORS	MODIFIER
Symptoms	Number Duration (>10 days) Severity
Signs	Prolonged LOC (>1min) Amnesia
Sequelae	Concussive convulsions
Temporal	Frequency -repeated concussion over time Timing - injuries close together "Recency" - recent concussion or TBI
Threshold	Repeated concussions occurring with progressively less impact force or slower recovery after each successive concussion
Age	Child and adolescent (< 18 years old)
Co and Pre-morbidities	Migraine, depression or other mental health disorders, attention deficit hyperactivity disorder (ADHD), learning disabilities (LD), sleep disorders
Medication	Psychoactive drugs Anticoagulants
Behaviour	Dangerous style of play
Sport	High risk activity Contact and collision sport High sporting level

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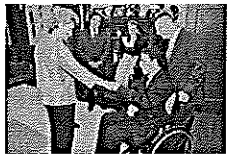
Concussion Management Potential Pitfalls

- Care at the time of injury particularly for youth athletes
- Care for athletes with persistent symptoms



Confounders: Influences on Post Concussive Syndrome

- Pre-morbid anxiety
  - Strong predictor of continued PCS
    - Ponsford J et al. Neuropsychology 2012;26:304-13
- Comorbid Major Depressive Disorder
  - Ranges from 26-42% in hospitalized TBI patients
  - 21.4% in mTBI
  - Can persist despite cognitive recovery
    - McCauley SR et al. Journal of Clinical and Experimental Neuropsychology 2001;23:792-808
- Negative illness perceptions
  - Hou R et al. J Neurol Neurosurg Psychiatry 2012;83:217-223
- Motivational factors
  - Miller L et al. Brain Injury 2001;15:297-304

Confounders: Baseline Symptoms

- Headache is common at baseline
  - 18% of patients w/ HA following brain injury had pre-existing primary HA disorder.

-Hoffmann et al. Natural history of headache after traumatic brain injury. Journal of neurotrauma. 2011. 28:1719-1725.

- Neck pain is common baseline symptom in athletes
  - 260 athletes, 167 no concussion hx and 17% reported neck pain on SCAT baseline.

-Shehata N. et al. Sport concussion assessment tool: baseline values for varsity collision sport athletes. BJSM 2009;43:730-4.

Psychological and Mental Health Issues

- Psychological approaches may have application especially in selected situations (modifiers)
- Evaluate for affective symptoms (depression, anxiety) as common in all forms of traumatic brain injury
- Depression-may be consequence of concussion, underlying pathophysiological abnormality, may be multifactorial but should be considered in management

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Confounders: Concussion Symptoms

- In concussed athletes, 20-35% report cervical pain
  - Guskiewicz K et al. Epidemiology of concussion in collegiate and high school football players. Am J SportsMed 2000; 28:643-650
- Post-traumatic headache is the most common symptom after a concussion (>90%)
  - Meehan et al. High school concussions in the 2008-2009 academic year: mechanism, symptoms, and management. Am J Sports Med 2010;38:2405-9.

Confounders

- Overlooking or misinterpreting pre-existing, co-existing and/or persisting musculoskeletal and psychological symptoms can result in spurious and expensive treatment, unnecessary restrictions from academic, sporting and social activities, and skewed data regarding sports concussions

Persistent Symptoms

- Persistent symptoms (>10 days) are generally reported in 10-15% of concussions. In general, symptoms are not specific to concussion and it is important to consider other pathologies.
- Cases of concussion in sport where clinical recovery falls outside the expected window (i.e. 10 days) should be managed in a multidisciplinary manner by health care providers with experience in sports-related concussion

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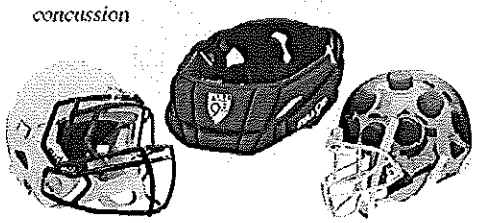
Graduated Return To Play Protocol

Rehabilitation stage	Functional exercise at each stage of rehabilitation	Objective of each stage
1 No activity	Symptom limited physical and cognitive rest	Recovery
2 Light aerobic exercise	Walking, swimming or stationary cycling keeping intensity < 70% MPHR No resistance training	Increase HR
3 Sport-specific exercise	Skating drills in ice hockey, running drills in soccer. No head impact activities	Add movement
4 Non-contact training drills	Progression to more complex training drills e.g. passing drills in football and ice hockey May start progressive resistance training	Exercise, coordination, and cognitive load
5 Full contact practice	Following medical clearance participate in normal training activities	Restore confidence and assess functional skills by coaching staff
6 Return to play	Normal game play	

- At least 24 hours per step (therefore about 1 week or longer for full protocol)
- If recurrence of symptoms at any stage, return to previous asymptomatic level and resume after further 24 hour or longer period of rest
- **RETURN TO PLAY IS A MEDICAL DECISION**

Equipment

- There is no good clinical evidence that currently available protective equipment will prevent *concussion*



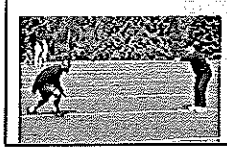
McCrory P et al. Consensus statement on concussion in sport: the 4th International Conference on Concussion in Sport held in

Return-To-Play

Post-Game Day

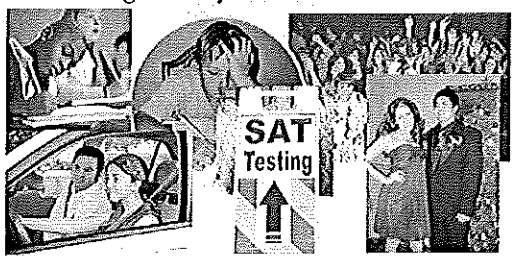
It is *essential* to:

- Determine the athlete is at baseline cognitively and physically before resuming any exertional activity.
  - amnesia may be permanent.
- Utilize progressive aerobic and resistance exercise challenge tests prior to full RTP.



Youth Sports Concussions

- Prolong recovery in student athletes

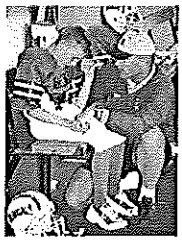


Return-To-Play

Post-Game Day

Concerns

- Prolonging recovery from the current concussion
- 2- 4X increased risk for recurrent concussion
- Post-concussive syndrome
  - 5- 8% of MTBI
- Cumulative brain trauma



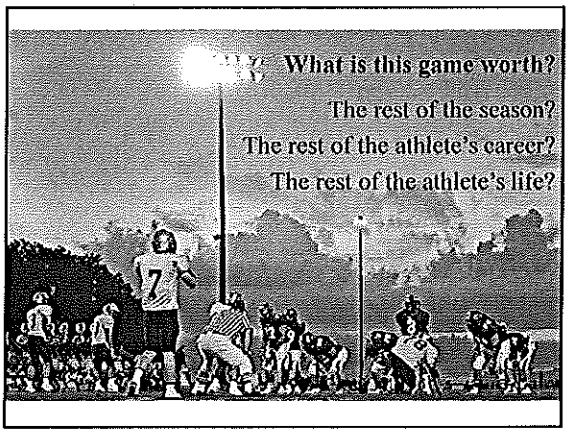
Return To Play

- The younger the athlete, the more conservative the treatment. No same day return to play for youth athletes.
- There is no simple test:
  - Use signs & symptoms, not grades
  - Concussion history
  - Concussion modifiers
- Be alert to subtle deficits:
  - e.g. neuropsychological data for cognitive assessment
- Clinical judgment is the final determinant of return to play.

Chronic Traumatic Encephalopathy (CTE)

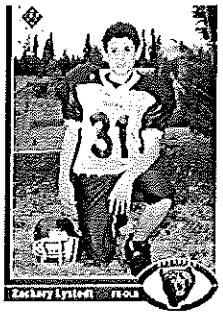
- Distinct tauopathy with an unknown incidence in athletic populations.
- Cause and effect relationship has not yet been demonstrated between CTE and concussions or exposure to contact sports.
- Interpretation of causation in the modern CTE case studies should proceed
- It is important to address the fears of parents/athletes from media pressure related to the possibility of CTE.

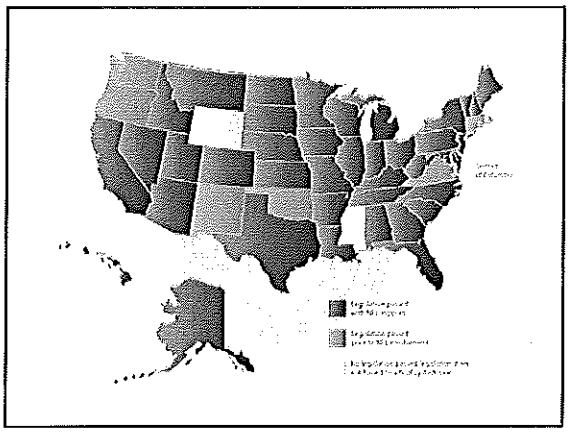
McCrory P et al. Consensus statement on concussion in sport: the 4th International Conference on Concussion in Sport held in Zurich, November 2012 Br J Sports Med 2013;47:250–258

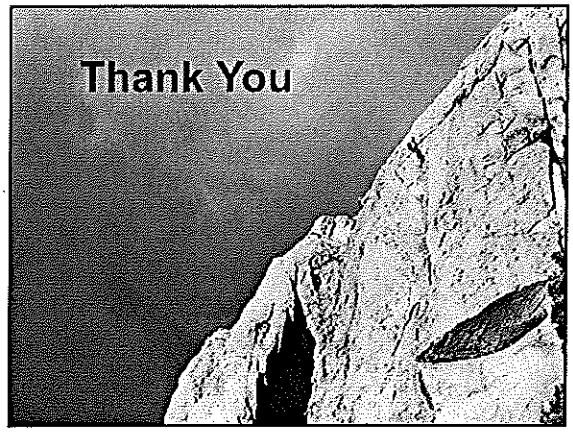


Concussion

- Remove from practice or play.
- Do not leave the player alone:
  - Assess, re-assess, and re-assess
- See a licensed healthcare provider trained in the evaluation and management of concussion.
- Return to play- medically supervised stepwise process.







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