Controversies in Concussion: Where are we now?
New Trends and Best Practices in the Management of Concussion
BILL MOREAU, DC, DACBSP®, FACSM
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Bill Moreau DC DACBSP FACSM
United States Olympic Committee, Managing Director of Sports Medicine
Chief Medical Officer Team USA – Rio 2016 Summer Olympic Games, 2013 Toronto Pan American Games
Medical Director Team USA – 2014 Sochi Winter Olympics, 2012 London Olympic Games
Professor – Southern California University of Health Sciences
Associate Professor – University of Western States
NFL International Think Tank on Concussion
University of Washington Sports Health and Safety Institute External Advisory Board Member

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Presentation Outcomes
• Look at new EBM trends in concussion evaluation and management using “prevention” and the ACBSP Position Statement on Concussion as a framework.
• Creating a framework of changing the discussion for the inclusion of the “qualified DC” to be included in State Concussion Return to Play
• Describe the importance of having a conceptual framework for managing patients with TBI.
• Identify important concepts in the assessment of an individual with TBI.
• Q&A if time allows

Where We are Headed – HANG ON!!
Concussion Is Still Big News

Concussion Literature in 2016:
- Google Scholar ~ 13,300 results in 0.06 sec
- PubMed = 312 manuscripts
- Journal of Chiropractic Medicine 2016

Berlin 2016: The 5th International Consensus Conference on Concussion in Sport
- International experts on concussion gather every four years to collaborate on the next best steps for the evaluation and management of concussion.
- For the first time - Two USA DCs were invited this year!
  - Bill Moreau DC DACBSP FACSM
  - Dustin Nabhan DC DACBSP
- For the first time three poster presentations from DCs were included:
  - Defining the elite: normative values for SCAT major components in healthy elite athletes. Moreau W, Walden T and Nabhan D.
  - Defining the Paralympic athlete: normative values for scat major components in healthy Paralympic athletes. Moreau W, Walden T and Nabhan D.
  - Concussed elite athletes have better tandem gait performance. Nabhan D, Walden T and Moreau W.

If we accept the best predictor of future injury is a history of prior injury, does it make sense that preventing concussion is a key to preventing concussion? Is reducing or preventing concussion even possible?

Proposed Prevention Prerequisites

Sport Concussion Knowledge and Clinical Practices of DC’s w/ SP MED CAQ

The study described the knowledge base and clinical practices regarding concussion by sports-certified doctors of chiropractic. A survey was distributed to the 312 attendees of the 2014 ACBSP Sports Sciences Symposium. Results measured by frequency analysis and descriptive statistics for all surveys.

All (N = 76) 100% respondents believe that the evaluation of concussion should be performed by a health care provider with training in concussion. The respondents strongly agreed on the treatment of concussed athletes. A majority (98%) believe that the sideline Concussion Assessment Tool—3 represents a current standard of care for the sideline evaluation of the athlete who possibly has sustained a sport concussion. Most agreed or strongly agreed that manual therapies may be appropriate in certain circumstances in adults (80%) and adolescents (75%).

Most respondents strongly believe that the evaluation of concussion should be performed by a health care provider with specific training in concussion, assess and manage sport concussion in their practice, and many of them endorse the use of the Sideline Concussion Assessment Tool—3 as a sideline assessment tool.


Current Practice Patterns by Health Care Providers who Manage Concussion

- Physical therapists, a group in which 31% to 38.6% of providers see at least 1 concussion a month, largely do not follow any concussion guidelines. (1, 2)
- A survey of Illinois physical therapists published in 2014 showed that only 14.6% of respondents were “very familiar” with the Consensus Statement on Concussion in Sport. (3)
- In a study of 73 emergency medicine physicians, only 23% use recognized concussion management guidelines. (4)
- Most respondents strongly believe that the evaluation of concussion should be performed by a health care provider with specific training in concussion, assess and manage sport concussion in their practice, and many of them endorse the use of the Sideline Concussion Assessment Tool—3 as a sideline assessment tool.

Reference:
3. Conidi, F.X., Drogan, O., Giza, C.C., Kutcher, J.S., Alessi, A.G., and Crutchfield, K.E. Pediatricians, a group in which 31% to 38.6% of providers see at least 1 concussion a month, largely do not follow any concussion guidelines. (1, 2)

Adherence to Guidelines

Guidelines aim to improve the quality of medical care and reduce treatment variation. The extent that guidelines are adhered to in the field of traumatic brain injury (TBI) is unknown. Systematic review of objective 1) quantifying adherence to guidelines in adults with TBI, 2) examining factors influencing adherence, and 3) study associations of adherence to clinical guidelines and outcome.

22 retrospective and prospective observational cohort studies, reported in 25 publications, were included, describing adherence to 13 guideline recommendations. Person-related factors, including age, gender, and neurologic evaluation methods, were associated with guideline adherence. Guideline adherence to Brain Trauma Foundation guidelines seemed to be associated with lower mortality. Guideline adherence in TBI is suboptimal and was variability between studies. Further research specifying hospital and management factors that explain variation in guideline adherence is warranted.

Current Practice Patterns by Health Care Providers who Manage Concussion

- Athletic trainers, who have been estimated to manage 10 concussions per provider each year, have been studied extensively for their practice patterns. Athletic trainer practice patterns have demonstrated a progression in management strategies, as a 2013 study showed that, since 1999, the use of multimodal concussion management strategies has increased significantly.

- In this population, the 2004 National Athletic Trainers Association Position Statement on Concussion in Sport (69.3%) was the concussion management document that most athletic trainers were familiar with, followed by the Consensus Statement on Concussion in Sport (48.6%) and the National Collegiate Athletic Association Concussion Management Plan legislation.

Where Next?

- Look for these changes in current standards of care within the next two years:
  1. Exercise as a treatment modality.
  2. Multimodal assessments
  3. Increased utilization of eye related testing to objectify the presence of concussion.
  5. Continued controversy regarding the legislative ruling around concussion management.

Access to care


Concussion is presently unregulated in Canada. Performed an independent, blinded Google internet search for the terms "concussion" and "concussion clinic" in Canada. The first 10-15 concussion healthcare providers per province were identified and a critical appraisal of type of healthcare personnel and services offered was conducted.

Study identified 58 concussion HCPs, 40% listed an on-site medical doctor (M.D.), 47% of concussion healthcare providers advertised access to a concussion clinic, program, or center. Professionals designated as the leaders among concussion clinics, programs, and centers included a neuropsychologist (15%), sports medicine physician (7%), neurologist (6%), and neurosurgeon (6%). Services offered by providers included baseline testing (6%), physical therapy (10%), and hyperbaric oxygen therapy (2%).

This study indicates that there are numerous concussion healthcare providers in Canada offering diverse services with clinics operated by professionals with varying levels of training in traumatic brain injury. In some cases, the practices of these concussion clinics do not conform to current expert consensus guidelines.


Telemedical Evaluation of Athletes with Suspected Concussion

Most elite-level athletes have access to providers with concussion expertise. This level of care is uncommon in amateur youth sports. > 7.5 M U.S. children participate in high school sports, the majority without access to athletic trainers. The volume of youth athletes exceeds the number of concussion experts. Telemedical concussion evaluations (teleconcussion) may address gaps in care.

N=11 consecutive collegiate football players with suspected concussion were assessed using the Standardized Assessment of Concussion (SAC), King-Devick Test (KD), and modified Balance Error Scoring System (mBESS). A remote neurologist assessed subjects w/ another provider performing a simultaneous F2F assessment. A remove-from-play determination was made. The remote and F2F providers were blinded to each other’s exam findings and remove from play decision.

The teleconcussion and F2F SAC were in agreement 100% of the time. Remote and F2F KD times were within a 3s difference 100% of the time. Remote and F2F mBESS scores were within 3 points 100% of the time. Remove from play decisions were in 100% of the time. Conclusions: This is the first study investigating teleconcussion feasibility for concussion assessments. These data suggest high levels of agreement between remote and a F2F providers regarding exam findings and remove from play decisions.

Creating a framework of changing the discussion for the inclusion of the “qualified DC” to be included in State Concussion Return to Play

Where are you now?

- All Inclusive?

  - This rule is being proposed in order to comply with ORC Section 3707.521 (E) that requires the Board to adopt a rule in order for chiropractic physicians to be authorized to assess and clear athletes for return to practice or competition under ORC Section 3313.539 or 3707.511.
  - Most all in efforts do not make it to the Governor
  - Specialty in Sports and sometimes neurology may make it
  - Could extra training and a State Association “registry” be the path?

State Association Driven Concussion Registry

- The State Association Concussion Registry may be built as a first-of-its kind Concussion Credential Registry that will allow any public user to see the credentials in terms of competencies, transfer value, assessment, rigors, third-party approval status.
- Open and voluntary registry could include all kinds of credentials, but expect pushback and set a drop back position to the DC in your State
- Each Registry “concussion credential” would describe the name, competencies, assessment, accreditations, references, value, renewal, etc.
- The goals are transparency and clarity, and to help assure these with questions that the DC on the Registry has the knowledge and skills to more than adequately meet the needs of the athletes, parents, State Athletic Associations, and other rule makers.

Statutory Description of a Health Care Provider Knowledgeable in Concussion Management:

The following is an annotated and abbreviated list of state concussion statutory language:

- AK: “qualified person who has received training, as verified in writing or electronically by the qualified person, in the evaluation and management of concussion”
- CA: “licensed health care provider trained in management of concussions and acting within scope of practice”
- CO: “doctors of chiropractic with the U.S. Olympic team”
- DC: “licensed or certified health care provider”
- FL: “appropriate health care practitioner trained in DX, evaluation and management of concussions as defined by the Sports Medicine Advisory Committee of the Florida High School Athletic Association”
- IA: (chiropractors are legally qualified by chiropractic licensure)
- IN: “licensed health care provider trained in evaluation, management of concussions & head injuries”
- MA: “other trained/licensed health professional allowed by the Dept. of Public Health”
- MD: “licensed health care provider trained in the evaluation and management of concussions”
- ME: “licensed health care provider trained in concussion management”

J. Schwartzbauer (FCLB) Personal correspondence April 9, 2016

Effects of Legislation on Sports-Related Concussion

- Following the lead of Washington state and passage of the Lystedt Law in 2007, all states now have sports concussion laws designed to help protect youth athletes.
- Current concussion legislation centers on the following three points: 1) Education of athletes, parents, and coaches; 2) Removal from practice or play for suspected concussion; and 3) Clearance by a health care provider before medically supervised graded return to play.
- Sports concussion laws are not designed for primary prevention but instead aid in proper diagnosis and management, thereby preventing the tragedies that may occur from premature return to play.
- Laws are living documents and can be amended as more research becomes available.
- In 2014, less than 5 years later, all 50 states and the District of Columbia had also adopted youth sports concussion laws. To put this in perspective, only 21 states require bicycle helmets for children, and only 34 have a primary seat belt law.


Udall, Rockefeller Introduce Bill to Help Protect Young Athletes from Sports-Related Traumatic Brain Injuries

The Youth Sports Concussion Act will:

- Instruct the Consumer Product Safety Commission (CPSC) to review the findings of a forthcoming National Academy of Sciences (NAS) report on sports-related concussions in youth;
- Authorize the CPSC to make recommendations to manufacturers and, if necessary, promulgate new consumer rules for protective equipment based on the findings of the NAS report; and
- Allow the Federal Trade Commission (FTC) to impose civil penalties for using false claims to sell protective gear for sports. State attorneys general could also enforce such violations.

Soccer and Heading the Ball

Soccer has seen a rapid increase in popularity in the United States over the past 3 decades with increased concerns regarding the safety of heading the soccer ball. A study evaluated boys' and girls' high school soccer SRCs to identify injury SRC mechanisms, when most SRCs occur, detail heading-related soccer concussion mechanisms, and to compare concussion symptom patterns by injury mechanism.

627 concussions were sustained during 1.4M athlete exposures
- Contact with another player was the most common SRC mechanism
- Heading was the most common soccer-specific activity
- Contact with another player was the most common mechanism of injury in heading-related concussions
- Although heading is the most common activity associated with concussions, the most frequent mechanism was athlete-athlete contact. Banning heading from youth soccer would likely prevent some concussions, reducing athlete-athlete contact across all phases of play would likely be a more effective way to prevent concussions as well as other injuries.


Protective Equipment - FB Helmets

- Generally speaking there has been little to offer in regards to disruptive innovations in football helmets over the last 50 years.
- For example, heads are not round so why do we fit helmets by circumference?

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Concussion – FB Helmet Design

- This Football Helmet Crumples—and That’s Good Thing.


Helmet Fit and Concussion

Looked at the relationship between football helmet fit and concussion severity. (Level 3 evidence)

4580 concussions were analyzed. 3.2% w/ SRC and a helmet that did not fit properly, had higher rates of drowsiness, hyperexcitability, phonophobia, more symptoms, and had longer symptom duration.

Athletes with helmets lined with an air bladder had greater rates of photophobia, phonophobia, and longer symptom duration compared with foam or gel liners.

CONCLUSION: An improperly fitted football helmet is a risk factor for a concussion with more symptoms and of longer duration. Concussions of longer duration are also more common in players with an air bladder-lined helmet. Current high school football rules should mandate supervision and maintenance of helmet fit throughout the season, prior to impact.

CLINICAL RELEVANCE: Team physicians, athletic trainers, coaches, and high school officials should ensure proper oversight of helmet fit in high school athletes to decrease concussion severity and duration.

Helmet Type and Concussion

HS Football helmets, despite differences in construction, should provide comparable SRC protection. There is debate regarding differences in the rates or severity of concussions based on helmet design, manufacture, age, etc.

HS football SRC and helmet data was collected from 2008-2013. 2,900 SRC football concussions were reported. SRC rates significantly increased from 2008 through 2013. SRC rates were similar among players wearing new or reconditioned helmets. SRC rates, number symptoms, resolution time, and time to RTP were similar for the most common helmet manufacturers and models.

Outcome: Overall, the most common helmets, new and reconditioned football helmets, provide high school football players with similar protection against concussions.

SRC Under Reporting

- Previous studies found substantial proportions of athletes with undisclosed concussions.
- Study examined the prevalence and factors associated with nondisclosure of reported SRC in former collegiate athletes.
- N=800 former collegiate athletes used an online questionnaire to recall self-identified sport-related concussions (SRCs) while playing in HS, college, or professionally.
- 26.9% reported at least 1 SRC was not disclosed.
- 33.2% reported not disclosing all SRCs.
- Male athletes were more likely to report SRC than female athletes.

Computerized Neurocognitive Assessment Tools

- Limited data exist comparing the performance of computerized neurocognitive tests (CNTs) for assessing sport-related concussion.
- Across time, the CNTs' sensitivities were highest in those athletes who became asymptomatic within 1 day before neurocognitive testing but was similar to the test's false positive rates when including athletes who became asymptomatic several days earlier. They are useful for early assessment.
- Analyses of group effect sizes, discrimination, and sensitivity and specificity suggested that the CNTs may add incrementally (beyond symptom scores) to the identification of clinical impairment within 24 hr of injury or within a short time period after symptom resolution but do not add significant value over symptom assessment alone.
- The rapid clinical recovery course from concussion and modest stability probably jointly contribute to limited signal detection capabilities of neurocognitive tests outside a brief post-injury window.

SRC present a substantial public health burden

- Athletes failing to report SRC and continue play are at risk of catastrophic neurologic consequences.
- Understanding why athletes do or do not report SRC is critical for strategies on risk reduction.
- Psychosocial theories are useful in framing this problem.
- The study quantifies the pressure that athletes experience to continue playing after a head impact from coaches, teammates, parents, and fans.
- Results found 22% had experienced pressure from at least one source to continue playing after a SRC.
- Athletes who experienced pressure were significantly more likely to continue playing in the future than were athletes who had no pressure, or only pressure from coaches and teammates.
- Findings underscore the importance of designing interventions that address the system in which athletes make decisions about concussion reporting, including athletes, parents, rather than focusing solely on modifying the individual's reporting cognitions.

Social Pressure

- More than half of sports medicine clinicians had experienced pressure from coaches and athletes to return athletes to participation prematurely after a concussion.
- Clinicians experienced greater pressure from coaches at schools where the sports medicine department reported to the athletic department than at schools where the sports medicine department reported to an independent medical institution.
- Female clinicians experienced greater pressure from coaches than male clinicians.
- More research is needed to determine how pressure affects clinical practice and whether pressure on clinicians affects return-to-participation decisions.
One study (Rezai-Zadeh) demonstrated that Green tea is a commonly discussed product that contains many natural compounds that have been investigated for their potentially neuroprotective antioxidant and anti-inflammatory properties.

Green tea is a commonly discussed product that contains many natural compounds that have been investigated for their neuroprotective antioxidant and anti-inflammatory properties. A study by Resch, J. E. et al. in BMJ Open Sport Exerc Med 2016;2:1 indicated that green tea reduced the amount of tau phosphorylation and beta-amyloid deposition in a mouse model of Alzheimer disease, which may be relevant given the pathological findings in CTE.

Concussion Guidelines Step 1: Systematic Review of Prevalent Indicators.

The sensitivity and specificity of clinical measures of sport concussion: Three tests are better one. Resch, J. E. et al. BMJ Open Sport Exerc Med 2016;2:1

A multidimensional assessment of concussed athletes that included a symptom checklist and computerized measures of cognitive function and balance resulted in sensitivity of 80% or 100% using predictive discriminant analysis or clinical interpretation guidelines, respectively. Individual sensitivities of the component measures using PDA ranged from 52.5% to 77.5%, with an overall sensitivity of 80%.

Overall sensitivity of the battery based on clinical interpretation guidelines was 100%, with sensitivity of each individual measure ranging from 55% to 97.5%. Findings support the use of clinical interpretation of multidimensional assessment procedures in the management of SC.

Concussion: Three Tests are Better than One
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Will eye tracking change the way we diagnose and classify concussion and structural brain injury?

- Without accurate diagnostics, classification schemes, outcome measures, and even a definition, the idea of estimating the incidence and impact of brain injury is a daunting task.
- Modern era optometrists can detect abnormal eye movements in up to 90% of patients with so-called mild traumatic brain injury or concussion.
- The most commonly detected abnormal eye movement associated with brain injury is vergence problem. Vergence is the ability of the both eyes to focus together on a single point.
- “I would argue that eye tracking might ultimately be used to classify – or even define concussion – and limit its scope to traumatic neurologic injury not apparent on CT scanning and resulting in intracranial mass effect, elevated intracranial pressure or disruption of neurologic pathways.”


Neuroprotection – Hypothermia

- The role of hypothermia in the management of severe traumatic brain injury remains controversial.
- Recent trials not only failed to demonstrate benefit but also revealed a tendency towards clinical harm.
- The time may have come to reconsider the role of hypothermia in the management of severe traumatic brain injury.


Neuroprotection – Cannabidiol

- Cannabidiol (CBD) is a non-psychotomimetic phytocannabinoid derived from Cannabis sativa.
- It has possible therapeutic effects over a broad range of neuropsychiatric disorders.
- CBD attenuates brain damage associated with neurodegenerative and/or ischemic conditions. It also has positive effects on attenuating psychotic, anxiety- and depressive-like behaviors.
- CBD affects synaptic plasticity and facilitates neurogenesis.
- The mechanisms of these effects are still not entirely clear but seem to involve multiple pharmacological targets.


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Vestibular/Ocular Motor Screening (VOMS)

VOMS evaluates vestibular and ocular motor symptom provocation after SRC. The study examined the internal consistency of the VOMS in a large sample of healthy, nonconcussed collegiate athletes.

263 D1 NCAA athletes completed self-reported demographic and medical history at preseason physical examinations and baseline screening. A series of univariate nonparametric tests were used to examine the associations among medical history risk factors and VOMS clinical cutoff scores, with higher scores representing greater symptom provocation.

Internal consistency of the VOMS was high. Female athletes and those with a personal history of motion sickness were more likely to have 21 VOMS scores above cutoff level.

Conclusion: The VOMS possesses internal consistency and an acceptable face validity and may be a useful tool in healthy collegiate student athletes. Further research into the impact of VOMS is required.

The King-Devick test of rapid number naming for concussion detection: meta analysis and systematic review of the literature

- Vision encompasses a large component of the brain’s pathways, yet is not represented in current sideline testing.
- The efferent visual pathways are particularly vulnerable to injury in the acute setting of concussion and may be assessed through visual performance measures such as rapid number naming tasks.
- The K-D test is a two minute rapid number naming assessment in which an individual reads numbers aloud quickly from test cards or a computer-based application.

This meta-analysis demonstrates that preseason baseline scores are consistent across published studies, with high degrees of precision.
- The K-D test detects concussion with high degrees of sensitivity and specificity, with any worsening of time score from baseline, indicating a five-times greater likelihood of concussion.
- Test-retest reliability is high, and vigorous exercise alone is associated with mild learning effects rather than worsening of scores from preseason baseline.
- Among youth, collegiate and adult amateur and professional athletes, rapid number naming using the K-D test adds significantly to sideline assessment and contributes a critical dimension of vision to sports-related concussion testing.

Can Rest Actually Be Harmful?

- Prolonged vestibular adaptation
- Chronic fatigue
- Depression
- Maintenance of anxiety/PTSD (supporting avoidance)

Rest vs. Exercise for Post concussion Cares

- “The cornerstone of concussion management is physical and cognitive rest until the acute symptoms resolve and then a graded program of exertion prior to medical clearance and RTP. The current published evidence evaluating the effect of rest following a sports-related concussion is sparse.”

- Consensus statement on concussion in sport: the 4th International Conference on Concussion in Sport held in Zurich, November 2012

- How many clinical trials or carefully controlled studies relating to the benefits of rest in the first 2 weeks following sport-related concussion have been published?

- Zero

- After 3-6 days of bed rest, some people complain of headache, restlessness, and difficulty sleeping.

- Rothey, Schneider, and Greenleaf (2011)
Evidence Description

A  A strong recommendation that the clinicians provide the intervention to eligible patients. Good evidence was found that the intervention improves important health outcomes and concludes that benefits substantially outweigh harms.

B  A recommendation that clinicians provide the intervention to eligible patients. At least fair evidence was found that the intervention improves health outcomes and concludes that benefits outweigh harms.

C  No recommendation for or against the routine provision of the intervention is made. At least fair evidence was found that the intervention can improve health outcomes, but concludes that the balance of benefits and harms is too close to justify a general recommendation.

D  Recommendation is made against routinely providing the intervention to patients. At least fair evidence was found that the intervention is ineffective or that harms outweigh benefits.

I  The conclusion is that the evidence is insufficient to recommend for or against routinely providing the intervention. Evidence that the intervention is effective is lacking, or poor quality, or conflicting, and the balance of benefits and harms cannot be determined.

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Rest vs. Exercise for Post concussion Cares

- Exercise facilitates molecular markers of neuroplasticity and promotes neurogenesis in the healthy rodent brain and the injured brain.
- Associated with changes in neurotransmitter systems.
- (Chauvel, 1989; Mohini, Ying, & Gomez-Pinilla, 2002)
- Improved mood and lower stress. (Callaghan, 2004; Conn, 2010)
- Improved deep quality. (Youngstedt, 2005)
- Positive effects on self-esteem. (Bekend, Heien, Hagen, Abbott, & Nordheim, 2004)
- Effective treatment or adjunctive treatment for milder forms of anxiety and depression. (Baker, 2008; Mead et al., 2006; Wehrli, Wilf, & Zaiden, 2005)
- Associated with reduced pain and disability in patients with chronic low back pain. (Bell & Burnett, 2007; Mengez & Kurze, 2006)
- Regular long-term aerobic exercise reduces migraine frequency, severity, and duration. (Koseoglu, Akboyraz, Soyuer, & Ensoy, 2003; Locklitt & Carpentier, 1992)

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Second Impact Syndrome SIS

- Post game, he reported HA, he attributed specifically to the hit, telling a teammate, "That was the hardest I've been hit in my whole life."
- Over the next 3 days he resumed typical activities but complained of fatigue and apparent difficulty.
- He felt momentarily dazed, telling a teammate, "I feel dizzy, I can't really see straight,"

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Exercise for Post concussion Cares

1. Bed rest >3d is NOT recommended (Strength:D)
2. Gradual resumption of activities should begin as soon as tolerated (I)
3. For contact sports and other activities with high MTBI exposure risk, a delay of at least 1 week will help reduce the risk of overlapping injuries. (II)
4. Medium and long term risks to exacerbate symptoms are unknown. Heavy exertion that causes pain may be harmful, exercise should be temporarily modulated to reduce symptoms and then return to activity at a slower pace. (III)
5. After 1 month supervised exercise should be considered as a part of the treatment plan for individuals who remain symptomatic. (I C)

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Second Impact Syndrome SIS

- Several plays later he went down to a knee w/ dizziness, HA, "could not feel his legs."
- He subsequently became unresponsive, and there was generalized muscle activity and he was air evacuated to a trauma center.
- He was intubated at a local emergency department where noncontrast CT of the brain demonstrated thin bilateral subdural hematomas.
- Upon presentation he was intubated w/ a GCS of 7, ICP of 25-30 mm Hg, pupil were 3mm bil and sluggish, DTR 3+, Bob absent bil.
- His hospital course was complicated by hypotension, severe metabolic acidosis, renal failure requiring hemodialysis, sepsis, ventilator-associated pneumonia. He required thoracotomy, disseminated intravascular coagulation, and cardiac arrest.

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Second Impact Syndrome SIS

- Premature return to play for the concussed pediatric athlete may result in devastating neurological injury. Identification of at-risk patients and ideal management of the concussed athlete remain a challenge.
- Authors review a case of SIS in which neuroimaging was obtained between the first and second impacts.
- A previously healthy 17-year-old high school football player sustained a helmet-to-helmet hit with an opposing player during a punt return.
- He felt momentarily dazed, telling a teammate, "I feel dizzy, I can't really see straight," but continued playing.
- Witnesses reported that he played the remaining 15 minutes of the game with no apparent difficulty.

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Second Impact Syndrome SIS

- Post game, he reported HA, he attributed specifically to the hit, telling a teammate, “That was the hardest I’ve been hit in my whole life.”
- He felt momentarily dazed, telling a teammate, “I feel dizzy, I can’t really see straight,” but continued playing.
- After a hit during the drill he was slow in getting up and complained of a HA.
Second Impact Syndrome SIS

Images obtained after second impact.
A: Arrows point to thin bilateral ASIH.
B: Sagittal T1-weighted brain MR image. Arrows point to downward descent of the midline structures.
C: Axial T2-weighted MR image. Arrows point to thalamic injury.
D: Axial diffusion-weighted MR image. Arrow points to left thalamic injury. Restricted diffusion was proven by calculation of apparent diffusion coefficient (not shown).


Second Impact Syndrome SIS

- He was transferred to rehabilitation on hospital Day 54, and discharged to home on hospital Day 98. At the time of discharge he was nonverbal and nonambulatory.
- More than 3 years after his injury, our patient is living at home and has regained limited verbal, motor, and cognitive skills.

The pathophysiology of SIS is poorly understood, but has previously been thought to reflect loss of cerebral autoregulation and resultant massive brain swelling, frequently with brain herniation.
- A number of authors have hypothesized that this disruption of autoregulation results from re-injury to neuronal cells within a vulnerable period of ongoing derangement from previous injury.
- Importantly, this case shows that a normal head CT scan does not obviate the need for close clinical follow-up and for the athlete to be cognitively normal and asymptomatic before return to play.