

NH STATE ADVISORY COUNCIL ON SPORT-RELATED CONCUSSION

BRAIN INJURY ASSOCIATION OF NEW HAMPSHIRE

109 N. State Street * Concord, NH 03301 * 603-225-8400
Help Line: 1-800-773-8400 * Fax: 603-228-6749 * www.bianh.org

MISSION:

IMPROVE
CONCUSSION-
RELATED SAFETY
YOUNG ATHLETES
IN NEW
HAMPSHIRE

Bureau of
Developmental Services,
NH Department of
Health and Human
Services

Children's Hospital at
Dartmouth Injury
Prevention Program

Injury Prevention
Program, NH
Department of Health
and Human Services

New Hampshire
Association of School
Psychologists

New Hampshire Athletic
Directors Association

New Hampshire Athletic
Trainers Association

New Hampshire
Department of
Education

New Hampshire
Interscholastic Athletic
Association Sports
Medicine Committee

New Hampshire
Musculoskeletal Institute

New Hampshire Medical
Society

New Hampshire Pediatric
Society

New Hampshire School
Learning Incentives
Concussion 911

New Hampshire School
Nurses Association

Northern New England
Neurological Society

Traumatic Brain Injury
Program-Dartmouth

Sport-Related Concussion Consensus Statement

Laura C. Decoster, ATC
Consensus Committee Chair/
Advisory Council Vice Chair

NOTE: Members of the Council are available to educate and assist the NH public with implementing and/or updating concussion management protocols. Please contact the NH Brain Injury Association office: 603-225-8400.

Table of Contents

Preamble.....	4
Executive Summary	5
Definition of Concussion.....	6
Prevention of Concussion	7
Helmets, mouthguards and other personal protective devices	7
Enforcement of rules and teaching of safe playing techniques	8
Role of Baseline Testing in Management of Concussion.....	9
Neurocognitive performance, balance, concussion signs and symptoms.....	9
Appropriate administration and interpretation of neurocognitive testing.....	9
Acute Concussion Recognition and Assessment	11
Signs and Symptoms of Concussion.....	11
Significance of Loss of Consciousness & Amnesia in Determining the Severity of Concussion	12
Grading Scales.....	13
Ongoing Assessment and Management of Concussion.....	14
External Factors that May Complicate Concussion Management.....	14
Multiple Concussions.....	15
History of Previous Concussions.....	15
Second Impact Syndrome	15
Recommendations for Consideration of Season Disqualification	16
Recommendations for Consideration of Retirement from High Risk Sports.....	16
Return to School after Concussion	17
Sample School Accommodations for Concussed Athletes	17
Return to Sport after Concussion	18
Special Considerations:.....	19

	3
Pediatric Concussion.....	19
Gender Differences.....	20
Medical Personnel in the Schools.....	22
Certified Athletic Trainers.....	22
Team Physicians.....	22
School Nurses.....	23
Neuropsychologists.....	23
Education of Coaches, Parents and Athletes.....	24
Education of Healthcare Providers.....	25
Resources.....	26

Sport-Related Concussion Consensus Statement

Preamble

The New Hampshire State Advisory Council on Sport-Related Concussion was created to provide guidance for school and youth league administrators, coaches, parents and athletes on this very important topic. The purpose of this consensus statement is to guide the creation and implementation of a best-practice model for sport-related concussion management including safe return to sports and return to school. This statement does not include specific protocols but serves as the basis for such protocols. Medical science concerning sport-related concussion is a rapidly growing field; the most recent research was used in the preparation of this statement. Statements are based on evidence but users should be aware that there are still many areas of controversy in this relatively young research field. Because of this fact, this document will be reviewed at least yearly to take advantage of advances in our knowledge about concussions.

Feasibility

The Council recognizes that schools and youth leagues have varying degrees of resources for implementing the recommendations contained herein. However, it is important for administrators to express and demonstrate support for adherence to best-practice sports medicine to the extent possible.

NOTE: Throughout the document, citations within quoted material are references from the source article.

Executive Summary

- A concussion is a serious injury. Colloquial terms such as "ding" or "bell ringer" minimize and trivialize an injury that may have lasting consequences. Those terms should be eliminated from the concussion vocabulary. All injuries to the brain, regardless of how apparently minor they seem, should be managed appropriately.
- Neither loss of consciousness nor amnesia is a required element for the diagnosis of a concussion. In the majority of concussions, neither is present.
- A young athlete (through high school) who experiences concussion signs or symptoms after a direct or indirect blow to the head should not return to activity on the same day. Some brain injuries evolve slowly and the true severity of an injury may not be apparent initially.
- Signs and symptoms of concussion may fall into multiple categories in somatic, cognitive and emotional domains. Headache, fatigue, irritability, difficulty concentrating and sleep disturbance are a few examples. Coaches, athletes, parents and school officials should be familiar with common signs and symptoms so concussions and/or their sequelae do not go unrecognized.
- Each concussion is unique. Concussion grading scales fail to account for the individuality of injury and may result in an athlete being sent back to activity too soon or held out too long. In place of concussion grading scales, healthcare providers are advised to manage concussions on an individual basis with careful monitoring of clinical symptoms, physical signs, behavior, balance, sleep and cognition in the assessment and monitoring of concussion. Once all signs and symptoms have resolved, a monitored gradual, structured return to activity is recommended.
- School personnel (nurse, guidance, teachers) should be informed of the occurrence of a concussion and student-athletes who have suffered a concussion should be monitored at school for academic performance difficulties and behavior changes.
- Evidence suggests that pediatric athletes may be more vulnerable to concussion, may require a longer recovery period and may suffer more long-term sequelae than adults. There may also be an increased risk of second-impact syndrome, an often-fatal brain swelling, which has almost exclusively been documented in young athletes.
- Neurocognitive baseline assessment of athletes who participate in collision or contact sports is recommended whenever it is feasible as it can be used by healthcare providers as objective evidence of an injured athlete's return to cognitive normalcy. However, neurocognitive testing is only one element of what should be a multipronged approach to assessing and managing sport concussion. Computerized or formal neurocognitive test administration should be appropriately supervised and neuropsychologists are in the best position to interpret test results by virtue of their background and training.
- Athletic programs, both school and community-based, should adopt a sport concussion management protocol. The NH Council has developed a template for such a program that should be adapted according to each program's resources and in consultation with team physicians.
- Coaches, athletes and interested parties (parents, administrators, etc.) should receive current basic education on the topic of sport-related concussion.
- Physicians must stay abreast of current practice guidelines and topics regarding the appropriate management of athletes who have suffered a concussion, especially return-to-play decision-making.

Definition of Concussion

Experts present at the First International Conference on Concussion in Sport (2001)¹ agreed on the following components of the definition of concussion. Major statements published since that date²⁻⁵ have agreed and provided minor updates. The definition from the recent 3rd International Conference on Concussion in Sport (Zurich, 2008) is:

Concussion is defined as a complex pathophysiological process affecting the brain, induced by traumatic 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:

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.
3. Concussion may result in neuropathological changes but the acute clinical symptoms largely reflect a functional disturbance rather than a structural injury.
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 a small percentage of cases however, postconcussive symptoms may be prolonged.
5. No abnormality on standard structural neuroimaging studies is seen in isolated concussion.

The NH State Advisory Council believes it is important for all concerned to realize that even a mild concussion is a brain injury and should be treated with appropriate respect and caution. It is also important to understand that concussion resolution may require only a few days but can require weeks to months.

Prevention of Concussion

Making specific recommendations regarding concussion prevention is difficult because research has yet to provide strong evidence in support of many seemingly likely approaches. Indeed, recent research performed and reviewed by Guskiewicz and Mihalik⁶ demonstrates that although we're now able to measure impact parameters with in-helmet accelerometers, that data suggests the relationship between impact and clinical symptoms is unclear. Their research has shown that very low impacts can cause concussion and it has also shown that very high (over 80gs) can be sustained with no acute symptoms. However, some general recommendations are acceptable as common sense and the following suggestions have been made by one of the world's foremost concussion experts, Dr. Cantu:⁷

- Athletes in organized sports should have a pre-participation physical and in cases with any questions of readiness the athlete should not be allowed to participate.⁷
- Adequate strength and conditioning, including muscular strength of the neck may be important in absorbing head impacts and mitigating their effects.⁷
- All field equipment should meet safety regulations (e.g., goalposts, pole vaulting pit padding), be installed correctly and be regularly inspected.⁷
- Helmets and other protective devices should be properly fitted and always worn appropriately with proper adjustment and use of all straps or other devices for securing the device in the appropriate position.⁷

Helmets, mouthguards and other personal protective devices

Despite the fact that no protective equipment has been found to prevent sport-related concussion, helmets definitely protect wearers from severe head and brain trauma.^{8,9} For example, in activities like skiing, snowboarding and bicycling, helmets have been shown to have a considerable role in reducing serious head injuries.⁸ Since the advent of helmet use in football, skull fractures have been nearly eliminated from the game.¹⁰ In sports that include the use of a projectile (e.g., baseball, softball, etc...) head protection should be worn by runners, batters, batting practice pitchers, base coaches (and other managers and or non-players) when they are on the field.⁷

Football helmet manufacturers have claimed that they've created concussion-proof helmets, but high quality research does not exist to support those claims. Although football helmets have been shown to reduce surrogate headform acceleration in the lab, the relevance of those findings to concussion is unknown.⁸ Clinical evidence that helmets/headgear prevent sport-related concussions is inconclusive.^{8,9} Helmets *do*, however, protect against scalp and skull injuries and should be worn according to manufacturer and sport governing body

recommendations. Evolution in helmet materials and design continues and future research may demonstrate evidence of concussion prevention that has not been shown to date.

There is a popular belief that mouthguards can prevent or reduce the severity of concussion by absorbing impacts that would otherwise be transmitted to the brain. Although several studies have been conducted on this question, high quality research has not demonstrated reduced concussion risk related to mouthguards.⁸ However, there is considerable support for mouthguards' effectiveness in protecting athletes from dental injuries. Therefore, mouthguards should be worn because they do significantly reduce the risk and severity of dental injuries. Future research may demonstrate a role in concussion prevention that has not been shown to date.

Enforcement of rules and teaching of safe playing techniques

Officials should be strict in the enforcement of game rules⁷, many of which were designed to prevent injury. For example, spearing (hitting an opponent with the top of the helmet, using the helmet as a weapon) was outlawed in football in a successful effort to reduce catastrophic neck injuries.¹⁰ Research suggests that awareness of an imminent hit to the head reduces sustained impact,¹¹ therefore it's possible that enforcement of rules outlining blind hits might reduce concussion. In youth hockey, research has shown that head impacts resulting from plays involving rules infractions involve significantly greater head accelerations than those resulting from those sustained from legal contact.¹¹

In addition to officials' enforcement of rules, coaches must teach proper fundamental skills for their sport. When they are available, coaches should pursue certificates of proficiency for coaching their sport.⁷ Among the most important lessons in helmeted sports is that the helmet is a protective device and should never be used as a weapon.⁷

Role of Baseline Testing in Management of Concussion

Neurocognitive performance, balance, concussion signs and symptoms

Care of concussed athletes by healthcare providers experienced in the assessment and management of concussion is the foundation of appropriate care. However, because of the subjectivity of many signs and symptoms of concussion, accepted practice has moved toward the use of baseline assessment to provide some objectivity to concussion management. The body of literature in this area is growing rapidly. Briefly, the theory behind baseline testing is that examining an athlete prior to injury (i.e., at baseline) will allow healthcare providers to compare post-injury to pre-injury performance. This would provide an objective assessment to help identify resolution of concussion effects and be an important adjunct to clinical decision-making. Other current means of assessing the progression and resolution of a concussion are subjective, and are unfortunately therefore vulnerable to the [misguided] efforts of those motivated to return an athlete as soon as possible regardless of the risk (or perhaps in ignorance of the risk). Certainly the clinical impression of experienced health-care providers is imperative, but in the absence of other objective means (e.g., a molecular marker) the Council believes that athletes are best served by the inclusion of a baseline testing approach. When logistically feasible, school-based sports medicine providers (certified athletic trainers) should be trained in and implement a multi-faceted baseline testing program for contact/collision sports with high concussion risk. The addition of this data to the healthcare provider's clinical impression serves to enhance the decision-making process.

Several types of tests have been used for baseline, and subsequent follow-up, assessments including: paper and pencil neurocognitive tests (e.g., Trail Making Test, Stroop), computerized neurocognitive test batteries (e.g., ImPACT, ANAM), sideline concussion assessment tools (e.g., **Sport Concussion Assessment Tool 2, Standardized Assessment of Concussion**), balance (e.g., **Balance Error Scoring System**) and graded symptom checklists. Periodic re-administration of baseline tests is recommended for youth athletes to account for ongoing cognitive and physical maturation. The combination of two or more types of assessment to provide information about recovery of various systems during concussion resolution is recommended (e.g., cognitive and balance testing).¹²

Appropriate administration and interpretation of neurocognitive testing

While it is possible for individual athletes to take a web-based computerized neurocognitive test at home, this approach is not appropriate. Test administration should be supervised by trained administrators to insure valid test results. Appropriate supervision allows confirmation of the named test taker, clarification of test instructions and resolution of confusion and misunderstandings frequently encountered in test sessions.

With regard to interpretation of neurocognitive tests, the experts present at the Zurich³ meeting agreed as follows:

Neuropsychologists are in the best position to interpret [neurocognitive tests] results by virtue of their background and training.... There may be situations where neuropsychologists are not available and other medical professionals may perform or interpret...tests.... In [child and adolescent athletes] it is more important to consider the use of trained neuropsychologists to interpret assessment data, particularly in children with learning disorders and/or ADHD who may need more sophisticated assessment strategies.^{31,32,101}

The NH State Advisory Council on Sport-Related Concussion recommends baseline assessment with validated assessment tools. Training and supervision in the use of these tools is a critical component of best practice standards. Baseline assessments should be repeated at least every two years for high school-aged athletes. Baseline testing results should be reviewed to screen for effects of poor effort or other suspicious results. Neurocognitive test administration should be appropriately supervised. Neuropsychologists are in the best position to interpret results of computerized or formal neurocognitive tests based on their background and training and represent one important adjunct in the interdisciplinary management of concussion.

The Council recognizes that schools and youth leagues have varying degrees of resources for implementing the recommendations contained herein. However, it is important for administrators to express and demonstrate support for adherence to best-practice sports medicine to the extent possible.

Acute Concussion Recognition and Assessment

In the presence of a possible mechanism of concussive injury with one or more signs or symptoms of concussion, youth athletes should be removed from play for the remainder of the day.³ This protects athletes from exposure to subsequent head impacts as well as from negative consequences that might result from exertion and allows time for the athlete's condition to declare itself; research indicates that concussion signs and symptoms may continue to develop up to a week post-injury.¹³ Assessment of the concussed athlete can be difficult because other conditions (either concomitant or pre-existing) may mimic concussion and complicate or confound diagnosis. Examples of external factors that may interfere with diagnosis include chronic headaches, systemic illness (e.g., sinus infection, cold or flu) and heat illness. A healthcare provider experienced in concussion management must evaluate the athlete and make a determination, as making the concussion diagnosis is the indispensable first step in concussion management. Once a diagnosis of concussion is made, serial monitoring of physical and cognitive symptom resolution will inform management and ultimately guide safe return to sports.

The diagnosis of acute concussion usually involves the assessment of a range of domains including clinical symptoms, physical signs, behavior, balance and cognition.³ A detailed concussion history is an important part of the evaluation. The suspected diagnosis of concussion can include one or more of the following clinical domains:

- (a) Symptoms—somatic (e.g. headache), cognitive (e.g. feeling like in a fog) and/or emotional symptoms (e.g. emotional lability);
- (b) Physical signs (e.g. loss of consciousness, amnesia);
- (c) Behavioral changes (e.g. irritability);
- (d) Cognitive impairment (e.g. slowed reaction times);
- (e) Sleep disturbance (e.g. drowsiness);

If any one or more of these components is present, a concussion should be suspected and the appropriate management strategy instituted.

Signs and Symptoms of Concussion

Many symptoms of concussion are subjective and may be misunderstood, or deliberately hidden, by concussed athletes. Education of athletes about concussion signs and symptoms is imperative. Schools and youth sports programs should consider implementing a policy similar to the NCAA's, which requires education followed by the athletes' signed acknowledgement of receipt of educational materials and agreement to honestly report all possible concussion signs and symptoms to coaches and/or team medical personnel.

Several symptom checklists or scales exist and are useful; all are very similar. The following list was published in the National Athletic Trainers' Association Position Statement: Management of Sport Related Concussion.²

Blurred Vision	Dizziness
Drowsiness	Excess Sleep
Easily Distracted	Fatigue
Feel "In a Fog"	Feel "Slowed down"
Headache	Inappropriate Emotions
Irritability	Loss of Consciousness
Loss of Orientation	Memory Problems
Nausea	Nervousness
Personality Change	Poor Balance/Coordination
Poor Concentration	Ringing in Ears
Sadness	Seeing "Stars"
Sensitivity to Light	Sensitivity to Noise
Sleep Disturbance	Vacant Stare/Glassy Eyes
Vomiting	

Significance of Loss of Consciousness & Amnesia in Determining the Severity of Concussion

Arguably, the two most readily identifiable signs of concussion are loss of consciousness and amnesia. Recognition that neither is required for an injury to be diagnosed as a concussion is very important. In fact, research has shown they actually present rather infrequently, in 9% and 27% respectively, in one study.¹⁴ That study found that symptoms such as headache, dizziness, confusion and disorientation were much more common. Further, when brief loss of consciousness does occur in sport related concussion, it appears to be a weak predictor of outcome as evident in research cited in the NATA position statement²:

Studies involving high school and collegiate athletes with concussion revealed no association between (1) [loss of consciousness] and duration of symptoms or (2) [loss of consciousness] and neuropsychological and balance tests at 3, 24, 48, 72, and 96 hours postinjury.^{21,28,29*} In other words, athletes experiencing [loss of consciousness] were similar to athletes without [loss of consciousness] on these same injury severity markers.

There is continuing support in the Zürich statement³ for the concept that there is limited value associated with using the presence or absence of loss of consciousness of less than one minute in length as a predictor of outcome. (They did, however, suggest that loss of consciousness for more than one minute should be considered in the management of concussion.)

In the overall management of moderate to severe traumatic brain injury, duration of [loss of consciousness] is an acknowledged predictor of outcome.⁷⁹ While published findings in concussion describe [loss of consciousness] associated with specific early cognitive deficits it has not been noted as a measure of injury severity.^{80,81}

Because of this, the experts at the Zürich conference³ recommended that, despite its association with early neuropsychological deficits, loss of consciousness should not be relied upon as a measure of acute concussion severity.

Experts in Zürich made a similar recommendation regarding amnesia:

Published evidence suggests that the nature, burden and duration of the clinical post-concussive symptoms may be more important than the presence or duration of amnesia alone.^{8,15,17}

It is important to note, however, that while loss of consciousness and amnesia may not be good predictors of ultimate injury severity or outcome (recovery), they must still be respected. The NATA² advised that, "Athletes who experience loss of consciousness or amnesia should be disqualified from participating on the day of the injury." This recommendation was expanded in the Zürich statement³ which concluded that pediatric athletes (through high school) experiencing *any* signs or symptoms of concussion should not return to play on the day of injury.

The NH State Advisory Council believes it is important for all concerned to realize that loss of consciousness and amnesia, although often apparent and sometimes dramatic, are present in only a small percentage of concussions. Concussions characterized by other signs and symptoms may be equally or more significant and warrant appropriate care.

*References within quoted material are from the original text.

Grading Scales

More than 20 concussion grading scales have been devised to date.¹⁵ One significant motivation for the creation of these scales was to provide guidance regarding return-to-play decision-making (e.g., the worse the concussion "grade," the longer athletes would be held out of sports). Knowledgeable experts in the field have been responsible for most of the scales; however, it is important to note that these scales are based on experience and anecdotal evidence rather than research-based evidence. Further, many make grading decisions based on the occurrence of loss of consciousness. However, research published since the development of these scales has shown that loss of consciousness is not always predictive of post-concussion sequelae. (See sections on the significance of loss of consciousness and amnesia.) A consensus of experts at the Vienna¹ and Prague⁵ international conventions on sport-related concussion experts stated, "... that injury grading scales be abandoned in favor of combined measures of recovery to determine injury severity (and/or prognosis) and hence individually guide return to play decisions received continued support."⁵ Demonstrating true international consensus on this issue, the more recent Zürich statement³ makes no mention whatsoever of concussion grading scales.

Ongoing Assessment and Management of Concussion

While initial evaluation is often appropriately completed by a primary care or emergency room doctor, certified athletic trainer or school nurse, current guidelines recommend a multi-disciplinary approach to management when possible. Especially in patients with more severe concussion signs/symptoms or co-morbidities, best-practice management of recovery should include integrated care from several specialists for monitoring of symptoms, cognition and behavior, with practices based on scientific evidence.³ Assessments should be provided at the beginning of the injury and then as needed until symptoms have resolved. Neuropsychological screening continues until those scores are back to baseline. Bi-weekly is typically sufficient.

During recovery “rest” is recommended³; however, the term rest is not well understood. It is generally accepted that levels of physical and mental exertion should be kept to a level that does not increase symptoms or worsen cognition. Activities that can be detrimental include insufficient sleep, testing and other school demands, social media, video games, reading, and exercise^{16, 17} however, attention to (and management based on) individual presentation is essential. Low to moderate levels of exertion may be tolerated, and may be beneficial^{18, 19} though physical activity that jars the head should be avoided (e.g., running). Unfortunately, the adolescent athlete frequently under-reports increases in symptoms.

External Factors that May Complicate Concussion Management

Migraines, other chronic headaches, depression anxiety (primary and/or secondary), ADHD, LD, sleep deficit can complicate interpretation of recovery. In the adolescent athlete, it is important to recognize the contribution of these state factors as well as developmental factors in assessing the recovery process.

The NH State Advisory Council on Sport-Related Concussion recommends individualized management using careful monitoring of clinical symptoms (somatic, cognitive, emotional), physical signs, behavior, balance, sleep and cognition in the assessment of concussion.

Multiple Concussions

History of Previous Concussions

Research on athletes at both the high school and college levels has demonstrated that a history of previous concussions lowers the threshold for sustaining a subsequent concussion. Recovery may also be slower in those with a history of previous concussions. Guskiewicz et al provided an excellent review of this research in the NATA Position Statement.²

Once an athlete has suffered a concussion, he or she is at increased risk for subsequent head injuries.^{21,43,86*} Guskiewicz et al^{21,23} found that collegiate athletes had a 3-fold greater risk of suffering a concussion if they had sustained 3 or more previous concussions [self-reported] ... and that players with 2 or more previous concussions required a longer time for total symptom resolution after subsequent injuries.²¹ Players also had a 3-fold greater risk for subsequent concussions in the same season,²³ whereas recurrent, in-season injuries occurred within 10 days of the initial injury 92% of the time.²¹ In a similar study of high school athletes, Collins et al⁸² found that athletes with 3 or more prior concussions were at an increased risk of experiencing LOC (8-fold greater risk), anterograde amnesia (5.5-fold greater risk), and confusion (5.1-fold greater risk) after subsequent concussion...Most important is that these data provide evidence for exercising caution when managing younger athletes with concussion and athletes with a history of previous concussions.

Increased susceptibility to subsequent concussions and prolonged recovery (e.g. post-concussion syndrome) are also concerns related to multiple *current* concussions (i.e., a second trauma prior to resolution of an existing concussion). Athletes who suffer a second blow to the head prior to resolution of the first are at risk for more severe acute problems and longer recovery periods. The most dramatic potential consequence, though rare, of continuing or returning to play prior to concussion resolution is second impact syndrome.

Second Impact Syndrome

Second Impact Syndrome is defined as: a condition where the brain swells rapidly after receiving a second concussion before the symptoms/sequelae of the first concussion have subsided. This extremely rare condition has most often been reported in adolescent males, and is thought to be related to failure of the neurological control of blood flow to the brain. The time from second impact to critical, life-threatening brain swelling is reported to be quite short, taking two to five minutes. If swelling of the brain leads to critically high pressure on the centers that regulate respiration in the brain stem, respiratory failure occurs and leads to death without life support. Despite its extreme rarity, the dramatically life-threatening nature of Second Impact Syndrome is enough to cause concern and heightened awareness of the need to insure complete resolution of concussion before exposure to further risk. The Council espouses this approach.

From Kirkwood et al:^{15*}

Clinical evidence also suggests that physiologic responses are age-dependent after [mild traumatic brain injury]. Most prominently, age-based differences are seen in “second-impact syndrome,” which, as commonly described, results from a second blow to the head while a youth is still symptomatic from a previous concussion.^{47,48} Disruption to autoregulation of the brain’s blood supply is thought to underlie second-impact syndrome, the symptoms of which may include vascular engorgement, diffuse cerebral swelling, increased intracranial pressure, brain herniation, and ultimately coma and death.⁴⁹ Although controversy continues about whether the second impact actually plays a role in triggering the neurologic consequences,^{50,51} agreement exists that diffuse cerebral swelling or malignant cerebral edema does occur in very rare cases after [mild traumatic brain injury] and that immaturity of the brain is a clear risk factor.^{52–55}

Recommendations for Consideration of Season Disqualification

For athletes who suffer a severe concussion (severe symptoms, prolonged recovery) or two concussions of lesser severity, the question of season disqualification should be considered. Objective indicators that it is appropriate to consider season disqualification include prolonged post-concussion syndrome and diminished academic or athletic performance.²⁰

Recommendations for Consideration of Retirement from High Risk Sports

Given the emerging consensus that a history of 3 concussions predisposes athletes to more frequent concussions and increasing recovery times, more attention to the accumulation of concussions in an athlete's history seems warranted.²⁰ While it is too early to propose hard and fast guidelines, a mechanism for discussing the athlete's participation seems reasonable. Organizations should develop mechanisms for discussing participation when athletes accumulate a pre-determined number (or other factors such as persistent post-concussion syndrome) of concussions. Policies should include who to include (parent, PCP, AD, principal), and when the discussion is triggered. A history of three concussions should trigger consideration of steps that may be necessary to protect the athlete, including retirement from collision sports.

The NH State Advisory Council on Sport-Related Concussion recognizes that insuring resolution of concussion prior to allowing return to sport activity is the basis of safe management of sport concussion. The Council further recognizes that a history of multiple concussions should prompt more conservative management and may warrant consideration of the advisability of continued participation in contact or collision sports.

*References within quoted material are from the original text.

Return to School after Concussion

Experts convened at the international concussion in sport meetings^{3,5} agreed that the scholastic demands regularly place on school-age children are cause for concern during concussion recovery. Kirkwood¹⁵ points out several non-sport related considerations that should be implemented when dealing with concussed athletes:

- Provide general concussion education to patient, parents, and school personnel
- Ensure appropriate support in place for transition back to school
- Treat each medical problem symptomatically
- Expect positive outcome for most children
- When recovery is not proceeding as expected, promptly refer to specialists (e.g., in neuropsychology, neurology, rehabilitation, sports medicine, pain management, education, behavioral health)

Sample School Accommodations for Concussed Athletes

There are several modifications that might be made to ease the transition back to school including a gradual return, reduced workload and adequate rest/breaks.^{15, 17, 21} Temporary accommodations may be needed to allow for ‘cognitive rest.’ While it is possible that some students could use this as an excuse for reducing expectations, the Advisory Council believes it is better to err on the side of caution. Ongoing monitoring and communication with school personnel should reduce risks to the athlete. The Centers for Disease Control’s document Acute Concussion Evaluation (ACE) Care Plan and a growing number of scientific papers^{15, 17, 21} can be consulted for suggested accommodations to facilitate return to school.

The NH State Advisory Council on Sport-Related Concussion recommends systematic involvement of school personnel such as nurse, counselor, and/or psychologist to advocate for and support appropriate accommodations for athletes who have suffered a concussion. A multidisciplinary approach to concussion management may help ensure that physical, cognitive and social aspects are managed appropriately.

Return to Sport after Concussion

There is expert consensus³ that for injured children and adolescents, a more conservative return-to-play approach is recommended. One specific area of conservative management is the recommendation that it is not appropriate to return a young athlete to play on the day of the concussive injury.³ Experts^{1, 2, 5} further agree that the earliest any athlete should return to play is when:

- no concussion-related signs or symptoms of any kind are apparent at rest or during exertion (no athlete should return to play while still symptomatic in any way); and
- neurologic examination is normal.

Experts^{1, 2, 5} also agree that once all signs and symptoms have resolved (including test results back to/near baseline), a stepwise progression beginning with light aerobic activity and culminating with a return to game play should be employed. Progression through this protocol should take several days; athletes who experience a return of symptoms during the protocol should stop exercising and resume the protocol the next day or after the subsequent resolution of symptom, whichever is LATER.

Schools (and their associated healthcare providers) that employ baseline testing should seek neuropsychological consultation regarding the interpretation of neuropsychological test protocols and scores, as recommended by the Zurich statement.³ Further, schools should endeavor to insure that their team physician has appropriate training and knowledge in the management of sport-related concussion. Physicians and other healthcare providers who assume responsibility for managing athletes who have suffered a concussion, must stay abreast of current practice guidelines and topics, especially return-to-play decision-making.

The NH State Advisory Council on Sport-Related Concussion recommends that athletes be returned to play only after symptoms and objective test results have returned to their baselines, and an appropriate sequence of graded exertional exercises is completed with no return of signs or symptoms.

Special Considerations:

Pediatric Concussion

A general tenet of pediatrics is that children should not be treated as or considered to be small adults. This concept extends to the management of concussion, though not without some controversy. Until the facts of pediatric concussion risk are elucidated by research, the NH Council considers it best to err on the side of caution. The Zurich³ consensus includes this general statement:

The panel strongly endorsed the view that children should not be returned to practice or play until clinically completely symptom free, which may require a longer time frame than for adults. In addition, the concept of 'cognitive rest' was highlighted with special reference to a child's need to limit exertion with activities of daily living and to limit scholastic and other cognitive stressors (e.g. text messaging, videogames, etc.) while symptomatic. School attendance and activities may also need to be modified to avoid provocation of symptoms.

Specific areas of concern regarding pediatric concussion are noted below. There is some evidence that concussion is more prevalent among younger athletes^{14, 22} and concern exists that their injuries have the potential to be of greater severity and take longer to resolve. Kirkwood, et al's¹⁵ review of the management of pediatric concussion provides a nice summary about the possibility of increased vulnerability:

Traditionally, young age at the time of brain injury has been thought to have protective benefits; the "Kennard principle" holds that the young brain's plasticity would allow for more recovery after insult.^{56*} However, a growing literature, including studies of more severe TBI, strongly indicates that the immature brain is more vulnerable, not more plastic, to diffuse injury.⁵⁷⁻⁶⁷ Several hypotheses have been put forth to help explain this increased vulnerability: skills not yet well established at the time of insult could be more susceptible to disruption than well-established ones; the brain systems responsible for skill acquisition could be affected directly by diffuse injury; functional recovery may be restricted by the injured child's smaller repertoire of existing skills; and an injury to the immature brain could interfere neurobiologically with the intricate sequence of chemical and anatomic events necessary for normal development.^{44,68-70}

In addition to increased vulnerability, there is concern that children suffering concussion may require longer recovery periods. Field, et al²³ compared concussed high school and collegiate athletes and found that the high school athletes demonstrated prolonged memory dysfunction compared with the collegiate athletes. Lovell, et al²⁴ have found that high school athletes sustaining mild injuries may experience symptoms that can last for days post-injury.

Another area of concern relates to the heightened demands of school and learning. This was recognized during the Second International Conference on Concussion in Sport⁵ where the, "... concept of "cognitive rest" was introduced with special reference to a child's need to limit

exertion with activities of daily living and to limit scholastic activities while symptomatic." This area of concern is also nicely summarized by Kirkwood, et al.¹⁵

The contextual or environmental demands faced by children and adults differ as well. Adults have already learned and mastered much of the knowledge and many of the skills they need to function successfully in everyday settings. In contrast, children are continually expected to acquire new information and skills, especially during the school months. Thus, they are often expected to use a set of neurobehavioral skills that are vulnerable to [mild traumatic brain injury], such as the ability to focus and sustain attention, rapidly process information, and hold information in mind while generating a response.^{16,72,73} As a result, clinical management of pediatric concussion requires an understanding of the contextual demands that children face across development⁷⁴ to allow for the provision of suitable assistance.

Finally, several reasons exist for increased conservatism in making the return-to-play decision concerning concussed pediatric athletes. Once again, Kirkwood¹⁵ provides a nice summary:

In the pediatric athlete, a number of additional reasons exist to suggest that the return-to-play decision should be made with ample care. First, we do not yet have a clear understanding of how repeated brain insult could change neurobiological or neurobehavioral development over the long run. Second, the risk-benefit analysis in younger athletes is often considerably different from that in adults, weighted much more heavily toward potential loss or future functional disruption as opposed to immediate gain from returning to competition. Third, although extremely rare, second-impact syndrome has been documented almost exclusively in immature brains, suggesting that the young athlete is at heightened risk for the potentially catastrophic consequences that have been reported after repeated injury.

Authors of the NATA Statement² agree that the potential for second-impact syndrome is of concern and they have included the following recommendation. "Because damage to the maturing brain of a young athlete can be catastrophic (i.e., almost all reported cases of second-impact syndrome are in young athletes), athletes under age 18 years should be managed more conservatively, using stricter [return-to-play] guidelines than those used to manage concussion in the more mature athlete."

Gender Differences

There are several studies that seem to indicate that females may be more vulnerable to concussion and may recover from concussion at different rates compared to males. A current review of these studies is provided by Covassin and Elbin.²⁵ These possible differences reinforce the recommendation that all concussions should be managed based on individual presentation.

The NH State Advisory Council on Sport-Related Concussion agrees that school personnel and primary-care physicians need to be informed of the occurrence of a concussion. Further, student-athletes who have suffered a concussion should be monitored at school for academic-performance difficulties in addition to monitoring for return to play. In general, the younger the concussed athlete, the more conservative the management approach should be.

*References within quoted material are from the original text.

Medical Personnel in the Schools

Certified Athletic Trainers

There should be a qualified allied healthcare provider available to student athletes at the school on a daily basis. A qualified healthcare provider is educated in the prevention, immediate care, treatment and rehabilitation of athletic injuries. The IDEAL choice would be a Certified Athletic Trainer.^{26, 27} The American Medical Association believes that school administrators, athletic directors, and coaches should work with local physicians, medical societies, and medical specialty societies, as well as government officials and community groups to undertake appropriate measures to ensure funding to provide the services of a certified athletic trainer to all high school athletes. The Council agrees with this statement.

Athletic training is not the same profession as personal training. Athletic trainers are healthcare professionals who collaborate with physicians to optimize activity and participation of patients and clients. Athletic training encompasses the prevention, diagnosis, and intervention of emergency, acute, and chronic medical conditions involving impairment, functional limitations, and disabilities.

To become certified athletic trainers, students must graduate with bachelors or masters degree from an accredited professional athletic training education program and pass a comprehensive test administered by the Board of Certification. Once certified, they must meet ongoing continuing education requirements in order to remain certified. More than 70 percent of certified athletic trainers hold at least a master's degree.

The NH State Advisory Council on Sport-Related Concussion recommends schools have appropriate coverage by AT's for all athletic teams, and contact/collision teams in particular. As part of their role, the AT will identify and assess concussions, and manage the return-to-play protocols.

Team Physicians

All certified athletic trainers are required to work under the supervision of a physician. Generally this physician assumes the role of team physician and provides direction to the AT regarding the management of injuries, including concussion. Frequently there are written standing orders regarding management of specific types of injuries. The management of concussion should be discussed and included in management directives. In schools or programs with no AT, the school administration should enlist the services of a qualified (preferably one with sports medicine and/or team physician training) physician to provide direction for their athletic programs. Physicians and other healthcare providers who assume responsibility for

managing athletes who have suffered a concussion must stay abreast of current practice guidelines and topics, especially return-to-play decision-making.

The NH State Advisory Council on Sport-Related Concussion recommends that team physicians have appropriate training and knowledge in the management of sport-related concussion.

School Nurses

School nurses have long been the front-line of medical care in the schools. In the context of sports-related concussions, schools can provide important monitoring and communication functions as a liaison between the AT and the school faculty. Nurses can also serve as advocates for obtaining accommodations for students who have academic or behavioral difficulty as a consequence of concussion.

The NH State Advisory Council on Sport-Related Concussion recommends involvement and training of school nurses.

Neuropsychologists

Neuropsychologists are licensed as clinical psychologists and have additional training in neurology, neuroanatomy, brain-behavior relationships, psychometrics and treatment. Neuropsychology is a specialty recognized by the American Psychological Association and requires specific course work, pre-doctoral and post-doctoral training. Neuropsychological tests should be appropriately supervised. Neuropsychologists are in the best position to interpret neuropsychological test results by virtue of their background and training.

The NH State Advisory Council on Sport-Related Concussion recommends that neuropsychologists review neuropsychological and cognitive testing as part of the best-practice protocol.

Education of Coaches, Parents and Athletes

Research has demonstrated a significant general lack of knowledge about the signs and symptoms and potential sequelae of concussion. Significant risk is attached to that ignorance because injuries that are not recognized by the athlete or those around him cannot be properly managed; the injured athlete cannot be protected from potential second impact if he is still playing. Many symptoms of concussion are subjective and may be misunderstood, or deliberately hidden, by concussed athletes. Education of athletes about concussion signs and symptoms is imperative.

Athletes, coaches and parents should all be educated about the signs and symptoms and about the importance of reporting them to appropriate medical personnel. Web-based concussion training programs for coaches are available at no charge; at least two offer certification upon completion of training. Schools and youth sports programs should consider implementing a policy requiring education followed by the athletes' signed acknowledgement of receipt of educational materials and agreement to honestly report all possible concussion signs and symptoms to coaches and/or team medical personnel.

Another education effort should focus around updating the language of concussion to ensure appropriate respect for the injury. For example, the NATA recommends elimination of the use of words like "ding" and "bell ringer" to describe concussive episodes because they tend to minimize the importance of the injury, which may preclude appropriate management.² In light of the recent tragic death of Natasha Richardson, one of the NATA's recommendations is particularly timely: "It is essential that this injury be reevaluated frequently to determine if a more serious injury has occurred, because often the evolving signs and symptoms of a concussion are not evident until several minutes to hours later."

The NH State Advisory Council on Sport-Related Concussion recommends that coaches, athletes and interested parties (parents, administrators, etc.) receive current basic education on the topic of sport-related concussion. The Council also recommends that governing bodies and individual schools/youth leagues consider requiring coaches to complete training within one month of hire or the implementation of this requirement. Schools and youth programs should also consider implementing a policy which requires athletes to take responsibility (e.g., via signed agreement) for honestly reporting concussion signs and symptoms to team/medical personnel.

Education of Healthcare Providers

It is sometimes difficult for busy physicians to stay abreast of rapidly changing research in a very specific area like sport-related concussion. This is especially true of physicians with broad responsibility for healthcare (e.g., pediatricians, primary care physicians) but is also true of specialists like neurologists whose daily practice may be largely filled with the management of traumatic brain injuries which have different characteristics and management requirements. Physicians who accept the responsibility of determining appropriate return-to-play timing for athletes who have suffered concussions must educate themselves and stay abreast of current practice guidelines on this topic.

The NH State Advisory Council on Sport-Related Concussion recommends that physicians who accept the responsibility of caring for concussed athletes stay up-to-date on current practice guidelines and consensus statements (e.g., Zurich) released on the topic of sport-related concussion.

Resources

Position, Consensus and Other Statements

International Concussion in Sport Group

McCrary P, Meeuwisse W, Johnston K, et al. Consensus statement on Concussion in Sport-The 3rd International Conference on Concussion in Sport held in Zurich, November 2008. *J Sci Med Sport*. Apr 8 2009.

American Academy of Neurology

Position Statement Sports Concussion, October 2010:

<http://www.aan.com/globals/axon/assets/7913.pdf>.

National Athletic Trainers Association

Guskiewicz KM, Bruce SL, Cantu RC, et al. National Athletic Trainers' Association Position Statement: Management of Sport-Related Concussion. *J Athl Train*. Sep 2004;39(3):280-297.

American Academy of Pediatrics

Halstead ME, Walter KD, The Council on Sports M, Fitness. Sport-Related Concussion in Children and Adolescents. *Pediatrics*. Sep 2010;126(3):597-615.

CDC Resources can be accessed at <http://www.cdc.gov/concussion/sports/index.html>

Acute Concussion Evaluation (ACE) Care Plan

Heads Up to Schools: Know Your Concussion ABC's

Heads Up: Concussion in Youth Sports

Heads Up: Concussion in High School Sports

Heads Up: Brain Injury in Your Practice

Heads Up: Concussion Facts for Parents – Lacrosse (available at:

http://www.cdc.gov/concussion/HeadsUp/pdf/Lacrosse_Fact%20Sheets_Parents.pdf)

Podcasts and videos for various audiences from athletes to physicians on concussion at:

<http://www.cdc.gov/Features/Concussion/>

NH Resources**General Brain Injury Services and Information**

Brain Injury Association of New Hampshire
109 N. State Street, Suite 2
Concord, NH 03301
www.bianh.org
(603) 224-8400

Bureau of Developmental Services
Brain Injury Services
John Capuco, Psy.D.
Administrator, Brain Injury Services
105 Pleasant Street
Concord, NH 03301
Office: (603) 271-5035
Fax: (603) 271-5166
jcapuco@dhhs.state.nh.us

Neuropsychologists:

A partial listing of sports neuropsychologists is available on the Brain Injury Association of NH's website:
<http://www.bianh.org/concussion/NHSNeuropsychList.pdf>

References

1. Aubry M, Cantu R, Dvorak J, Graf-Baumann T, Johnston K, Kelly J, et al. Summary and agreement statement of the First International Conference on Concussion in Sport, Vienna 2001. Recommendations for the improvement of safety and health of athletes who may suffer concussive injuries. *Br J Sports Med* 2002;36(1):6-10.
2. Guskiewicz KM, Bruce SL, Cantu RC, Ferrara MS, Kelly JP, McCrea M, et al. National Athletic Trainers' Association Position Statement: Management of Sport-Related Concussion. *J Athl Train* 2004;39(3):280-97.
3. McCrory P, Meeuwisse W, Johnston K, Dvorak J, Aubry M, Molloy M, et al. Consensus statement on Concussion in Sport-The 3rd International Conference on Concussion in Sport held in Zurich, November 2008. *J Sci Med Sport* 2009.
4. Herring SA, Bergfeld JA, Boland A, Boyajian-O'Neill LA, Cantu RC, Hershman E. Concussion (mild traumatic brain injury) and the team physician: a consensus statement. *Med Sci Sports Exerc* 2006;38(2):395-9.
5. McCrory P, Johnston K, Meeuwisse W, Aubry M, Cantu R, Dvorak J, et al. Summary and agreement statement of the 2nd International Conference on Concussion in Sport, Prague 2004. *Br J Sports Med* 2005;39(4):196-204.
6. Guskiewicz KM, Mihalik JP. Biomechanics of sport concussion: quest for the elusive injury threshold. *Exerc Sport Sci Rev* 2010;39(1):4-11.
7. Cantu RC, Mueller FO. The prevention of catastrophic head and spine injuries in high school and college sports. *Br J Sports Med* 2009;43(13):981-6.
8. Benson BW, Hamilton GM, Meeuwisse WH, McCrory P, Dvorak J. Is protective equipment useful in preventing concussion? A systematic review of the literature. *Br J Sports Med* 2009;43 Suppl 1:i56-67.
9. Navarro RR. Protective equipment and the prevention of concussion - what is the evidence? *Curr Sports Med Rep* 2010;10(1):27-31.
10. Mueller FO, Cantu RC. *Annual Survey of Catastrophic Football Injuries 1977-2009*. . Chapel Hill: University of North Carolina; 2010.
11. Pellman EJ, Viano DC, Tucker AM, Casson IR, Waeckerle JF. Concussion in professional football: reconstruction of game impacts and injuries. *Neurosurgery* 2003;53(4):799-812; discussion 12-4.
12. Guskiewicz KM, Valovich McLeod TC. Pediatric Sports-related Concussion. *PM R* 2011;3(4):353-64.
13. McCrea M, Guskiewicz KM, Marshall SW, Barr W, Randolph C, Cantu RC, et al. Acute effects and recovery time following concussion in collegiate football players: the NCAA Concussion Study. *JAMA* 2003;290(19):2556-63.
14. Guskiewicz KM, Weaver NL, Padua DA, Garrett WE, Jr. Epidemiology of concussion in collegiate and high school football players. *Am J Sports Med* 2000;28(5):643-50.
15. Kirkwood MW, Yeates KO, Wilson PE. Pediatric sport-related concussion: a review of the clinical management of an oft-neglected population. *Pediatrics* 2006;117(4):1359-71.
16. Logan K. **Cognitive Rest Means I Can't Do What?!** *Ath Tr & Sports Health Care* 2009;1(6):2.
17. McGrath N. Supporting the Student-Athlete's Return to the Classroom After a Sport-Related Concussion. *J Athl Train* 2010;45(5):492-8.
18. Leddy JJ, Kozlowski K, Donnelly JP, Pendergast DR, Epstein LH, Willer B. A preliminary study of subsymptom threshold exercise training for refractory post-concussion syndrome. *Clin J Sport Med* 2010;20(1):21-7.

19. Majerske CW, Mihalik JP, Ren D, Collins MW, Reddy CC, Lovell MR, et al. Concussion in sports: postconcussive activity levels, symptoms, and neurocognitive performance. *J Athl Train* 2008;43(3):265-74.
20. Sedney CL, Orphanos J, Bailes JE. When to consider retiring an athlete after sports-related concussion. *Clin Sports Med* 2011;30(1):189-200.
21. Halstead ME, Walter KD, The Council on Sports M, Fitness. Sport-Related Concussion in Children and Adolescents. *Pediatrics* 2010;126(3):597-615.
22. Gessel LM, Fields SK, Collins CL, Dick RW, Comstock RD. Concussions among United States high school and collegiate athletes. *J Athl Train* 2007;42(4):495-503.
23. Field M, Collins MW, Lovell MR, Maroon J. Does age play a role in recovery from sports-related concussion? A comparison of high school and collegiate athletes. *J Pediatr* 2003;142(5):546-53.
24. Lovell MR, Collins MW, Iverson GL, Field M, Maroon JC, Cantu R, et al. Recovery from mild concussion in high school athletes. *J Neurosurg* 2003;98(2):296-301.
25. Covassin T, Elbin RJ. The female athlete: the role of gender in the assessment and management of sport-related concussion. *Clin Sports Med* 2011;30(1):125-31.
26. Almquist J, Valovich McLeod TC, Cavanna A, Jenkinson D, Lincoln AE, Loud K, et al. Summary statement: appropriate medical care for the secondary school-aged athlete. *J Athl Train* 2008;43(4):416-27.
27. Neurology AAo. Position Statement Sports Concussion (October, 2010). St. Paul, MN; 2010.