Concussion

Research based recommendations on management of sport related concussion: summary of the National Athletic Trainers' Association position statement

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Sport related concussion should always be treated seriously and systematically

Sport related concussion has received considerable attention in both the lay media and medical literature in recent years. As a result, clinicians, coaches, parents, and athletes at all levels of competition are becoming educated about the necessity to treat concussions seriously. In time, this will help to create a safer playing environment for athletes at all levels of competition. Despite an array of complexities associated with studying sport related concussion, new scientific research and clinically based literature have provided sports medicine professions with a wealth of updated information on the treatment of sport related concussion.

For example, there is now sufficient literature supporting the notion that once you experience a concussion, you are more likely to sustain future concussions[1 2]; and a strong likelihood exists that the symptoms following these repeat concussions may be more serious and resolve at a slower rate.[1 3] Several recent research papers and consensus statements indicate the necessity to use a systematic approach to evaluating the severity and duration of all possible signs and symptoms after a concussion, and to be cautious of not returning players to competition too quickly.[4–16] Loss of consciousness and amnesia are two important parameters associated with cerebral concussion, but headaches, dizziness/balance deficits, concentration deficits, and feeling ''slowed down'' are more common.[1 2 6 9 14 17–20] Extensive research has also been conducted on neuropsychological testing[17 19–34] and postural stability testing,[20 35–37] both of which are considered to be key markers for tracking recovery after cerebral concussion. Recent concussion publications on topics such as physician referral and home care,[13 38] youth athletes,[39 40] and protective equipment[41] have also provided clinicians with a better understanding of how better to manage sport related concussion.

To provide certified athletic trainers (ATCs), doctors, and other medical professionals with a comprehensive list of recommendations for managing concussions, the National Athletic Trainers' Association (NATA) formed a committee charged with developing a research based position statement derived from these most recent studies. The recommendations are intended for the treatment of concussed athletes at the youth, high school, collegiate, and elite levels. The writing committee consisted of a team doctor, a neurosurgeon, a neurologist, a neuropsychologist, and four ATCs.

The following summary includes recommendations that can be found in the full article published in the *Journal of Athletic Training* 2004;**39**:278–95. The full text and complete reference list for this peer reviewed position statement is also available at http://www.pubmedcentral.nih.gov and http://www.nata.org/publicinformation/position.htm.

The summary statement is organised into the following sections: Defining and recognising the concussion; Evaluating and making the return to play decision; Concussion assessment tools; When to refer to a physician; When to disqualify an athlete; Special considerations for young athletes; Home care; Equipment issues.

DEFINING AND RECOGNISING THE CONCUSSION

(1) The ATC should develop a high sensitivity for the various mechanisms and presentations of traumatic brain injury, including mild, moderate, and severe cerebral concussion, as well as the more severe but less common head injuries that can cause damage to the brain stem and other vital centres of the brain.

(2) The colloquial term ''ding'' should not be used to describe a sport related concussion. This stunned confusional state is a concussion most often reflected by the athlete's initial confusion, which may disappear within minutes, leaving no outward observable signs and symptoms. Use of the term ''ding'' generally carries a connotation that diminishes the seriousness of the injury. If an athlete shows concussion-like signs and reports symptoms after a contact to the head, the athlete has, at the very least, sustained a mild concussion and should be treated for a concussion.

(3) To detect deteriorating signs and symptoms that may indicate a more serious head injury, the ATC should be able to recognise both the obvious signs (fluctuating levels of consciousness, balance problems, memory and concentration difficulties, etc) and common self reported symptoms (headache, ringing in the ears, nausea, etc).

(4) The ATC should play an active role in educating athletes, coaches, and parents about the signs and symptoms associated with concussion, as well as the potential risks of playing while still symptomatic.

(5) The ATC should document all pertinent information surrounding the concussive injury, including, but not limited to, (*a*) mechanism of injury, (*b*) initial signs and symptoms, (*c*) state of consciousness, (*d*) findings on serial testing of symptoms, neuropsychological function, and postural stability (noting any deficits compared with baseline), (*e*) instructions given to the athlete and/or parent, (*f*) recommendations provided by the physician, (*g*) date and time of the athlete's return to participation, and (*h*) relevant information on the player's history of prior concussion and associated recovery pattern(s).

EVALUATING AND MAKING THE RETURN TO PLAY DECISION

(6) ATCs and team physicians working together should agree on a philosophy for managing sport related concussion before the start of the athletic season. Currently three approaches are commonly used: (*a*) grading the concussion at the time of the injury; (*b*) deferring final grading until all symptoms have resolved; or (*c*) not using a grading scale but rather focusing attention on the athlete's recovery by symptoms,

neurocognitive testing, and postural stability testing. After deciding on an approach, the ATC-physician team should be consistent in its use regardless of the athlete, sport, or circumstances surrounding the injury.

(7) For athletes playing sports with a high risk of concussion, baseline cognitive and postural stability testing should be considered. In addition to the concussion injury assessment, the evaluation should also include an assessment of the cervical spine and cranial nerves to identify any cervical spine or vascular intracerebral injuries.

(8) The ATC should record the time of the initial injury and document serial assessments of the injured athlete, noting the presence or absence of signs and symptoms of injury. The ATC should monitor vital signs and level of consciousness every five minutes after a concussion until the athlete's condition improves. The athlete should also be monitored over the next few days after the injury for the presence of delayed signs and symptoms and to assess recovery.

(9) Concussion severity should be determined by paying close attention to the severity and persistence of all signs and symptoms, including the presence of amnesia (retrograde and anterograde) and loss of consciousness, as well as headache, concentration problems, dizziness, blurred vision, etc. It is recommended that ATCs and physicians consistently use a symptom checklist similar to the one provided in appendix A.

(10) In addition to a thorough clinical evaluation, formal cognitive and postural stability testing is recommended to assist in objectively determining injury severity and readiness to return to play. No one test should be used solely to determine recovery or return to play, as concussion presents in many different ways.

(11) Once symptom-free or asymptomatic, the athlete should be reassessed to establish that cognition and postural stability have returned to normal for that player, preferably by comparison with pre-injury baseline test results. The return to play decision should be made after an incremental increase in activity with an initial cardiovascular challenge, followed by sport specific activities that do not place the athlete at risk of concussion. The athlete can be released to full participation as long as no recurrent signs or symptoms are present.

CONCUSSION ASSESSMENT TOOLS

(12) Baseline testing on concussion assessment measures is recommended to establish the individual athlete's ''normal'' pre-injury performance and to provide the most reliable benchmark against which to measure recovery. Baseline testing also controls for extraneous variables (attention deficit disorder, learning disabilities, age, education, etc) and for the effects of previous concussion, while also evaluating the possible cumulative effects of recurrent concussions.

(13) The use of objective concussion assessment tools will help ATCs in more accurately identifying deficits caused by injury and recovery from injury and protect players from the potential risks associated with prematurely returning to competition and sustaining a repeat concussion. The concussion assessment battery should include a combination of tests for cognition, postural stability, and self reported symptoms known to be affected by concussion.

(14) A combination of brief screening tools appropriate for use on the sideline—for example, standardised assessment of concussion (SAC), balance error scoring system (BESS), symptom checklist—and more extensive measures—for example, neuropsychological testing, computerised balance testing—to evaluate more precisely recovery later after injury is recommended.

(15) Before instituting a concussion neuropsychological testing battery, the ATC should understand the test's user requirements, copyright restrictions, and standardised instructions for administration and scoring. All evaluators should be appropriately trained in the standardised instructions for test administration and scoring before embarking on testing or adopting an instrument for clinical use. Ideally, the sports medicine team should include a neuropsychologist, but in reality, many ATCs may not have access to a neuropsychologist for interpretation and consultation, nor the financial resources to support a neuropsychological testing program. In this case, it is recommended that the ATC use screening instruments (SAC, BESS, symptom checklist) that have been developed specifically for use by sports medicine clinicians without extensive training in psychometric or standardised testing and that do not require a special license to administer or interpret.

(16) ATCs should adopt for clinical use only, those neuropsychological and postural stability measures with population specific normative data, test-retest reliability, clinical validity, and sufficient sensitivity and specificity established in the peer reviewed literature. These standards provide the basis for how well the test can distinguish between those with and without cerebral dysfunction in order to reduce the possibility of making false positive and false negative errors, which could lead to clinical decision-making errors.

(17) As is the case with all clinical instruments, results from assessment measures to evaluate concussion should be integrated with all aspects of the injury evaluation—for example, physical examination, neurological evaluation, neuroimaging, player's history, etc—for the most effective approach to injury management and return to play decision making. Decisions about an athlete's return to play should never be based solely on the use of any one test.

WHEN TO REFER TO A PHYSICIAN

(18) The ATC or team physician should monitor an athlete with a concussion at five minute intervals from the time of the injury until the athlete's condition completely clears or the athlete is referred for further care. Coaches should be informed that in situations when a concussion is suspected but an ATC or physician is not available, their primary role is to ensure that the athlete is immediately seen by an ATC or physician.

(19) An athlete with a concussion should be referred to a physician on the day of injury if he or she lost consciousness, experienced amnesia lasting longer than 15 minutes, or meets any of the criteria outlined in appendix B.

(20) A team approach for the assessment of concussion should be used to include a variety of medical specialties. In addition to family practice or general medicine physician referrals, the ATC should secure other specialist referral sources within the community. For example, neurologists are trained to assist in the management of patients experiencing persistent signs and symptoms, including sleep disturbances. Similarly, a neuropsychologist should be identified as part of the sports medicine team for assisting athletes who require more extensive neuropsychological testing and for interpreting the results of neuropsychological tests.

(21) A team approach should be used in making return to play decisions after concussion. This approach should involve input from the ATC, physician, athlete, and any referral sources. The assessment of all information including the physical examination, imaging studies, objective tests, and exertional efforts should be considered before making a return to play decision.

WHEN TO DISQUALIFY AN ATHLETE

(22) Athletes who are symptomatic at rest and after exertion for at least 20 minutes should be disqualified from

returning to participation on the day of the injury. Exertional exercises should include sideline jogging followed by sprinting, sit ups, push ups, and any sport specific, non-contact activities (or positions or stances) the athlete might need to perform on returning to participation. Athletes who return on the same day because symptoms resolved quickly (<20 minutes) should be monitored closely after they return to play. They should be repeatedly re-evaluated on the sideline, after the practice or game, and again at 24 and 48 hours after the injury to identify any delayed onset of symptoms.

(23) Athletes who experience loss of consciousness or amnesia should be disqualified from participating on the day of the injury.

(24) The decision to disqualify from further participation on the day of a concussion should be based on a comprehensive physical examination, assessment of self reported post-concussion signs and symptoms, functional impairments, and the athlete's history of concussions. If assessment tools such as the SAC, BESS, neuropsychological test battery, and symptom checklist are not used, a seven day symptom-free waiting period before returning to participation is recommended. Some circumstances, however, will warrant even more conservative treatment (see recommendation 25).

(25) ATCs should be more conservative with athletes who have a history of concussion. Athletes with a history of concussion are at increased risk of sustaining subsequent injuries, as well as slow recovery of self reported post-concussion signs and symptoms, cognitive dysfunction, and postural instability after subsequent injuries. In athletes with a history of three or more concussions who are experiencing slow recovery, temporary or permanent disqualification from contact sports may be indicated.

SPECIAL CONSIDERATIONS FOR YOUNG ATHLETES

(26) ATCs working with younger (paediatric) athletes should be aware that recovery may take longer than in older athletes. In addition, these younger athletes are maturing at a relatively fast rate and will probably require more frequent updates of baseline measures compared with older athletes.

(27) Many young athletes experience sport related concussion. ATCs should play an active role in helping to educate young athletes, their parents, and coaches about the dangers of repeated concussions. Continued research into the epidemiology of sport related concussion in young athletes and prospective investigations to determine the acute and long term effects of recurrent concussion in younger athletes are warranted.

(28) Because damage to the maturing brain of a young athlete can be catastrophic (almost all reported cases of second-impact syndrome are in young athletes), younger athletes (under the age of 18 years) should be managed more conservatively, using stricter return to play guidelines than those used to manage concussion in the more mature athlete.

HOME CARE

(29) An athlete with a concussion should be instructed to avoid taking drugs except acetaminophen after the injury. Acetaminophen and other drugs should only be given at the recommendation of a physician. In addition, the athlete should be instructed to avoid ingesting alcohol, illicit drugs, or other substances that might interfere with cognitive function and neurological recovery.

(30) Any athlete with a concussion should be instructed to rest, but complete bed rest is not recommended. The athlete should resume normal activities of daily living as tolerated, while avoiding activities that potentially increase symptoms. Once he or she is asymptomatic, the athlete may resume a graded programme of physical and mental exertion, without contact or risk of concussion, up to the point at which post-concussion signs and symptoms recur. If symptoms appear, the exertion level should be scaled back to allow maximal activity without triggering symptoms.

(31) An athlete with a concussion should be instructed to eat a well balanced diet that is nutritious in both quality and quantity.

(32) An athlete should be awakened during the night to check on deteriorating signs and symptoms only if he or she experienced loss of consciousness, had prolonged periods of amnesia, or was still experiencing significant symptoms at bedtime. The purpose of the wake ups is to check for deteriorating signs and symptoms, such as decreased levels of consciousness or increasing headache, which could indicate a more serious head injury or a late onset complication such as an intracranial bleed.

(33) Oral and written instructions for home care should be given to the athlete and to a responsible adult—for example, parents or roommate—who will observe and supervise the athlete during the acute phase of the concussion while at home or in the dormitory. The ATC and physician should agree on a standard concussion home instruction form similar to the one presented in appendix C, and it should be used consistently for all concussions.

EQUIPMENT ISSUES

(34) The ATC should enforce the standard use of helmets for protecting against catastrophic head injuries and reducing the severity of cerebral concussions. In sports that require helmet protection (football, lacrosse, ice hockey, baseball/softball, etc), the ATC should ensure that all equipment meets either the National Operating Committee on Standards for Athletic Equipment (NOCSAE) or American Society for Testing and Materials (ASTM) standards.

(35) The ATC should enforce the standard use of mouthguards for protection against dental injuries, even though the scientific evidence supporting their use for reducing concussive injury is not yet convincing.

(36) At this time, the ATC should neither endorse nor discourage the use of soccer headgear for protecting against concussion or the consequences of cumulative, subconcussive impacts to the head. Currently, no scientific evidence supports the use of headgear in soccer for reducing concussive injury to the head.

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Appendix A

Graded symptom checklist (GSC)

Symptom	Time of injury	2–3 h after injury	24 h after injury	48 h after injury	72 h after injury
Blurred vision					
Dizziness					
Drowsiness					
Excess sleep					
Easily distracted					
Fatigue					
Feel ''in a fog''					
Feel ''slowed down''					
Headache					
Inappropriate emotions					
Irritability					
Loss of consciousness					
Loss or orientation					
Memory problems					
Nausea					
Nervousness					
Personality change					
Poor balance/coord.					
Poor concentration					
Ringing in ears					
Sadness					
Seeing stars					
Sensitivity to light					
Sensitivity to noise					
Sleep disturbance					
Vacant stare/glassy eyed					
Vomiting					

Note: the GSC should be used not only for the initial evaluation but for each subsequent follow up assessment until all signs and symptoms have cleared at rest and during physical exertion. In lieu of simply checking each symptom present, the ATC can ask the athlete to grade or score the severity of the symptom on a scale of 0–6, where 0 = not present, 1 = mild, 3 = moderate, and 6 = most severe.

Appendix B

Physician referral checklist

Day of injury referral
1. Loss of consciousness on the field
2. Amnesia lasting longer than 15 minutes
3. Deterioration of neurological function*
4. Decreasing level of consciousness*
5. Decrease or irregularity in respirations*
6. Decrease or irregularity in pulse*
7. Increase in blood pressure
8. Unequal, dilated, or unreactive pupils*
9. Cranial nerve deficits
10. Any signs or symptoms of associated injuries, spine or skull fracture, or bleeding*
11. Mental status changes: lethargy, difficulty maintaining arousal, confusion, agitation*
12. Seizure activity*
13. Vomiting
14. Motor deficits subsequent to initial on-field assessment
15. Sensory deficits subsequent to initial on-field assessment
16. Balance deficits subsequent to initial on-field assessment
17. Cranial nerve deficits subsequent to initial on-field assessment
18. Post-concussion symptoms that worsen
19. Additional post-concussion symptoms as compared with those on the field
20. Athlete is still symptomatic at the end of the game (especially at high school level)

Delayed referral (after the day of injury)
1. Any of the findings in the day of injury referral category
2. Post-concussion symptoms worsen or do not improve over time
3. Increase in the number of post-concussion symptoms reported
4. Post-concussion symptoms begin to interfere with the athlete's daily activities (sleep disturbances, cognitive difficulties)

*Requires the athlete be transported immediately to the nearest emergency department.

REFERENCES

1 **Guskiewicz KM**, McCrea M, Marshall SW, *et al.* Cumulative effects of recurrent concussion in collegiate football players: the NCAA Concussion Study. *JAMA* 2003;**290**:2549–55.
2 **Guskiewicz KM**, Weaver NL, Padua DA, *et al.* Epidemiology of concussion in collegiate and high school football players. *Am J Sports Med* 2000;**28**:643–50.
3 **Iverson GL**, Gaetz M, Lovell MR, *et al.* Cumulative effects of concussion in amateur athletes. *Brain Injury* 2004;**18**:433–43.
4 **Aubry M**, Cantu R, Dvorak 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**:6–10.
5 **Bailes JE**, Hudson V. Classification of sport-related head trauma: a spectrum of mild to severe injury. *J Athl Train* 2001;**36**:236–43.
6 **Cantu RC**. Posttraumatic retrograde and anterograde amnesia: pathophysiology and implications in grading and safe return to play. *J Athl Train* 2001;**36**:244–8.
7 **Giza CC**, Hovda DA. The neurometabolic cascade of concussion. *J Athl Train* 2001;**36**:228–35.
8 **Guskiewicz KM**, Cantu RC. The concussion puzzle: evaluation of sport-related concussion. *Am J Med Sports* 2004;**6**:13–21.
9 **Kelly JP**. Loss of consciousness: Pathophysiology and implications in grading and safe return to play. *J Athl Train* 2001;**36**:249–52.
10 **Lovell MR**, Iverson GL, Collins MW, *et al.* Does loss of consciousness predict neuropsychological decrements after concussion? *Clin J Sport Med* 1999;**9**:193–8.
11 **Lovell MR**, Collins MW, Iverson GL, *et al.* Recovery from mild concussion in high school athletes. *J Neurosurg* 2003;**98**:296–301.
12 **Lovell MR**, Collins MW, Iverson GL, *et al.* Grade 1 or ''ding'' concussions in high school athletes. *Am J Sports Med* 2004;**32**:47–54.
13 **McCrory P**. What advice should we give to athletes postconcussion? *Br J Sports Med* 2002;**36**:316–18.
14 **McCrory P**, Ariens T, Berkovic SF. The nature and duration of acute concussive symptoms in Australian football. *Clin J Sport Med* 2000;**10**:235–8.
15 **Oliaro S**, Anderson S, Hooker D. Management of cerebral concussion in sports: the athletic trainer's perspective. *J Athl Train* 2001;**36**:257–62.
16 **Practice parameter: the management of concussion in sports (summary statement)**. Report of the Quality Standards Subcommittee of the American Academy of Neurology. *Neurology* 1997;**48**:581–5.
17 **Collins MW**, Iverson GL, Lovell MR, *et al.* On-field predictors of neuropsychological and symptom deficit following sports-related concussion. *Clin J Sport Med* 2003;**13**:222–9.
18 **Erlanger D**, Kaushik T, Cantu R, *et al.* Symptom-based assessment of the severity of a concussion. *J Neurosurg* 2003;**98**:477–84.
19 **Erlanger D**, Saliba E, Barth JT, *et al.* Monitoring resolution of postconcussion symptoms in athletes: preliminary results of a web-based neuropsychological test protocol. *J Athl Train* 2001;**36**:280–7.
20 **McCrea M**, Guskiewicz KM, Barr W, *et al.* Acute effects and recovery time following concussion in collegiate football players: the NCAA Concussion Study. *JAMA* 2003;**290**:2556–63.
21 **Barr WB**, McCrea M. Sensitivity and specificity of standardized neurocognitive testing immediately following sports concussion. *J Int Neuropsychol Soc* 2001;**7**:693–702.
22 **Bleiberg J**, Cernich AN, Cameron K, *et al.* Duration of cognitive impairment after sports concussion. *Neurosurgery* 2004;**54**:1073–80.
23 **Collie A**, Darby D, Maruff P. Computerised cognitive assessment of athletes with sports related head injury. *Br J Sports Med* 2001;**35**:297–302.
24 **Collie A**, Maruff P, Makdissi M, *et al.* CogSport: reliability and correlation with conventional cognitive tests used in postconcussion medical evaluations. *Clin J Sport Med* 2003;**13**:28–32.
25 **Collins MW**, Field M, Lovell MR, *et al.* Relationship between postconcussion headache and neuropsychological test performance in high school athletes. *Am J Sports Med* 2003;**31**:168–73.
26 **Collins MW**, Grindel SH, Lovell MR, *et al.* Relationship between concussion and neuropsychological performance in college football players. *JAMA* 1999;**282**:964–70.
27 **Collins MW**, Lovell MR, Iverson GL, *et al.* Cumulative effects of concussion in high school athletes. *Neurosurgery* 2002;**51**:1175–81.
28 **Daniel JC**, Olesniewicz MH, Reeves DL, *et al.* Repeated measures of cognitive processing

Appendix C

Concussion home instructions

_____

I believe that _____ sustained a concussion on _____. To make sure he/she recovers, please follow the following important recommendations:

1. Please **remind**_____ to report to the athletic training room tomorrow at _____ for a follow-up evaluation.
2. Please **review** the items outlined on the enclosed **Physician Referral Checklist**. If any of these problems develop prior to his/her visit, please call_____at _____ or contact the local EMS. Otherwise, you can follow the instructions outlined below.

It is OK to:	There is NO need to:	Do NOT:
• Use acetaminophen (Tylenol) for headaches • Eat a light diet • Use ice pack on head & neck as needed for comfort • Return to school • Go to sleep • Rest (no strenuous activity or sports)	• Stay in bed • Check eyes with flashlight • Wake up every hour • Test reflexes	• Drink alcohol • Eat or drink, spicy foods or drinks

Special recommendations:

_____

_____

Recommendations provided to: _____

Recommendations provided by: _____Date: _____ Time: _____

Please feel free to contact me if you have any questions. I can be reached at: _____

Signature: _____ Date: _____

efficiency in adolescent athletes: implications for monitoring recovery from concussion. *Neuropsychiatry Neuropsychol Behav Neurol* 1999;**12**:167–9.

29 **Echemendia R**, Putukian M, Mackin RS, *et al*. Neuropsychological test performance prior to and following sports-related mild traumatic brain injury. *Clin J Sport Med* 2001;**11**:23–31.

30 **Makdissi M**, Collie A, Maruff P, *et al*. Computerised cognitive assessment of concussed Australian Rules footballers. *Br J Sports Med* 2001;**35**:354–60.

31 **McCrea M**. Standardized mental status assessment of sports concussion. *Clin J Sport Med* 2001;**11**:176–81.

32 **McCrea M**. Standardized mental status testing on the sideline after sport-related concussion. *J Athl Train* 2001;**36**:274–9.

33 **McCrea M**, Kelly JP, Randolph C, *et al*. Immediate neurocognitive effects of concussion. *Neurosurgery* 2002;**50**:1032–42.

34 **Pottinger L**, Cullum M, Stallings RL. Cognitive recovery following concussion in high school athletes. *Arch Clin Neuropsychol* 1999;**14**:39–40.

35 **Guskiewicz KM**, Ross SE, Marshall SW. Postural stability and neuropsychological deficits after concussion in collegiate athletes. *J Athl Train* 2001;**36**:263–73.

36 **Peterson CL**, Ferrara MS, Mrazik M, *et al*. An analysis of domain score and posturography following cerebral concussion. *Clin J Sport Med* 2003;**13**:230–7.

37 **Riemann BL**, Guskiewicz KM. Effects of mild head injury on postural stability as measured through clinical balance testing. *J Athl Train* 2000;**35**:19–25.

38 **de Kruijk JR**, Leffers P, Meerhoff S, *et al*. Effectiveness of bed rest after mild traumatic brain injury: a randomised trial of no versus six days of bed rest. *J Neurol Neurosurg Psychiatry* 2002;**73**:167–72.

39 **Adams J**, Frumiento C, Shatney-Leach L, *et al*. Mandatory admission after isolated mild closed head injury in children: is it necessary? *J Pediatr Surg* 2001;**36**:119–21.

40 **Field M**, Collins MW, Lovell MR. Does age play a role in recovery from sports related concussion? A comparison of high school school and collegiate athletes. *Am J Pediatr* 2003;**142**:546–53.

41 **Halstead DP**. Performance testing updates in head, face, and eye protection. *J Athl Train* 2001;**36**:322–7.