

Sport-related concussion: Evaluation and management

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Abstract

Concussion is a common injury among children and adolescents participating in organized sports and recreational activities. Any child or youth who sustains a concussion should be removed from play immediately and medically evaluated as soon as possible. Cognitive and physical rest are recommended to allow symptoms to resolve. Cognitive rest may require temporary school absence and/or a modified class work or homework load. After symptoms have completely resolved at rest and a full return to school is achieved, the student can progress through a medically supervised, stepwise exertion protocol to return to play. Everyone involved in child and youth sports must recognize the signs and symptoms of concussion, and ensure that any child or adolescent suspected of sustaining a concussion is properly evaluated and managed by qualified medical personnel. The present statement replaces a previous Canadian Paediatric Society position statement published in 2006 and revised in 2012.

Key Words: *Adolescents; Children; Concussion; Return to learn; Return to play; Sport; Youth*

Concussion in sport is an important topic. It is a common injury that occurs in children and adolescents participating in sports and recreational activities. In the United States, almost 175,000 children and adolescents are treated annually in emergency departments (EDs) for sport-related head injuries.^[1]

A Canadian ED study of head injuries involving five EDs in Edmonton (Alberta) found that 53.4% of head injuries in children 10 to 14 years of age and 42.9% of head injuries in adolescents 15 to 19 years of age were sport-related.^[2] Concussions account for 9% to 12% of injuries in high school athletics.^{[3][4]} Signs and symptoms of concussion can be subtle and easily overlooked by athletes, coaches or trainers, parents and even health care professionals. Injured athletes who do not recognize the signs or symptoms of concussion or who

choose to ignore them may not report their injury or seek medical attention.

The first Canadian Paediatric Society (CPS) position statement on sport-related concussion in children was published in 2006 and revised in 2012.^{[5][6]} The Fourth International Conference on Concussion in Sport was held later in 2012 and a consensus document updating recommendations for the management of sport-related concussions was published the following year.^[7] The present CPS statement reflects the latest recommendations and updates for managing sport-related concussions so as to better assist health care professionals in caring for injured children and adolescents five to 18 years of age. This statement reviews the definition of concussion; the evaluation of concussion including signs and symptoms; concussion management including return to learn (RTL) and return to play (RTP) guidelines; and prevention. The CPS recommendations in the present statement are guidelines only, based on current data and expert opinion. Concussion knowledge is continually evolving and health care professionals are encouraged to manage children and adolescents with sport-related concussions conservatively.

Definition of concussion

Concussion is a brain injury defined by the Concussion in Sport Group as “a complex pathophysiological process affecting the brain, induced by biomechanical forces” and resulting “in the rapid onset of short-lived impairment of neurological function that resolves spontaneously”.^[7] Concussion may result from a direct impact to the head, neck or face, or to somewhere else on the body that transmits an impulsive force to the head.^[7] Loss of consciousness is not a common feature of most concussions. The acute clinical symptoms of concussion represent a functional rather than a structural brain injury.^[7]

Evaluation of concussion

Signs and symptoms

There are many signs and symptoms that athletes may experience following a concussion (Table 1). A concussion should be suspected if an injured athlete exhibits any of these signs or symptoms and appropriate management should be initiated.

ed.^{[5][7]} Concussion signs and symptoms may develop within minutes to hours and sometimes even days following an injury. Signs and symptoms of concussion in younger children may be more subtle and difficult to ascertain because of limited communication skills.^[8] In adults and older adolescents, symptoms typically resolve in seven to 10 days.^[9] However, younger children can take longer to recover and, in some individuals, symptoms last weeks to months.^{[8][11]}

TABLE 1
Features of sport-related concussion

Symptoms/physical signs	Behavioural changes	Cognitive impairment	Sleep disturbances
Headache	Irritability	Slowed reaction times	Drowsiness
Nausea/vomiting	Emotional lability	Difficulty concentrating	Trouble falling asleep
Dizziness	Sadness	Difficulty remembering	Sleeping more than usual
Visual disturbances	Anxiety	Confusion	Sleeping less than usual
Photophobia	Inappropriate emotions	Feeling in a fog	
Phonophobia		Feeling dazed	
Loss of consciousness			
Amnesia			
Loss of balance or poor coordination			
Decreased playing ability			

The cognitive effects of concussion include decreased attention and concentration, reduced information processing speed, and impaired memory and learning.^{[9][10][12]} These effects may negatively impact a child's or adolescent's ability to learn and attend to school work.

Fatal diffuse cerebral swelling, known as malignant brain edema syndrome or second-impact syndrome, is a rare complication of head injury in children and adolescents.^[13] The phenomenon is believed to be caused by a loss of autoregulation in the brain's blood supply, causing rapid cerebrovascular congestion and increased intracranial pressure, with progression to brain stem herniation, coma and death.^{[8][13]}

Evaluation

For detailed protocols in the evaluation and treatment of acute head injuries in children and adolescents, see the CPS statement at www.cps.ca/en/documents/position/paediatric-patient-with-acute-head-trauma. Any athlete who sustains a head injury while participating in sports or recreational activities should immediately stop the activity and be removed from the game or practice. If there is loss of consciousness, a cervical spine injury should be suspected and appropriate cervical spine precautions should be taken (ie, collar and board, ambulance transfer to hospital), including assessment of airway, breathing and circulation.^{[5][7][14][15]}

The conscious athlete should be assessed for signs and symptoms of concussion and observed closely by a responsible adult for any signs of deterioration.^{[5][7][14][15]} Symptoms of concussion may develop or worsen in the hours or days following an injury. Medical evaluation, including neurological and cognitive assessment, should be performed as soon as possible to confirm a diagnosis of concussion.^{[5][7][14][15]} A detailed history should include: previous head and facial injuries (including diagnosed concussions); history of headaches or migraines in the patient and in the family; mental health issues; sleeping difficulties; and learning disabilities or attention-deficit hyperactivity disorder. The presence of these factors may identify patients at higher risk for prolonged recovery. Players should never return to sport until they are symptom free and have been medically cleared.^{[5][8]} Concussed athletes may experience impairments in attention, response time and memory, potentially increasing their risk for another concussion or other injury.^{[9][10][12]} If in doubt, sit them out!

A concussed athlete should be closely monitored by a responsible adult, ideally a parent, for 24 h to 48 h for signs of deterioration (eg, severe headache, persistent vomiting, seizure activity). Sleep is important for recovery; therefore, a child or youth with concussion should be checked throughout the night but not awakened unless there is concern about deterioration (eg, vomiting, seizure activity, difficulty breathing). Any sign of deterioration should prompt immediate evaluation in an ED.^{[5][7][15]}

Currently, there are two assessment tools that have been developed for the medical evaluation of concussions in athletes. The Sport Concussion Assessment Tool 3 (SCAT3) is recommended for use in patients ≥ 13 years of age. The Child-SCAT3 has been developed for use in children five to 12 years of age and includes a parent symptom report as well as more age-appropriate cognitive tests.^[7] Both tools allow for a brief neuropsychological assessment of attention, concentration and memory on the field of play by a health care professional as well as in an office setting.^[7] The Concussion Recognition Tool is designed for lay use.^[7] These tools have not yet been validated.

Investigations

Diagnostic imaging

Concussion is a functional brain injury and does not result in structural changes on routine neuroimaging. Routine structural neuroimaging (skull x-rays, computed tomography scans, magnetic resonance imaging) is not recommended unless a structural injury is suspected (focal neurological deficit, seizure activity, prolonged unconsciousness).^{[5][7][15][16]}

Specialized imaging techniques, including single-photon emission computed tomography, positron-emission tomography, and functional magnetic resonance imaging may demonstrate

physiological and functional abnormalities following concussion. However, these techniques are largely experimental and, therefore, not routinely available or recommended.^[7]

Neuropsychological testing

Neuropsychological testing (NPT) can be helpful in concussion management and in guiding RTP decisions.^{[7][11][17]} Brief neuropsychological testing, such as pen-and-paper tests and computer-based programs, have been shown to be useful in athletic populations.^{[7][11][17]} Preinjury baseline testing can be helpful in concussion evaluation but is not mandatory or practical in the paediatric age group due to lack of availability or resources, and cost.^{[7][11][14][18]} Children and adolescents experience rapid cognitive development, with substantial improvement in reaction times, working memory and new learning, particularly between nine and 15 years of age.^[19] These developmental improvements can, potentially, confound postinjury assessments by offsetting injury-related cognitive impairment. Therefore, baseline testing may be required as often as every six months.^[19] Thus, routine baseline testing is not recommended.^{[7][8]} When NPT is used in concussion management, it should be combined with repeated clinical assessment.^[7]

Age-appropriate, detailed NPT by a trained neuropsychologist may be necessary for athletes who have sustained multiple concussions and/or who experience prolonged postconcussive symptoms, to identify specific cognitive deficits and, possibly, aid in educational planning.^{[7][11][14]}

TABLE 2
Graduated Return to Learn protocol

Stage	Tasks
Cognitive rest	Decrease and limit cognitive tasks and screen time at home. No school.
Increase cognitive tasks	As symptoms improve, slowly increase cognitive tasks at home in 15 min to 20 min increments.
Resume modified school attendance	As symptoms continue to improve, resume school attendance. Start with half-days or only certain classes (avoid gym, music, shop). Limit homework assignments to 15 min to 20 min blocks.
Increase school attendance	Gradually increase school attendance to full days as symptoms allow. Specific accommodations may be required to avoid symptom exacerbation (Table 3). Tests should be limited to one per day in a quiet area, with unlimited time and frequent breaks.
Return to Play protocol	Once symptom-free and back to full-time school attendance without accommodations, the student can start with graduated return to play (Table 4).

**If symptoms worsen at any stage, decrease activity until they improve. Data from references [14][15][22]-[24]*

TABLE 3

Academic accommodations for concussed students

Postconcussion symptom	Effect of school attendance	Accommodation
Headache	Difficulty concentrating	Frequent breaks, quiet area, hydration
Fatigue	Decreased attention, concentration	Frequent breaks, shortened day, only certain classes
Photophobia/phonophobia	Worsening symptoms (headache)	Sunglasses, ear plugs or headphones, avoid noisy areas (cafeterias, assemblies, sport events, music class), limit computer work
Anxiety	Decreased attention or concentration, overexertion to avoid falling behind	Reassurance and support from teachers about accommodations, reduced workload
Difficulty concentrating	Limited focus on school work	Shorter assignments, decreased workload, frequent breaks, having someone read aloud, more time to complete assignments and tests, quiet area to complete work
Difficulty remembering	Difficulty retaining new information, remembering instructions, accessing learned information	Written instructions, smaller amounts to learn, repetition

Data from references 14,15,21-24

Management

Research evaluating the management of concussion in paediatric patients is sparse. A recent study involving college and high school athletes showed that cognitive and physical rest, both immediately after injury and later during recovery, decreased symptoms and improved performance on computerized neuropsychological tests.^[20] Consensus agreement is that rest, both physical and cognitive, is the most important aspect of concussion management.^{[5][7]} Following a concussion, participation in sports, physical education classes, exercise or recreational activities, such as cycling or even wrestling with friends or siblings, should be avoided. Cognitive rest involves limiting activities that require mental exertion, including reading, texting, watching television, computer work, electronic games ('screen time') and school.^{[5][8][11][15][21]} As symptoms improve, students can gradually increase cognitive tasks and social activities, including school, provided symptoms are not exacerbated.^{[7][12][21]}

Medications

Medications for treating concussion in paediatric athletes have not been studied. Acetaminophen or ibuprofen may decrease the severity and duration of symptoms postconcussion, particularly headache, but there is no evidence to support

this assertion. Nonsteroidal anti-inflammatory drugs may not be recommended after head trauma because of a theoretical risk of bleeding. In some cases, pharmacological agents are used to treat specific, prolonged symptoms such as headaches, sleep disturbances, depression or anxiety.^{[7][15]} Athletes should not take medications that can mask the signs or symptoms of concussion when returning to play.^{[7][15]}

Return to learn

Cognitive rest can be challenging for students. Participation in cognitive tasks that exacerbate symptoms, known as 'cognitive overexertion', may prolong recovery.^[22] Students may require a brief absence from school to allow symptoms to improve, followed by a gradual return (eg, attending half-days or only certain courses), until they are able to attend full-time without symptom exacerbation (Table 2).^{[14][15][22][24]} Students do not need to be symptom-free to return to school. However, accommodations or modifications to their schedule may be necessary to allow school return without symptom exacerbation.^{[14][15][21][24]} Table 3 lists examples of academic accommodations. Full return to academics must precede return to sports. If a prolonged absence from school (more than a couple of weeks) is necessary due to persistent symptoms, referral to a specialist with expertise in concussion, as well as a neuropsychologist, may be required.

TABLE 4
Graduated Return to Play protocol for athletes with concussion

Rehabilitation stage	Functional exercise at each stage of rehabilitation	Objective of each stage
1. No activity *	Symptom-limited physical and cognitive rest until symptom free	Recovery
2. Light aerobic exercise	Walking, swimming or stationary cycling No resistance training	Increase heart rate
3. Sport-specific exercise	Skating drills in ice hockey, running drills in soccer. No impact activities	Add movement
4. Noncontact training drills	Progression to more complex training drills (eg, passing drills in football and ice hockey) May start progressive resistance training	Exercise, coordination and cognitive load
5. Full-contact practice	Following medical clearance, participate in normal training activities	Restore confidence and assess functional skills by coaching staff
6. Return to play	Normal game play	

*Children and adolescents should remain at this step until symptom-free for several days (optimally seven to 10 days). Data from reference ^[7]

Return to play

RTP decisions following concussion can be difficult and controversial. There have been no double-blinded prospective studies evaluating RTP guidelines in young concussed athletes ^[25]; however, expert opinion is that RTP decisions for paediatric athletes should be more conservative, cautious and individualized.^{[5][7][21][25]}

A concussed athlete should not return to sports until all concussion signs and symptoms have resolved and she or he has been medically cleared.^{[5][8][15][21][25]} There should be no same-day RTP.^{[5][8][15][21][25]} Once symptoms have resolved and the individual has been symptom free for several days (up to seven to 10 days), he or she can progress through a medically supervised stepwise exertion protocol (Table 4).^{[5][8][15][21][25]}

Each step of the protocol should take a minimum of 24 h and progression to the next step should only occur if the athlete remains symptom free. If any symptom recurs, the individual should rest until it resolves (24 h to 48 h at a minimum) before trying again, this time starting with the last step at which they were asymptomatic.

Modifying factors in concussion management

Specific factors may result in prolonged or persistent symptoms and necessitate specialized concussion management beyond RTP advice.^{[7][26]} These ‘modifying’ factors include younger age, a history of multiple concussions and comorbidities such as a learning disability or attention-deficit hyperactivity disorder. Investigations, such as formal NPT and neuroimaging, and specific medications may be needed in this setting. Concussed athletes with modifying factors may require management by a multidisciplinary team, including physicians with specific concussion expertise.^{[7][26]}

One controversial area of concussion management involves the athlete with a history of multiple concussions. Evidence suggests that there is an increased risk for subsequent head injuries following a concussion and that concussive injuries may be cumulative.^[27] Consideration should be given to retiring from a particular sport or changing to a less risky position to reduce risk of recurrent head injury when a concussion:

- occurs with less force;
- results in more severe symptoms;
- is more likely because of an athlete’s playing style, position or sport; or
- occurs in the setting of a concomitant learning disability or persistent cognitive symptoms.^{[14][25]}

Persistent or prolonged symptoms

Although most patients recover from concussion within several weeks, some experience postconcussion symptoms for weeks to months after injury. Investigations, including neuroimaging and formal NPT, may be warranted in this group.^[28] Also, more targeted treatments beyond physical and cognitive rest may be necessary to help with symptom resolution. Symptoms are often nonspecific and may involve etiologies other than concussion; therefore, it is important to rule out other potential diagnoses.^[28] Patients with prolonged symptoms should be managed by a multidisciplinary team of experts with concussion expertise.^[7]

Although evidence in the paediatric age group is sparse, some specific symptoms may be amenable to targeted treatments (Table 5).^{[28][31]} Active rehabilitation with subthreshold activity (activity at a level below that which exacerbated symptoms) has improved symptoms in paediatric patients with postconcussion symptoms lasting longer than one month.^{[28][32]} Persistent symptoms affecting learning and school attendance

may require prolonged absences from school and/or sustained academic modifications.^[24] Specific paediatric guidelines for treatment of persistent symptoms are required.

TABLE 5
Targeted treatments for persistent postconcussion symptoms

Persistent headache	Lifestyle adjustments (proper hydration, adequate sleep, regular exercise) Avoidance of acetaminophen/ibuprofen overuse Prophylactic medications (eg, for migraines) Neurology referral
Neck pain	Physiotherapy
Balance problems/dizziness	Vestibular rehabilitation
Sleep disturbances	Sleep hygiene reinforcement Medications (eg, melatonin)
Depression/anxiety	Referral to a mental health professional; addressing social isolation or withdrawal Medications

Data from references 28-31

Prevention

Protective equipment, including helmets and mouth guards, does not prevent concussion.^[33] However, the wearing of certified helmets (see [Additional Resources](#)) in certain sports has been shown to protect against other head injuries such as skull fracture.^{[34][36]} Approved helmets should be worn by athletes participating in any contact sport or activity with a risk of head injury, including cycling, skateboarding, roller-blading, alpine skiing, snowboarding and equestrian.^{[5][7][37]} Equipment should be well fitted, worn properly and well-maintained.^[37] Damaged equipment should be replaced promptly and well-used equipment replaced according to manufacturers’ recommendations.

Athletes, coaches and parents must recognize that helmets are not ‘concussion proof’. Athletes who believe that wearing a helmet protects against concussion may adopt a more aggressive playing style (risk compensation) and increase injury risk.^{[5][7][38]} Good sportsmanship, respecting the rules of sport and practicing fair play all help to reduce the risk of head injury.

Coaches and trainers have an important role in reducing the incidence of concussive injuries. They must ensure that players learn and practice proper sport techniques including bodychecking in hockey, tackling in football and heading in soccer. They should also foster an atmosphere of respect, fair play and good sportsmanship among their athletes.

Enforcing sport rules and rule changes also helps to decrease the risk and incidence of concussion.^{[7][38]} A ban on spearing in football has reduced head and neck injuries.^[38] The CPS supports Hockey Canada's efforts to extend the fighting ban from minor league hockey (players eight to 15 years of age) to include junior league players (16 to 21 years of age), to increase sanctions for hits to the head and checking from behind at all levels, and to eliminate bodychecking in younger age groups, initiatives that may help reduce the risks of concussion.^{[7][39]} For more information on concussion and bodychecking, see the CPS statement at www.cps.ca/en/documents/position/bodychecking-ice-hockey. Discouraging participation in sports in which intentional head injury is encouraged, such as boxing, may also decrease concussion in young athletes (see the CPS position statement at www.cps.ca/en/documents/position/boxing).

Concussion education

Concussion education is vital for everyone involved in child and youth sporting activities. Athletes, coaches, trainers, parents, officials, teachers and health care providers must be able to recognize the signs and symptoms of concussion and be aware of appropriate management of concussive injuries.^{[5][7]} For more information on concussion and management, see [Additional Resources](#).

Recommendations

The CPS makes the following recommendations concerning the evaluation and management of sport-related concussion in children and adolescents:

- An athlete who has sustained a head injury during sport should be removed from play immediately and not allowed to return to play (RTP) that day. The athlete should be closely monitored for any signs of deterioration and should not be left alone.
- An athlete who sustains a head injury should be medically evaluated as soon as possible.
- Diagnostic imaging is not routinely recommended unless a structural injury is suspected.
- A concussed athlete should rest, physically and cognitively, until all symptoms have resolved.
- A temporary absence from school, followed by a gradual return, may be necessary after a concussion. Academic accommodations may be needed until symptoms resolve.
- Return to learn should precede return to sport.
- Only after an athlete has been symptom free for seven to 10 days and has fully returned to school should she or he begin a medically supervised, stepwise RTP protocol.

- RTP decisions for paediatric athletes should be conservative, cautious and individualized.
- Athletes who have concussions with modifying factors or prolonged symptoms may require management by a multidisciplinary team including physicians with specific concussion expertise.

Concussion prevention is very important. The CPS recommends the following policies and precautions:

- Approved helmets should be worn in all contact sports and activities in which there is a risk for head injury (ie, cycling, skateboarding, in-line skating, skiing, snowboarding, equestrian). Protective equipment should be well fitted, properly worn, well-maintained and replaced according to manufacturers' recommendations.
- Athletes should be taught appropriate skills and techniques as well as good sportsmanship to help reduce injuries.
- Sport rule changes that decrease the risk and incidence of concussive injuries should be adopted and enforced by sporting organizations and officials.
- Anyone involved with child and youth sport, including athletes, parents, coaches or trainers, teachers and officials, should be educated regarding the signs and symptoms of sport-related concussion. Medical school and paediatric residency curriculums should include concussion education.
- All provinces and territories should require by statute that regional sporting associations and school boards have a written policy on concussion recognition and management.

Physicians should advocate for their patients by:

- Discouraging participation in sports that involve intentional blows to the head, such as boxing.
- Educating coaches and trainers, parents, athletes, school staff and policy makers in sport about the signs and symptoms of concussion and the need for a medical evaluation and clearance before an injured athlete returns to play.
- Supporting the mandate that all coaches and trainers in sports organizations be educated about concussion risks, recognition and management.
- Supporting the development of policies on concussion in schools and sports organizations.

- Supporting legislation to make wearing a certified helmet mandatory for sports and activities for which there is a significant risk of head injury.
- Urging researchers and manufacturers to develop and improve protective equipment.

ADDITIONAL RESOURCES

More information about concussion management in athletes can be found on the following websites:

- Parachute: www.parachutecanada.org/injury-topics/top-ic/C9
- Centers of Disease Control and Prevention (US): www.cdc.gov/concussion/HeadsUp/youth.html, www.cdc.gov/concussion/sports/index.html
- Sport Concussion Assessment Tool 3: <http://links.lww.com/JSM/A30>
- Child SCAT3: <http://links.lww.com/JSM/A31>
- Concussion Recognition Tool: <http://links.lww.com/JSM/A32>
- Ontario Government website: www.ontario.ca/concussions
- McMaster Children's Hospital: http://www.canchild.ca/en/ourresearch/mild_traumatic_brain_injury_concussion_education.asp

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References

1. Centers for Disease Control and Prevention. Nonfatal traumatic brain injuries related to sports and recreation activities among persons aged ≥19 years – United States, 2001-2009. *MMWR* 2011;60(39):1337-42.
2. Kelly KD, Lissel HL, Rowe BH, Vincenten JA, Voaklander DC. Sport and recreation-related head injuries treated in the emergency department. *Clin J Sport Med* 2001;11(2):77-81.
3. 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.
4. Emery CA, Meeuwisse WH, McAllister JR. Survey of sport participation and sport injury in Calgary and area high schools. *Clin J Sports Med* 2006;16(1):20-6.
5. Purcell L; Canadian Paediatric Society, Healthy Active Living and Sports Medicine Committee. Identification and management of children with sport-related concussion. *Paediatr Child Health* 2006;11(7):420-8.
6. Purcell L; Canadian Paediatric Society, Healthy Active Living and Sports Medicine Committee. Evaluation and management of children and adolescents with sports-related concussion. *Paediatr Child Health* 2012;17(1):31.
7. McCrory P, Meeuwisse W, Aubry M, et al. Consensus statement on Concussion in Sport – 4th International Conference on Concussion in Sport held in Zurich, November 2012. *Clin J Sport Med* 2013;23(2):89-117.
8. Lovell MR, Fazio V. Concussion management in the child and adolescent athlete. *Curr Sports Med Rep* 2008;7(1):12-5.
9. 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.
10. Sim A, Terryberry-Spohr L, Wilson KR. Prolonged recovery of memory functioning after mild traumatic brain injury in adolescent athletes. *J Neurosurg* 2008;108(3):511-6.
11. Kirkwood MW, Yeates KO, Taylor HG, Randolph C, McCrea M, Anderson VA. Management of pediatric mild traumatic brain injury: A neuropsychological review from injury through recovery. *Clin Neuropsychol* 2008;22(5):769-800.
12. Fazio VC, Lovell MR, Pardini JE, Collins MW. The relation between post concussion symptoms and neurocognitive performance in concussed athletes. *NeuroRehabilitation* 2007;22(3):207-16.
13. McCrory P, Davis G, Makdissi M. Second impact syndrome or cerebral swelling after sporting head injury. *Curr Sport Med Rep* 2012;11(1):21-3.
14. 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.
15. Halstead ME, Walter KD; American Academy of Pediatrics, Council on Sports Medicine and Fitness. Clinical report – sport-related concussion in children and adolescents. *Pediatrics* 2010;126(3):597-615.
16. Osmond MH, Klassen TP, Wells GA, et al; Pediatric Emergency Research Canada (PERC) Head Injury Study Group. CATCH: A clinical decision rule for the use of computed tomography in children with minor head injury. *CMAJ* 2010;182(4):341-8.
17. Collie A, Maruff P, Makdissi M, McCrory P, McStephen M, Darby D. CogSport: Reliability and correlation with conventional cognitive tests used in postconcussion medical evaluations. *Clin J Sport Med* 2003;13(1):28-32.
18. Kirkwood MW, Randolph C, Yeates KO. Returning pediatric athletes to play after concussion: The evidence (or lack thereof) behind baseline neuropsychological testing. *Acta Paediatr* 2009;98(9):1409-11.
19. McCrory P, Collie A, Anderson V, Davis G. Can we manage sport-related concussion in children the same as in adults? *Br J Sports Med* 2004;38(5):516-9.
20. Moser RS, Glatts C, Schatz P. Efficacy of immediate and delayed cognitive and physical rest for treatment of sports-related concussion. *J Pediatr* 2012;161(5):922-6.
21. Davis GA, Purcell LK. The evaluation and management of acute concussion differs in young children. *Br J Sports Med* 2013;0:48(2):98-101.
22. Sady MD, Vaughan CG, Gioia GA. School and the concussed youth: Recommendations for concussion education and management. *Phys Med Rehabil Clin N Am* 2011;22(4):701-19, ix.

23. McGrath N. Supporting the student-athlete's return to the classroom after a sport-related concussion. *J Athl Train* 2010;45(5):492-8.
24. Centers for Disease Control and Prevention, 2010. Heads up to schools: Know your concussion ABCs: <http://www.cdc.gov/concussion/HeadsUp/schools.html> (Accessed January 13, 2014).
25. Purcell L. What are the most appropriate return-to-play guidelines for concussed child athletes? *Br J Sports Med* 2009;43(Suppl 1):i51-5.
26. Makdissi M, Davis G, Jordan B, Patricios J, Purcell L, Putukian M. Revisiting the modifiers: How should the evaluation and management of acute concussions differ in specific groups? *Br J Sports Med* 2013;47(5):314-20.
27. Moser RS, Schatz P, Jordan BD. Prolonged effects of concussion in high school athletes. *Neurosurgery* 2005;57(2):300-6.
28. Makdissi M, Cantu RC, Johnston KM, McCrory P, Meeuwisse WH. The difficult concussion patient: What is the best approach to investigation and management of persistent (10 days) postconcussive symptoms? *Br J Sports Med* 2013;47(5):308-13.
29. Guidelines for Concussion/mTBI and persistent symptoms, 2nd edn (2013): <http://onf.org/documents/guidelines-for-concussion-mtbi-persistent-symptoms-second-edition> (Accessed January 13, 2014).
30. Blume, HK. Pediatric headache: A review. *Pediatr Rev* 2012;33(12):562-76.
31. Alsalaheen BA, Mucha A, Morris LO, et al. Vestibular rehabilitation for dizziness and balance disorders after concussion. *J Neurol Phys Ther* 2010;34(2):87-93.
32. Gagnon I, Galli C, Friedman D, Grilli L, Iverson GL. Active rehabilitation for children who are slow to recover following sport-related concussion. *Brain Inj* 2009;23(12):956-64.
33. 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 Sport Med* 2009;43(Suppl 1):i56-67.
34. LeBlanc JC, Huybers S. Improving bicycle safety: The role of paediatricians and family physicians. *Paediatr Child Health* 2004;9(5):315-8.
35. Thompson RS, Rivara FP. Protective equipment for in-line skaters. *N Engl J Med* 1996;335(22):1680-2.
36. Russell K, Christie J, Hagel BE. The effect of helmets on the risk of head and neck injuries among skiers and snowboarders: A meta-analysis. *CMAJ* 2010;182(4):333-40.
37. Parachute. Helmet FAQ: <http://www.parachutecanada.org/injury-topics/topic/C8> (Accessed January 13, 2014).
38. Hagel B, Meeuwisse W. Risk compensation: A "side effect" of sport injury prevention? *Clin J Sport Med* 2004;14(4):193-6.
39. Emery CA, Kang J, Shrier I, et al. Risk of injury associated with body checking among youth ice hockey players. *JAMA* 2010;303(22):2265-72.

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