Concussions are common sport injuries, and are particularly common among children and adolescents involved in organized sports and recreational activities. Symptoms of concussion can be subtle and may be overlooked by athletes, coaches/trainers and parents. If a child or youth sustains a concussion, they should immediately be removed from play and assessed by a physician as soon as possible. The athlete should rest from physical and cognitive activities to allow for recovery from concussion. Once symptoms have completely resolved at rest, the athlete can progress through a medically supervised stepwise exertion protocol before being medically cleared to return to play. It is imperative that everyone involved in child and youth sports be aware of the signs and symptoms of concussion so that an accurate and timely diagnosis can be made, and proper evaluation and management instituted. The present position statement replaces the previous document published in 2006.

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

Definition of a concussion

Concussion is defined as “a complex pathophysiological process affecting the brain, induced by traumatic biomechanical
forces,” and resulting “in the rapid onset of short-lived impairment of neurological function that resolves spontaneously” (7-9). Concussion may be caused by a direct blow to the head, neck, or face, or by a blow somewhere else on the body which transmits an impulsive force to the head (7-9). Most concussions do not cause loss of consciousness, or cause only transient loss of consciousness (lasting seconds) (8).

Classification of Concussion Severity

Previous sport-related concussion grading systems have been largely abandoned because they were based on anecdotal experience and lacked validation (7-9). The simple versus complex terminology proposed in the Second International Conference on Concussion in Sport agreement statement (9), and endorsed in the original CPS statement (6), has also been abandoned because terms did not fully describe the entities involved or allow for adequate prediction of injury severity (7,10). Current recommendations are that the management of concussions should be individualized based on an athlete’s symptoms and recovery rather than on classification of severity, which can only be determined in retrospect after symptom resolution, cognitive recovery and passing a graduated exertional RTP protocol (7).

Evaluation of Concussion

Signs and symptoms

Table 1 lists many of the common signs and symptoms that athletes may experience following concussion. If any of these are exhibited following an injury, concussion should be suspected and appropriate management initiated (6-9). In younger children, signs and symptoms can be subtle, such as stomach pain or upset and behavioural changes rather than headache or cognitive symptoms; therefore, a concussion may not be recognized (11). Typically, symptoms resolve in seven to 10 days (7), although in some cases, concussion symptoms may be prolonged, even lasting weeks to months (4,12,13). There is evidence to suggest there are age-related differences in recovery following concussion, with younger children taking longer to recover (14,15).

Significant cognitive sequelae may result from concussion, including poor attention and concentration, reduced speed of information processing, and impaired memory and learning (11). In children and adolescents, these effects may negatively impact their ability to learn and attend to school work (12,13,16,17).

A rare complication of head injury in children and adolescents is fatal diffuse cerebral swelling, known as malignant brain edema syndrome (17,18). This phenomenon, which occurs almost exclusively in children and adolescents, is thought to result from a loss of autoregulation in the brain’s blood supply, causing rapid cerebrovascular congestion and increased intracranial pressure. Progression to brainstem herniation, coma and death may occur (4,17,18). This loss of cerebral vascular autoregulation is also believed to be the mechanism of injury in second impact syndrome, a rare, usually fatal event that occurs in paediatric athletes. Second impact syndrome is thought to occur when an athlete sustains a second concussion while still symptomatic from a previous concussion, causing the athlete to collapse and rapidly become comatose (4). Although there is a lot of fear regarding this entity, evidence that these catastrophic events are actually caused by a second impact is lacking (18). More likely, they are examples of diffuse cerebral swelling caused by an injury to the immature brain (18).
Initial evaluation

If a young athlete is suspected to have sustained a concussion, she/he should immediately stop the activity and be removed from the game or practice. If the athlete is unconscious, a cervical spine injury must be assumed and appropriate c-spine precautions should be taken (ie, collar and board, ambulance transfer to emergency department). Airway, breathing and circulation must be assessed in any unconscious athlete.

The conscious athlete should be observed closely for any signs of deterioration. Symptoms may develop or get worse later that day or the next day. Every concussed athlete should be medically evaluated by a physician, including a full neurological assessment and mental functional assessment, as soon as possible. A player should never return to sport if symptomatic. Concussed athletes frequently have reduced attention, impaired response times and memory deficits, which may lead to a decreased ability to avoid dangerous situations and put them at greater risk for another concussion or other injury. If in doubt, sit them out!

Following medical evaluation for concussion, an athlete should not be left alone for the first 24 to 48 h. A responsible adult, ideally a parent, should monitor the child or youth for worsening symptoms (eg, severe headache, persistent vomiting, seizure activity), and check through the night for signs of deterioration (eg, abnormal breathing, seizures). Because sleep is necessary for recovery, however, a child or youth with concussion should not be awakened during the night. If there are any signs of deterioration the child or youth should be re-evaluated immediately in an emergency department.

Investigations

Diagnostic imaging

Concussion is a functional rather than a structural brain injury. As such, conventional structural neuroimaging (skull x-rays, computerized tomography [CT] scans, magnetic resonance imaging [MRI]) is normal and therefore not routinely recommended. If there is suspicion of a structural injury (focal neurological deficit, seizure activity, prolonged unconsciousness), appropriate imaging should be obtained.

More specialized imaging techniques, such as single-photon emission computed tomography, positron-emission tomography, and functional MRI may be able to demonstrate physiological and functional abnormalities following concussion, but they are in early stages of development and therefore not routinely available or recommended.

Neuropsychological testing

Neuropsychological (NP) assessment in concussion has been shown to have clinical value and can be a useful tool in helping to guide RTP decisions. Numerous studies have evaluated brief (30 min) neuropsychological testing in the athletic population, including traditional pen-and-paper tests and, more recently, computer-based programs such as ImPACT and CogSport. If NP assessment is to be used in the concussion setting, experts recommend that pre-injury baselines should be established for all athletes at the beginning of each season to maximize clinical utility. However, this assessment should not be used in isolation; repeated clinical assessment is key.

A unique concern regarding NP testing in the pediatric population is that children and adolescents are undergoing rapid cognitive development. Studies using computerized neurocognitive programs have demonstrated that there is a substantial improvement in performance between nine and 18 years of age on tests of simple and choice reaction times, working memory and new learning, with the largest changes in function seen between the ages of nine and 15 years. These developmental changes can potentially confound post-injury assessments because maturational improvement may offset any injury-related cognitive impairment; children and youth may require baseline testing as often as every six months. The financial costs, time and resources required to implement baseline testing in the pediatric age group may prohibit NP assessment as a routine practice.

The Sport Concussion Assessment Tool (SCAT) was developed for medical evaluation of concussions in athletes in 2004 and updated in 2009 (SCAT2). This tool was designed to allow a brief neuropsychological assessment of attention and memory on the field of play. The SCAT2 includes more detailed assessments, such as a balance error scoring system (BESS) and the Glasgow Coma Scale, and is recommended for athletes 10 years of age and older. Athletes at the beginning of each season to maximize clinical utility. Numerous studies have evaluated brief (30 min) neuropsychological testing in the athletic population, including traditional pen-and-paper tests and, more recently, computer-based programs such as ImPACT and CogSport. If NP assessment is to be used in the concussion setting, experts recommend that pre-injury baselines should be established for all athletes at the beginning of each season to maximize clinical utility.

In athletes who have sustained multiple concussions and/or who demonstrate prolonged post-concussive symptoms, age-appropriate, detailed neuropsychological testing by a trained neuropsychologist may be needed to help identify specific cognitive deficits and to aid in educational planning.
**Management**

The most important aspect of concussion management is rest (6-9). This includes both physical and cognitive rest (6,7,9). The injured child or youth should not play sports, exercise or participate in recreational activities such as bike riding, or wrestling with friends or siblings. Cognitive rest includes limiting activities that require mental concentration, such as reading, texting, watching television, computer work and electronic games. Concussed athletes may even need to miss school or have modifications made to their learning program while symptomatic, to avoid worsening symptoms due to the mental effort required to perform school work (6,16). If an absence from school is necessary, children and adolescents should then return gradually (eg, attending half-days) as symptoms improve. If symptoms do not worsen or recur, they may return to school full-time. 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 may be required.

**Medications**

The use of medications for treating concussion in paediatric athletes has not been studied. Using acetaminophen or ibuprofen may help to decrease the severity and duration of symptoms post-concussion, but there is no evidence-based research to support this assertion at present. In certain circumstances, pharmacological therapy may be used to manage specific prolonged symptoms, such as sleep disturbances, depression or anxiety (7). However, athletes should not be taking any medications that may mask signs/symptoms of concussion when returning to play (7).

**Return to play**

The decision regarding RTP following concussion is one of the most difficult and controversial areas in concussion management. To date, there have been no double-blind prospective studies evaluating RTP guidelines in young concussed athletes (23). However, experts agree that RTP decisions should be more conservative, cautious and individualized for paediatric athletes (7,23).

An athlete with a concussive injury should not be allowed to return to activity until all signs and symptoms have resolved and he/she has been cleared to do so by a physician (6-9,23). Children and adolescents should not be allowed to return to play the same day (7,23). Once children and adolescents have been symptom-free for several days, they should then follow a medically supervised stepwise exertion protocol (Table 2) (6-9,23). Each step should take a minimum of 24 h. As long as symptoms do not return, athletes may progress to the next step. If symptoms recur, athletes should rest for 24 to 48 h before trying to progress again, and starting with the last level where they were asymptomatic.

**Modifying factors in concussion management**

Certain factors may affect the management of concussion and predict the potential for prolonged or persistent symptoms (7). These ‘modifying’ factors, including younger age, a history of multiple concussions, and co-morbidities (such as a learning disability or attention deficit hyperactivity disorder), are important to consider in a concussion history and may require additional management above and beyond RTP advice. Additional investigations, such as formal NP testing and neuroimaging, may play a more important role in this setting. Athletes who have concussions with specific modifiers should be managed by a multidisciplinary team, including physicians with specific concussion expertise (7).

An area of controversy involves the athlete who sustains multiple concussions. There is evidence to suggest that an athlete

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**Table 2:**

Graduated return-to-play protocol for athletes with sport concussion

<table>
<thead>
<tr>
<th>Rehabilitation stage</th>
<th>Functional exercise at each stage of rehabilitation</th>
<th>Objective of each stage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. No activity</td>
<td>Complete physical and cognitive rest</td>
<td>Recovery</td>
</tr>
<tr>
<td>2. Light aerobic exercise</td>
<td>Walking, swimming or stationary cycling</td>
<td>Increase heart rate</td>
</tr>
<tr>
<td>3. Sport-specific exercise</td>
<td>Skating drills in ice hockey, running drills in soccer No head impact activities</td>
<td>Add movement</td>
</tr>
<tr>
<td>4. Non-contact</td>
<td>Progression to more complex training drills, eg, passing drills in football and ice hockey May start progressive resistance training</td>
<td>Exercise, coordination, and cognitive load</td>
</tr>
<tr>
<td>5. Full-contact practice</td>
<td>Following medical clearance, participate in normal training activities</td>
<td>Restore confidence and assess functional skills by coaching staff</td>
</tr>
<tr>
<td>6. Return to play</td>
<td>Normal game play</td>
<td></td>
</tr>
</tbody>
</table>

Source: Reference (7)
who has sustained a concussion is at increased risk for subsequent head injuries, and that such injuries may be cumulative (24). Currently, it is prudent to assess each athlete on an individual basis. If subsequent concussions result in more severe symptoms; if symptoms occur with less force; if an athlete’s playing style, position or sport puts them at increased risk of future injuries; or if they have a learning disability or persistent cognitive symptoms, consideration should be given to a change in position or to a sport with reduced risk of head injury (6,23).

Prevention

There is no evidence that protective equipment, including helmets and mouth guards, prevents concussion (25). In certain sports, there is evidence that certified helmets do protect against other head injuries, such as skull fracture (8,9,26-28). Approved helmets (see Additional Resources) should be worn in all contact sports and activities with a risk of head injury (ie, cycling, skateboarding, in-line skating, downhill skiing, snowboarding, equestrian activities) (6-11). It is important that the equipment be fitted, worn properly and well-maintained (29). Damaged protective gear should be replaced promptly and well-used equipment replaced according to manufacturers’ recommendations.

It is critical to recognize that there is no such entity as a ‘concussion-proof’ helmet. Players may feel they are not at risk for head injury if they wear a helmet, and adopt a more aggressive playing style (risk compensation), thereby putting themselves at greater risk of injury (6-9,30). To minimize risk of concussion, athletes should also respect the rules of their sport and practice fair play.

Coaches/trainers play an important role in reducing the number of concussions. They must ensure that their athletes are taught and practice appropriate sport techniques, such as proper bodychecking in hockey, proper tackling in football, and proper heading in soccer. They should also encourage respect, fair play and good sportsmanship in their players.

Rule changes and enforcement help to decrease the risk and incidence of concussive injuries (8,9,30). Rules mandating padded goal posts in soccer and football, and a ban on spearing in football, have been shown to reduce the number of concussive injuries (4). In hockey, eliminating hits to the head, not allowing checking from behind, not allowing checking in younger age groups, and eliminating fighting, may help to reduce head injuries in this sport (8,9,31). Discouraging enrolment in sports where intentional head injury is promoted, such as boxing, may also decrease the risk of concussion in children and adolescents.

Concussion Education

It is vital that athletes, coaches/trainers, parents and health care providers, as well as anyone else involved in the supervision of children and adolescents participating in sports activities, be aware of the signs/symptoms of concussion and appropriate management of concussive injuries (5). For more information on concussion and management of concussed athletes, see Additional Resources.

Recommendations

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

- Athletes, parents, coaches/trainers and anyone working with children and adolescents involved in sports should be educated about the signs and symptoms of sport-related concussion.
- An athlete who has sustained a head injury during sport should be removed from play immediately and not allowed to return to play that game. The athlete should be closely monitored for any signs of deterioration, and should not be left alone.
- All athletes sustaining a head injury should be evaluated by a physician as soon as possible.
- Diagnostic imaging is not routinely recommended unless a structural injury is suspected.
- The athlete should rest postconcussion until all symptoms have resolved. This includes both physical and cognitive rest.
- Once the athlete has been symptom-free for several days, they can begin a medically supervised stepwise return-to-play protocol.
- Return to sport decisions should be more conservative, cautious and individualized in pediatric athletes.
- Athletes who have concussions with modifying factors may require management by a multidisciplinary team, including physicians with specific concussion expertise.
- Approved helmets should be worn in all contact sports and for all activities with a risk of head injury (ie, cycling, skateboarding, in-line skating, skiing, snowboarding or equestrian activities). All protective equipment should be properly worn, well-maintained, and replaced according to the manufacturers’ recommendations.
- Athletes should be taught proper sports techniques and good sportsmanship to help reduce injuries.
- Sport rule changes and enforcement should be adopted by sporting organizations and officials to decrease the risk and incidence of concussive injuries.
- All provinces and territories should require by statute that all provinces and territories should require by statute that regional sporting associations and schools have a written policy on concussion recognition and management that conforms in principle to the Canadian Paediatric Society’s concussion guidelines, and that their policy is enforced.
Physicians should advocate for their patients by practicing the following:

- Discouraging participation in sports that promote intentional injury to the head.
- Educating coaches/trainers, schools and policy-makers in sport about the signs/symptoms of concussion and the need for medical evaluation/clearance before an injured athlete returns to play.
- Supporting the mandate that all coaches/trainers in sports organizations be educated about concussion.
- Supporting the development of policies on concussion in sports organizations.
- Supporting legislation requiring the mandatory wearing of a certified helmet for all sports/activities where there is a significant risk of head injury, and
- Advocating for research to develop better protective equipment to help prevent sport-related concussions.

Additional Resources

More information about concussion and managing concussed athletes can be found on the following websites:

- Sport Concussion Assessment Tool 2: http://bjsm.bmj.com/content/43/Suppl_1/i85.full.pdf
- Pocket SCAT2: http://bjsm.bmj.com/content/43/Suppl_1/i89.full.pdf

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