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School Sport and Concussion What you Need to Know

Sport w szkole i wstrząśnienie mózgu — co należy wiedzieć

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Abstract

Every country around the world enjoys some sort of sport. The Olympics sees countries from all over the globe participate in elite sport, in both winter and summer competitions. Australia is widely known for cricket and rugby, America for baseball and gridiron football (amongst others). These sports are played at an elite level as well as beginners from early ages as young as 4yrs in the backyard. Yet it is also these sports that can deliver a ball at the speed of 112km/h (rugby), 105km/h (baseball), 150km/h (cricket) and 211km/h (soccer). This is the same force that a car collision can produce. That force eventually finds a target and in some cases unfortunately, it is a head. Damage to the brain is not only from the impact of the ball hitting its target, rather, the shearing forces of acceleration-deceleration injury that can cause extensive injuries. There has been much discussion of late regarding concussion in sport and the accumulative effects of head blows resulting in varying degrees of memory loss and dementia later in life. The media has been saturated with heightened awareness of chronic traumatic encephalopathy (CTE). This however, is still being researched. It is true that each concussion compounds the one before, but rather than focus on the injury, managers/coaches and sporting codes should be focusing on the identification and proper management of a suspected concussion and the return-to-play protocols. This is especially important in our schools where growing brains need nurturing. This paper will focus on concussion recognition and management in school sport. **(JNNN 2014;3(1):31–38)**
Key Words: concussion, head injury, post traumatic amnesia, chronic traumatic encephalopathy, second impact syndrome

Streszczenie

W każdym kraju na całym świecie jakaś dyscyplina sportu cieszy się szczególną popularnością. Igrzyska Olimpijskie goszczą kraje z całego świata, uczestniczące w konkurencjach sportów wyczynowych zarówno zimowych, jak i letnich. Australia powszechnie znana jest z krykieta i rugby, Stany Zjednoczone z baseballu oraz footballu amerykańskiego (między innymi). Dyscypliny te uprawiane są nie tylko na najwyższym poziomie wyczynowym, ale również przez początkujących w wieku nawet 4 lat na przydomowych boiskach. To w tych dyscyplinach piłka może osiągać prędkość 112 km/godz. (rugby), 105 km/godz. (krykiet) czy 211 km/godz. (piłka nożna). Jest to siła porównywalna do tej, jaka wytworzona jest przez samochód w momencie zderzenia. Siła ta osiąga w końcu swój cel, którym czasami niestety jest głowa. Uszkodzenie mózgu jest wynikiem nie tylko samego uderzenia piłki w cel, ale też i sił przyspieszania-hamowania, które wywołać mogą rozległe obrażenia. Ostatnio toczy się wiele dyskusji związanych z zagadnieniem wstrząśnienia mózgu wynikających z uprawiania sportu oraz narastającymi konsekwencjami uderzeń w głowę, skutkiem których jest różny stopień utraty pamięci oraz demencja w późniejszym okresie życia. W mediach widoczny jest wzrost świadomości dotyczącej przewlekłej encefalopatii pourazowej (CTE). Ta jednak jest obecnie przedmiotem badań. Prawdą jest, że każde nowe wstrząśnienie potęguje poprzednie, ale zamiast koncentrować się tylko na samym urazie managerowie/trenerzy, przepisy sportowe powinny skupiać się na rozpoznaniu i odpowiednim postępowaniu w przypadku potencjalnego wstrząśnienia, jak również na zasadach powrotu do uprawiania sportu. Jest to szczególnie istotne w szkołach, gdzie mózg młodego człowieka wymaga troski. Niniejszy artykuł skupiać się będzie na właściwym rozpoznaniu oraz postępowaniu w przypadku wstrząśnienia mózgu doznanego w sportach uprawianych na poziomie szkolnym. **(PNN 2014;3(1):31–38)**
Słowa kluczowe: wstrząśnienie mózgu, uraz głowy, amnezja pourazowa, przewlekła encefalopatia pourazowa, uraz wtórny

Introduction

Mild head injury or mild traumatic brain injury (mTBI) is defined as "a patient with an initial Glasgow Coma Scale (GCS) of 14–15 on arrival at hospital, following acute blunt head trauma with or without a definite history of loss of consciousness or post traumatic amnesia" [1].

Players, parents, teachers, coaches, managers and officials must be mindful and cautious of concussion in a culture that continues to honor and enjoy the camaraderie and skill building benefits that sport brings.

Unfortunately, recognizing, managing and treating mild head injury is a little more complicated than in the nursery rhyme *Jack and Jill* (Figure 1).

> "Jack and Jill went up the hill to fetch a pail of water. Jack fell down, and broke his crown and Jill came tumbling after….
>
> Up Jack got and home did trot as fast as he could caper. He went to bed to mend his head with vinegar and brown paper".

Fig. 1. Nursery Rhyme "Jack and Jill", Author unknown, c. 1765 [2]

Concussion

Concussion is a temporary *diffuse* injury to the brain, brought about by acceleration-deceleration force and shearing stress on the reticular formation [3]. The concussive injury can be insidious or dramatic. It can progress quickly or over time. Concussion is a traumatic brain injury — an injury to the head that may cause instant loss of awareness or alertness for a few minutes to a few hours after the traumatic event. It is defined as "an acute brain injury resulting from mechanical energy to the head from external forces" (WHO 2004; Zurich Consensus 2012). Although concussions usually occur following a direct blow to the head, they can occur as a result of a blow elsewherethat is transmitted to the head [4].

Concussion is a functional disturbance in cognitive function rather than a structural abnormality. This is why at present, in the concussed patient, magnetic resonance imaging (MRI) and computerized tomography (CT) are normal. However, Shin et al. [5], suggest that in the future, high definition fibre tracking (HDFT) will allow doctors to clearly see neural connections broken by mTBI.

Symptoms of concussions include headaches, difficulty falling/staying asleep or excessive sleepiness, nausea, dizziness, confusion, difficulty concentrating, short term memory dysfunction, problems with balance and coordination. They can be picked up on the sidelines or some at school when behavior is different. These symptoms are general and could mean many neurological illnesses. This is why the history and mechanism of injury is also important and should always be questioned. This can be done by asking the player, teammates, coaches or video referee. Any acceleration-deceleration injury can cause the brain fibres to stretch and distort leading to neurological impairment. For example, "It was a routine move, one of 40-odd tackles that "Jake" had made during the game on that Saturday afternoon. Jake, 15, star rugby league player, but in a split second tragedy struck. The "brilliant young player" collapsed after an opponent's knee hit the side of his head during the tackle — and he never regained consciousness. Life support was turned off the next day" [6].

Sports Concussion Australasia (2012) suggests that 3 players per team, per season will suffer a concussion. It is the recognition and management of these players that require further attention. The Zurich Consensus 2012 established that early diagnosis and appropriate management of individuals who have sustained an mTBI, facilitates good outcomes. Evidence suggests that cumulative effects of repeated concussions increase the likelihood of cognitive impairment later in life [7,8]. Guskiewicz et al. [9], found that once a person has had a concussion, he/she is as much as 4 times more likely to sustain a second one. Moreover, after several concussions, it takes less of a blow to cause the injury and requires more time to recover [8].

Concussive injuries often present when in the classroom, where children cannot focus on a task, cannot process information given, or who are just not themselves. This is usually picked up by the teacher, and as such, the teacher should be made aware of any concussive injuries the student may have had after school or over the weekend.

School Sport

Back in the mid 1990's the concept of youth-sport concussion was almost unknown to the general public. Many people could discuss the "punch-drunk" concussions that were primarily related to boxers, but that wasn't translated into childhood sports injuries. Today, it is becoming the 'norm' to see concussion-related stories on mainstream television, shows such as *Law & Order SVU*, *Criminal Minds*, *The Simpsons* and *60 Minutes*. These shows have brought concussion awareness into the lounge-rooms of everyday people.

Today, students have the opportunity to play a range of school sport including — gridiron football, Australian Rules Football, Rugby League, Rugby Union, Cricket, Equestrian, Basketball, Soccer, Hockey (Ice & Field), Skateboarding, Swimming, Baseball, Wrestling, Tennis,

Golf, Ski-ing, Netball, Water ski-ing, Squash, Ten-pin Bowling and more. Each of these sports has the potential for concussion or mTBI.

Concussion education and management programs are gaining momentum in school sport and are already mandatory in some USA sport — NFL (football) and NHL (ice hockey). For the first time in history, the majority of US states have instigated a law that requires parents to sign a form acknowledging the risks and dangers of concussion in a particular sport — the Zackery Lystedt Law, which can be found at www.cdc.gov/concussion. This Law was named after Zack Lystedt, a Seattle teenager who sustained a concussion during a game of football but kept on playing, collapsing afterwards and sustaining an extensive brain injury. From this, it is important for the school community to be prepared to create a safe sports environment, an environment where risk of concussion is limited and identification and treatment of concussion are of the best quality. There must be development of reasonable standards of Return-to-School firstly then Return-to-Sport programs.

Post Traumatic Amnesia (PTA)

PTA is one of the stages of recovery after a TBI, where there is confusion, disorientation and/or short term memory dysfunction. It can last for hours, days or weeks depending on the severity of the injury. The patient is unable to remember day-to-day events. They can usually remember up to the time of injury but not afterwards. When evaluating memory, the time of injury becomes the reference point, as the length of time in PTA is more significant than the length of time unconscious [3].

Once a person has had a concussion, he/she is as much as 4 times more likely to sustain a second one. Moreover, after several concussions, it takes less of a blow to cause the injury and requires more time to recover [3,8]. This is now thought to be of greater significance particularly for school age children and they should not be playing sport until they are completely symptom-free [10].

Despite the evidence, issues still surround the clearance of athletes/students. The National Collegiate Athletic Association (NCAA) [11], suggests that concussion is difficult to detect, with athletes often underreporting the injury, minimizing the importance or not recognizing the injury at all. Assessment and management of concussive injuries remains a difficult task. There are potentially serious complications following a blow to the head including, second impact syndrome, post concussive syndrome, post traumatic encephalopathy, seizures, cervical spine injuries, skull fractures, intracranial hemorrhage, subdural hematoma and/or extradural hematoma. Other obstacles include — the pressure from teams/parents to allow 'star' athletes to play, GP's not up-to-date in concussion management, and 'loop holes' in return to play guidelines.

A number of sporting codes have introduced rules to avoid dangerous play. In 2012, the NFL banned players from using their helmets to impact players on the head or neck, whereas in rugby, spear tackles, where a player lifts and dumps a player on his head, is deemed a red card offence [12].

Australian Sports Scene

Sports Concussion Australasia (2013) suggests that 3 players per team, per season will suffer a concussion. The opinion that no player who is suspected of concussion should return to the field on the same day, has now been accepted by all Australian football codes — AFL, NRL, FFA and the Australian Institute of Sport. The Australian Institute of Trauma Management [13], published guidelines for General Practitioners and hospital Emergency Departments in 2012 and included this advice. However, despite Regulation 10 of the IRB code, which says that any player suspected of concussion must be taken off and not allowed back on to the field, there is an accompanying rule for the 2013 season — *still on trial* — that states that if a player with suspected concussion can pass a series of tests lasting five minutes, then he can be allowed back into the game: the Pitch Side Concussion Assessment — or the 'five-minute rule'.

Regulation 10. Medical
10.1 Concussion
10.1.1 A Player who has suffered concussion shall not participate in any Matchor training session for a minimum period of three weeks from the time ofinjury, and may then only do so when symptom free and declared fit afterproper medical examination. Such declaration must be recorded in awritten report prepared by the person who carried out the medicalexamination of the Player.
10.1.2 Subject to sub-clause 10.3 below, the three week period may be reducedonly if the Player is symptom free and declared fit to play after appropriateassessment by a properly qualified and recognized neurological specialist. Such declaration must be recorded in a written report prepared by the properly qualified and recognized neurological specialist who carried out the assessment of the Player.
10.1.3 In age grade rugby the three week minimum period shall be mandatory.

Fig. 2. International Rugby Board Concussion Guidelines 2012 [14]

This is neither responsible, nor effective management of concussion. This is a "loophole" allowing for better management of the team result, rather than player care. For example, (Rugby Union) Wallaby player George Smith returned to the field of play against the British &

Irish Lions (July 10, 2013), after sustaining a technical concussion (he had 2 or more symptoms that showed positive for concussion on the initial sideline assessment). After one collision within the first few minutes of the game, he was dazed, clearly ataxic and had to be helped from the field. It was obvious to everyone watching that he was concussed. Yet a few minutes later he was back on the field, supposedly fully recovered. Hopefully this is not the 'norm' and that player safety is paramount in the minds of all who lead sporting codes and the management of play. Elite sport 'stars' and their management have an obligation to the juniors and fans to abide by the rules, to be a role-model and to show that player safety is first and foremost.

Most sporting codes in Australia as of 2011 have a concussion management plan on file [15]. Fine tuning of this plan, awareness and ramifications of the content require extensive education and teaching amongst all members of the team. It should not be left on the shelf. It needs to be adhered to and worked into play, regardless of the sporting score at the time.

Second Impact Syndrome

During the minutes to a few days after a concussion injury, brain cells that are not irreversibly destroyed remain alive but exist in a vulnerable state. Cantu [16], and Mueller [7], suggest that this concept of injury-induced vulnerability has been put forth to describe the fact that patients suffering from head injury are extremely vulnerable to the consequences of even minor changes in cerebral blood flow and/or increases in intracranial pressure and apnea.

Young brains are particularly susceptible to second impact syndrome. This results from acute, usually fatal cerebral edema, which occurs when a second concussion is sustained before complete recovery from the first concussion. It is almost completely preventable. It is thought to occur due to the loss of cerebral auto-regulation. Mechanisms of the cerebral vasculature fail, which leads to a rapid rise in ICP causing fatal herniation [17]. These authors express concern regarding diffuse cerebral swelling (DCS) following a head injury which is more common in children than in adults, and usually has a poor outcome.

Though concussion patients typically have negative head imaging, imaging is warranted in those with severe mechanism, significant loss of consciousness, focal neurologic deficit, or worsening symptoms.

Chronic Traumatic Encephalopathy (CTE)

Shows such as *Law & Order SVU*, *The Simpsons* and *Criminal Minds* have had story lines around CTE and dementia. Evidence from McKee, Cantu, Nowinski, Hedley-Whyte, Gavett & Budson (2009), shows that the cumulative effects of repeated concussions may increase the likelihood of cognitive impairment later in life. Once a person has had a concussion, they are 4 times more likely to sustain a second one and after several concussions, it takes less of a blow to cause the injury and requires more time to recover [18]. Seichepine et al. [18], describe former ice hockey and football players who sustained concussions have been found to perform badly with regard to executive and memory tests decades after their last concussion. These studies indicate that executive functioning is impaired in former contact-sport athletes many years after their last exposure to brain trauma. Further evidence is needed to fully understand this phenomenon. Many athletes from different sports are now donating their brains to the study of this illness.

Soccer & "Heading"

Soccer is considered the world's most popular team sport with over 265 million participants worldwide (Findings of the 2006 Big Count, a FIFA survey www.fifa.com) [19] in all age groups. Although there are no tackles as such in soccer, the sport does have some risk of concussion. The primary concern in soccer is after the attempt of "heading" the ball and the concern about the risk of damage caused by the repetition of headers. Some early studies are starting to show brain changes in soccer players who have not had concussions but have had a lot of headers [20]. There also appears to be greater risk for girl's high school soccer, where reports of sports-related concussions are higher [21]. This is most likely due to neck strength. Men tend to have stronger necks, and a stronger neck can help reduce the risk of a concussion by slowing down the movement of the head [8].

Proper heading technique is the athlete's greatest defense against injury from heading a ball. Many coaching books do not address soccer heading until the age of 12 years, and it is recommended waiting until 14yrs before attempting heading [20,22]. Children who are not 14yrs are more vulnerable to injury because they are not yet physically mature; they have weak necks, immature musculature, and brains that are still developing [20]. Once soccer athletes do begin heading, coaches should instruct them to strike the ball just below the hairline on the frontal bone, the thickest part of the cranium, while simultaneously isometrically contracting the neck musculature [20,23].

The potential for risks associated with chronic soccer heading has led some soccer leagues to mandate the use of headgear. Although manufacturers have designed and promoted these headbands to decrease the forces associated with heading a soccer ball, their efficacy has not been tested. In a study by Broglio, Ju, Broglio & Sell [24], they found a significant reduction in peak force of impact with all headgear on the market at that time.

Helmets & Mouth-guards

While many companies are looking at creating better technology and equipment to reduce head impact, these improvements have not decreased concussions. A concussion results from the brain moving about INSIDE the skull. A safety device such as a helmet or mouth-guard, whilst important for protecting the player from injury will not protect them from a concussion. The Zurich Consensus (2012) [10], suggests stronger rules against hitting would be more beneficial to prevent concussions than a 'concussion-proof' helmet. However, headgear and mouth-guards are recommended to prevent other mTBI that can occur in contact sports. The better management for concussion is to recognize the symptoms, remove from play and refer for medical review. A gradual return to school and then return to sport is advised [17].

Mouth-guards do prevent injury by providing a "cushion" that absorbs impact. Mouth-guards were originally developed in the late 1800's as "gum shields", a means of protection from lip lacerations for boxers. Today, there are many different types of mouth-guards on the market — simple mouth-guards, boil & bite mouth-guards and dentist-prepared mouth-guards. In general terms, a custom fitting design is necessary to ensure retention in collision or contact sports. However, mouth-guards often fit poorly therefore providing less protection and can interfere with breathing and speech on the field. Currently, there are no international standards for mouth-guards. Although hard evidence is limited in studies pertaining to prevention of brain and spinal injuries when wearing a mouth-guard, evidence does show that there is a cushioning effect and lip/mouth/teeth injuries are less often reported in individuals wearing mouth-guards. As a parent, this must be comforting considering the cost of dental treatments.

Critical Role of Coaches in Concussion Care

Players, parents, teachers, coaches, managers and officials must be mindful and cautious of concussion in a culture that continues to honor and enjoy the camaraderie and skill building benefits sport can bring.

Coaches have a vital role to play in recognizing concussion, being alert to the warning signs, referring players to medical care, being involved in rehabilitation and insisting on final medical clearance from a medical doctor before the player is involved in contact training. At the community sport level, return-to-play after concussion should be conservative i.e. preferentially take longer than sooner. In school sport, the ARU insists that a player should only start team training a minimum of 2 weeks after symptoms have disappeared [8,20].

The 2013 Concussion in Sport Conference was held in Melbourne [15], Australia and was supported by all Australian football codes — Australian Football League (AFL), Australian Rugby Union (ARU), National Rugby League (NRL) and Soccer (FFA/FIFA). Players, coaches, referees, first-aiders and medical personnel were represented. Australian and International experts from a range of sports (including American Grid-iron Football and Ice Hockey) spoke on topics including:

- Current best practice management of concussion in elite and community level sport,
- Latest research about the short and possible longer term effects of concussion,
- Putting concussion research into practice,
- Priorities for concussion related research now and into the future,
- Implementation of outcomes from the 2012 Zurich International Conference on Concussion in Sport.

A number of sporting codes have introduced rules to avoid dangerous play. In 2012 the American NFL banned players from using their helmets to impact players on the head or neck, whereas in rugby (league and union), spear tackles, where a player lifts and dumps a player on his head, is deemed a red card offence.

The 2013 outcomes included:

- Rule Changes — regarding substitutes and eliminating the shoulder charge.
- Education for players, coaches, family, GPs, schools.
- Strict enforcement of rule changes — fines to clubs and individuals.
- Encouragement of sportsmanlike behavior.
- Encouragement of helmets & mouth-guards where appropriate.
- The use of the SCAT 3 and Pocket Concussion Recognition Tool (PCRT) in elite, club and school sports.
- Recognize — Remove — Refer.

Discussion needs to include the definition of "rest" nowadays following a concussion. This means no reading, no TV, no computer, no hand held electronic devices (iPods, iPhones, iPads, Gameboys etc.). There must be complete mental and physical rest until ALL symptoms have gone. It is important to return the player to school first and then to sport.

Fig. 3. Pocket Concussion Recognition Tool (PCRT) Reproduced with permission, from the ©2013 Concussion in Sport group

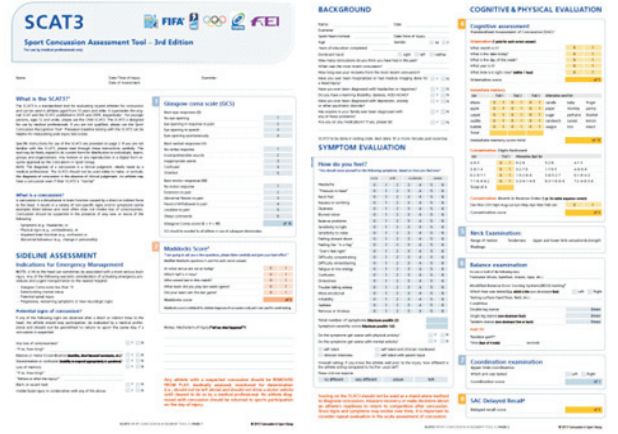

Fig. 4. SCAT3.Reproduced with permission, from the ©2013 Concussion in Sport group

Pre-Season Testing can give an accurate evaluation of an athlete's capabilities before an injury occurs. It is advisable that season preparation include shoulder and neck strengthening exercises, baseline SCAT3 test (see Figure 4), education for the coaches and officials regarding the use and interpretation of the PCRT (see Figure 3), and education regarding the use of the SCAT3 by medically trained personnel.

The SCAT3 covers:

- Memory function
  - "What venue are we at today?"
  - "Which half is it now?"
  - "What team did you play?"
  - "Did your team win last week?"
- Neuropsychological testing: cognitive ability & reaction times
- Balance Testing: tandem stance (heel-toe 20seconds — hands on hips, eyes closed)

The General Practitioner/Medical Doctor will screen for, and look at:

- Anxiety; Depression; Stress; Teacher concern at school — "Zoning out", bad behavior, disruptive, grades dropping; Time since discharged from hospital; Mechanism of injury; Protective equipment at time of injury; Loss of consciousness, concussion or symptoms; PTA — &/or period of amnesia; Previous incidence(s) of concussion.

Return to School

No child should return to play without a thorough examination by a health care provider trained in sports concussion. Preseason baseline neuropsychological testing, coupled with post-concussion testing, greatly enhances the decision to return to play. Despite this knowledge, most schools do not have such testing programs in place. Children may not exhibit the first signs of concussion until days after a particularly hard knock or rough tackle, which makes diagnosing concussion difficult [8].

It is paramount that the student be returned to school as a priority before returning to sport. Concussion symptoms may not only affect an athlete on the sports field, but also in the classroom. "When I got a concussion (while playing soccer), I expected to sit out some games, but I never realized that it would actually hurt to think." This is a common observation. After a concussion, rest is critical to help the brain heal. During this time, not only physical activities, but also activities that involve learning and concentration, which are common in the classroom, can aggravate concussion symptoms (such as an inability to pay attention or learn new information, fatigue, headaches). Concussion symptoms can hamper memory and information processing, which interferes with the child's ability to learn in the classroom. Medical clearance is required before children return to school. Teachers should be made aware that a concussion has taken place, as they are at the forefront to pick up any subtleties that child may display. It is normal for a child to miss a day or two following a concussion. In some children, a graduated return to school may be necessary and a pediatric neuropsychologist may be required for the more difficult cases.

School management of concussion and mTBI rehabilitation involves:

- Teacher/Nurse — Return to Learn
- Physiotherapist — Return to Vision & Balance
- Coach — Return to Exercise/Sport
- Hospital/Medical Doctor — Final Medical Clearance

Return to Sport

Aubry et al. [25], suggest that concussion must be recognized and treated appropriately. However, the most important decision is the timing of the return to play. The player should NOT return to play until completely symptom-free. The mantra of **"IF IN DOUBT — SIT IT OUT"** should be followed. The Return to Sport is a graded step-by-step process and progressing to the next step should only be done when symptom-free in each step.

Return to Sport Guideline
(*Proceed to the next step only when symptoms are completely gone*).

1. No activity, complete rest.
2. Light aerobic exercise such as walking or stationary cycling. Monitor for symptoms and signs. No resistance training or weight lifting.
3. Sport — specific activities and training. No contact or risk of contact.
4. Drills without body contact. May add light resistance training and then progress to heavy weights. The time needed to progress from non-contact to contact exercise will vary with the severity of the concussion and player.
5. Begin drills with body contact.
6. Game play.

Fig. 5. Return to Sport Guideline [26]

Conclusion

Sport provides children with an avenue for setting and achieving goals, learning discipline and building team skills. They are encouraged to take pride in success and be gracious in defeat. It is widely agreed that children who play sport have stronger self-esteem, perform better in school, and are healthier and fitter than those who do not play an active sport. The general concepts of sport include:

- Physical activity keeps us healthy.
- Play safely — by being in good physical shape.
- Practicing the skills of the game through drills & structured workouts — improves game play, mobility, hand-eye coordination, balance…
- Teach sportsmanship — it's not personal — don't respond in an aggressive way on the field.
- Teach in the "spirit of the game" where "Doing my best doesn't mean winning at any cost".
- Discourage unsafe play.
- Be aware of the signs & symptoms of a concussion.
- "When in doubt: sit it out".
- Encourage and enforce safety standards — helmets, mouth-guards.

Head injuries will never be totally eliminated from contact sports, but with proper education, awareness and preventative measures in place, the frequency and severity can be dramatically reduced. Athletes, parents, teachers and coaches should be educated about the signs and symptoms associated with concussion as well as the dangers of recurrent injury. A comprehensive understanding of concussion and its related risks is important in making return-to-play decisions as well as health care and league policy.

Sporting rules and equipment need to be modified in order to prevent concussions from occurring. Two of the main reforms that relate specifically towards children are that tackling during football and heading the ball during soccer should be limited until the age of fourteen.

Great advances in technology could make diagnosing concussion possible in the future. High definition fiber tracking is a promising technology to directly measure breaks in brain fibers that control function. This technology will allow for biological diagnosis of concussion — "proof" that a brain injury has occurred.

As the hunt for better tests continues, the bigger message is to take steps to protect young brains by new rules, strengthening exercises and protective equipment. However, what makes the biggest difference is everybody, from children riding bikes, school children at sport, athletes playing elite sport, to soldiers at war, is the awareness, recognition and management of TBI. It's not OK to return to play unless ALL symptoms have cleared. As the saying suggests, "there is no I in TEAM" — everyone has a role to play in the recognition and management of concussion — for the good of the player, the team and the sport.

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