

Sport Concussion Education and Prevention

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There has been a remarkable increase in the past 10 years in the awareness of concussion in the sports and recreation communities. Just as sport participants, their families, coaches, trainers, and sports organizations now know more about concussions, health care professionals are also better prepared to diagnose and manage concussions. As has been stated in the formal articles in this special issue on sport-related concussion, education about concussion is one of the most important aspects of concussion prevention, with the others being data collection, program evaluation, improved engineering, and introduction and enforcement of rules. Unfortunately, the incidence of concussion appears to be rising in many sports and thus, additional sports-specific strategies are required to reduce the incidence, short-term effects, and long term consequences of concussion. Enhanced educational strategies are required to ensure that individual participants, sports organizations, and health care professionals recognize concussions and manage them proficiently according to internationally recognized guidelines. Therefore, this paper serves as a “brief report” on a few important aspects of concussion education and prevention.

Keywords: concussion, education, prevention, neuropsychology, sport, athlete

Concussions in sport are a significant public health issue because of their frequency of occurrence and their potential short- and long-term consequences. Therefore, recognition of the signs and symptoms of concussion and some knowledge of the principles of management should be included in the purview of all sports participants, their families, and sports personnel such as coaches, trainers, and therapists. In general, the five “Es” of injury prevention include epidemiology, education, engineering, enforcement/legislation of rules, and evaluation of injury prevention programs. With respect to prevention of concussion, all five are certainly essential. Similar to the prevention of other sports/recreation injuries, the measures required to combat concussions are multifactorial, and although there are certain strategies common to all sports, the measures should be targeted and sport-specific (Tator, 2008).

The purpose of this brief report is to alert readers of this timely special series to the importance of concussion education and prevention. Luckily, there has been a remarkable enhancement in knowledge about sport concussion in the past 10 years among participants, the general public, and health care professionals. There are many reasons for this development, including the extensive research on concussion, both clinical and basic, that has occurred. Likewise, there has been widespread dissemination of this knowledge to the sports communities (Tator, 2009a,b). Unfortunately, there is still a great deal of knowledge translation required about concussion, because a large amount of incorrect information still exists, even among health care professionals. For example, some still believe that the definition of concussion includes loss of consciousness, although it is now known that about 95% of concussions occur without loss of consciousness. In addition, many sports participants still do not recognize that “dings” or “seeing stars” are likely to be concussions, and most importantly, there is still some uncertainty regarding whether concussions are brain injuries.

As has been discussed throughout this special issue, one of the stimuli for the improvement in knowledge has been the convening of international consensus conferences on sports concussion research, definitions, and management, which were held in 2001, 2004, and 2008. The proceedings of these conferences have been disseminated widely (McCrory et al., 2009) and have led to the development of a rational nosology that has been internationally endorsed in the field of concussion. It has even been recommended that other communities of researchers and clinicians, including those who engage with other major injury groups (such as those working with motor vehicle traffic) should adopt the methodology of concussion assessment and management pioneered in the sports community (Tator, 2009c,d). In fact, older terms that are perhaps inexplicable to the public, such as “mild traumatic brain injury,” should be reserved for the academic literature. Indeed, it has been pointed out that the use of the term “mild” to describe many sports concussions is a misnomer and may be misleading (Meehan & Bachur, 2009). These consensus conferences have adhered rigorously to adopting evidence-based definitions and management principles. For example, it was determined that previous attempts to grade concussions were not evidence-based, and subsequently, such grading criteria were dropped from the guidelines. Similarly, previous return-to-play recommendations based on concussion grades were eliminated and replaced by more rational guidelines.

Education of Specific Sports Communities About Concussion

In sports, it is essential to educate a large array of individual groups in order to achieve improvement in the recognition, management, and prevention of sports concussion. The sports communities that require concussion education include the participants themselves; their parents, the coaches, trainers, therapists, and referees; sports organizations/leagues; the media; teachers; and health care professionals. Gains in recognition and management that impact upon concussion prevention can only be made through widespread dissemination of knowledge about concussion. In fact, this issue was the subject of a recent review of knowledge transfer

that concentrated on sports concussions (Provvidenza & Johnston, 2009). In the United States, the Centers for Disease Control (CDC) have also played a major role during this time and have created educational opportunities for sports personnel and health care professionals.

Educational Strategies and Resources on Concussion

A wide variety of strategies and resources are necessary to increase awareness of concussion in the sports community. The principal targeted activities should be those with the highest incidence of concussion, which in North America comprise the team sports of football and hockey but also include soccer, rugby, lacrosse, and others. Yet while the aforementioned sports appear to carry the highest incidence of concussion, it is important to recognize that individual participant sports such as bicycling, skiing, snowboarding, tobogganing, horseback riding, and squash may also result in concussions. Therefore, educational strategies on concussion must reach a multitude of sport and recreational participants and support personnel for overall effectiveness. While approximately 90% of the content is uniform, it is suggested that such information be as sport-specific as possible. Additionally, educational information should always comply precisely with the international consensus statements previously mentioned (McCrory et al., 2009), and consistency of information about concussion is essential.

Concussion education and awareness committee. One possible educational strategy is to have a multidisciplinary committee directing concussion education programs. For example, the Concussion Education and Awareness Committee was constituted in 2004 to oversee the development and dissemination of concussion education resources in Canada. This multidisciplinary, country-wide committee includes sports organizations such as Hockey Canada, teachers, coaches, engineers, physicians, surgeons, sports medicine specialists, athletic therapists, and trainers. The Committee members have been of great assistance in the development and dissemination of the resources and events described below.

Concussion road shows. Concussion road shows are half day to full day events can be held in larger centers and are often sponsored and endorsed by consortia of agencies and leagues to bring concussion education to attendees of varying backgrounds. They are intended to reach out to a wide variety of people, including sport participants, parents, coaches, trainers, referees, physicians, and the media. To my knowledge, audience numbers have ranged from 50–500 participants, and speakers have included coaches, trainers, psychologists, therapists, physicians, media personalities, and concussed athletes and their family members.

Websites. There are several websites specializing in concussion. The most complete are those organized by the CDC (cdc.gov/concussions) and ThinkFirst (thinkfirst.ca) websites. The latter contains a large number of resources on concussion, including several videos and targeted tip sheets for specific activities and specific groups such as health care professionals and parents. Many sports leagues, such as Hockey Canada, provide web-based concussion information.

Concussion cards. Another avenue for the dissemination of concussion education is to develop sport-specific concussion cards containing concussion signs and

symptoms and recommendations about return to play. These cards may increase the likelihood that participants and league officials and administrators will be aware of the principles of concussion management.

Mandatory concussion education. Many states in the United States have followed the lead of the State of Washington in mandating concussion education for players, parents, and coaches of high school aged sports teams. The legislation was prompted by Zachary Lystedt's repeated concussions and neurological deterioration, with the development of permanent neurological deficits from second impact syndrome (Adler & Herring, 2011). Since then, many states have enacted similar legislation, but it is too early to assess the impact of these mandatory educational efforts. It is well recognized that there is poor compliance with sport concussion reporting, which subsequently accounts for under-reporting (McCrory et al., 2005) and poor compliance with sport concussion management (Ackery, Provvidenza, & Tator, 2009). It is possible that mandatory education will lead to a reduction in the incidence of concussions and improved compliance with reporting and management, thus preventing brain deterioration in both the short and long term.

Preseason sports team meetings on concussion education. One potentially effective strategy for educating players, parents, coaches, trainers, and referees is through the mechanism of preseason sports team meetings on concussion education. Such meetings are typically held specifically for concussion education and comprise a 45-minute laptop computer based "course" on concussion that includes diagnosis, signs and symptoms, and return-to-play guidelines shown in a video and slide show format. The coach of the sports team, whether school-based or league-based, can be responsible for organizing the event prior to the onset of the season. Players, their parents, coaches, and trainers and referees can be invited to attend, and attendance could be voluntary or mandatory. In some leagues, preseason meetings are held for administrative purposes, and the concussion education session could be completed at that time.

Locker room posters. Professional sports leagues have begun to play an important role in educating their players about concussion. A wonderful example is the locker room poster campaign initiated in 2010 by the National Football League (NFL) in the United States. These posters urge players to report their concussions to team officials to enhance compliance with appropriate management of concussion. This type of awareness campaign should theoretically improve compliance with the reporting of concussions. Consistent reporting is essential for proper management, including guidance about return-to-play decision making.

Journal articles/continuing education/webinars. There have been excellent and informative articles on sports concussion in scientific journals, and entire issues of journals, such as the Journal of Clinical Sport Psychology, have been devoted to educating a variety of health care professionals about concussion. In addition, webinars about concussion are evolving into an effective way to reach health care professionals, coaches, and trainers. Through these means, it is possible to correct deficiencies in concussion education among all types of health care professionals.

Prevention of Concussion

The prevention of any type of injury involves primary, secondary, and tertiary strategies. Primary strategies are those that prevent concussions from happening, such as the elimination of “body checking” in ice hockey until a certain age. Secondary prevention refers to expert management of a concussion that has already occurred; such strategies are designed to prevent worsening, such as that which occurs most dramatically with second impact syndrome. Tertiary strategies help prevent the long-term complications of concussion, such as chronic traumatic encephalopathy (McKee et al., 2009) by advising the participant to permanently discontinue play based on evidence-based guidelines (Tator, 2009d).

Epidemiology of Concussion

Precise knowledge of how concussions occur in a given sport is essential for devising effective prevention programs. Currently, the field is gaining more information about the effects of age, gender, position of play, and mechanisms of concussion, and this information is essential for informing concussion prevention programs. For example, data on 13–14-year-olds collected by Goodman et al. (Goodman, Gaetz, & Meichenbaum, 2001) indicate the occurrence of far fewer concussions than among 18-year-olds recently reported by Echlin et al. (Echlin, Tator et al., 2010). Additionally, there were fewer concussions at the high school level than at the collegiate/university level in several sports (Gessel, Fields, Collins, Dick, & Comstock, 2007). Indeed, in the Echlin et al. study, concussions were observed in 36.5% of junior level hockey games, a much higher incidence than previously reported. They concluded that it is necessary to have trained observers to obtain accurate data on the incidence of concussion. Some reports indicate a higher incidence of sports concussions among women than among men (Agel, Dick, Nelson, Marshall, & Dompier, 2007; Gessel et al., 2007), and more information is needed to understand this possible occurrence.

Education About Concussion

As noted above, there are many strategies for educating the sports community about concussion, and there is evidence that education about concussion leads to a reduction in the incidence of concussion and improved outcomes from concussion (Delaney, Lacroix, Leclerc, & Johnston, 2000; Goodman & Gaetz, 2002; McCrea, Hammeke, Olsen, Leo, & Guskiewicz, 2004). For example, Cook and colleagues (Cook, Cusimano, Tator, Chipman, & Macarthur, 2003) showed that a single viewing of an education and prevention video was effective in enhancing the knowledge of concussion in young hockey players. Also, Echlin et al. showed that a single viewing of a DVD-based resource on concussions was effective at enhancing knowledge of concussion among players averaging 18 years of age (Echlin, Johnson et al., 2010). In Minnesota, the Hockey Education Project (HEP) was initiated in 2003 and involves Fair Play components, which had been shown earlier to reduce injuries (Roberts, Brust, Leonard, & Hebert, 1996). It has been shown that with Fair Play rules there are fewer incidents of head checking (Smith et al., 2009). Taken together, there appear to be worthwhile educational efforts

aimed at preventing concussion, but more work needs to be done to apply these systems more broadly and to assess their true impact on the incidence of concussions. Although education can be an effective injury prevention measure, education must be supplemented by additional measures to effect a major reduction in the incidence of concussions.

Engineering to Prevent Concussions

Improved engineering is an important injury prevention strategy in all sport and recreational activities. For example, there has been a marked reduction in catastrophic brain injuries in many sports due to the wearing of helmets (Macpherson et al., 2002). Helmets are designed to protect against major brain injuries (including bleeding into or around the brain) and brain contusions and lacerations, but to date there is no evidence that helmets actually protect against concussion (Roberts et al., 1996). At this time, there is no concussion-proof helmet, and some engineers are sceptical that one is possible within the helmet weight and size restrictions of sports such as football and ice hockey (Hoshizaki & Brien, 2004). The most important mechanism for producing a concussion appears to be rotary acceleration. Yet, rotary acceleration is poorly controlled by currently available helmets, which appear best suited to control linear acceleration.

Interestingly, while helmets have been engineered to theoretically reduce concussions, in football, the helmet is instead often used as an offensive weapon to the detriment of both the attacker and defender. Likewise, while elbow and shoulder pads worn by ice hockey players were designed to reduce injury to elbow and shoulder joints, they too have been used as offensive weapons to inflict head injuries. In fact, some have suspected that heavily armoured players will take greater risks and negate the effects of protective equipment such as helmets. Luckily, some injury prevention strategies appear to be without negative secondary consequences. For example, international ice hockey sized rinks (which have larger dimensions) have been shown to reduce player collisions and therefore cut down on injuries in general, and breakaway goal posts are another important injury prevention strategy. Nonetheless, there is little evidence to support the risk compensation theory as applied to sports equipment (Pless, Magdalinos, & Hagel, 2006).

Enforcement/Legislation of Rules to Prevent Concussions

The rules of the game and the enforcement of those rules are of major importance with respect to the incidence of sports injuries in general. In football in the United States, there was a marked reduction in cervical spine injuries and fatal head injuries with the introduction of specific rules against “spearing” and “clothes lining” (Mueller, 2001; Mueller, Zemper, & Peters, 1996). The Fair Play system of hockey rules noted previously has been used in both Quebec and Minnesota and has been shown to reduce the incidence of injuries, including concussion (Brunelle, Goulet, & Arquin, 2005; Roberts et al., 1996). The issue of the age of introduction of body checking in relation to the incidence of concussion and other injuries is of major interest, with many conflicting views. A study on the differences in concussion incidence among specific age groups and levels of play between Alberta and Quebec argued for delaying body checking until age 13 or higher (Emery et al., 2010). However, it is well known that other types of injuries, such as spinal injuries

in hockey, are lower in Quebec, which has been attributed to improved coaching and culture, such as Fair Play rules rather than body checking alone (Brunelle et al., 2005; Tator, Provvidenza, & Cassidy, 2009). Some have advocated for the total elimination of body checking in youth hockey, and it has been suggested that helmet legislation has helped prevent brain injuries in bicycling in many countries (Macpherson & Spinks, 2007).

Certainly, in contact sports such as ice hockey and football, a major reduction of hits to the head must occur if concussions are to be significantly reduced. In ice hockey, hits from behind into the boards must also be reduced or eliminated, and this can be accomplished by a combination of education and legislation. Legislation should include steeply escalating penalties involving lengthy or even permanent suspension from further play for repeat offenders. Of course, any legislation must be consistently enforced in order to be effective.

Evaluation of Concussion Prevention Programs

It is essential to evaluate any programs that are offered for concussion prevention to ensure effectiveness. Unfortunately, evaluation is often not performed at all or is performed with surrogate markers such as knowledge gain rather than injury incidence. Demonstrating a reduction in injury incidence requires long-term longitudinal studies to establish the effectiveness of a given strategy. For example, with broken necks in ice hockey, it was necessary to maintain a consistent registry of spinal injuries over several decades to indicate a definite reduction in incidence. Even then, it was not possible to ascribe the reduction to a specific injury prevention measure, but rather to several measures that had been introduced over this time span (Tator et al., 2009). Overall, while studies are emerging, more research is needed to provide the type of evaluation of injury prevention measures that are required to prove effectiveness of a given strategy (Emery et al., 2010).

Conclusion

Although knowledge of concussion has increased among the sports community, there are still many who are uninformed about the signs and symptoms of concussion and the guidelines for management. Further efforts must be made to enhance concussion education, as education is very important for primary, secondary, and tertiary concussion prevention. Participants, their families, coaches, trainers, and therapists and sports organizations all must continually update their knowledge of concussion. As can be gleaned from this brief report, educational strategies are essential to ensure that individual participants, sports organizations, and health care professionals recognize concussions and manage them proficiently and according to internationally recognized guidelines. Fortunately, there are a number of ways of accomplishing this important task. Yet education alone is insufficient to cause a major reduction in the incidence of concussion. Of critical importance, education must be augmented by careful epidemiological studies, engineering enhancements, and rule introduction and enforcement. Unfortunately, the incidence of concussion appears to be rising in many sports, and thus, additional sports-specific strategies are required to reduce the incidence and short- and long-term consequences of concussion.

References

- Ackery, A., Provvidenza, C., & Tator, C.H. (2009). Concussion and other head injuries in hockey: Compliance with return to play advice and follow-up status. *Canadian Journal Neurological Sciences*, 36(2), 207-212.
- Adler, R.H., & Herring, S.A. (2011). Changing the culture of concussion: Education meets legislation. *The American Academy of Physical Medicine and Rehabilitation*, 3(Suppl.), S468-470.
- Agel, J., Dick, R., Nelson, B., Marshall, S.W., & Dompier, T.P. (2007). Descriptive epidemiology of collegiate women's ice hockey injuries: National Collegiate Athletic Association injury surveillance system, 2000-2001 through 2003-2004. *Journal of Athletic Training*, 42(2), 249-254.
- Brunelle, J.P., Goulet, C., & Arquin, H. (2005). Promoting respect for the rules and injury prevention in ice hockey: Evaluation of the fair-play program. *Journal of Science and Medicine in Sport*, 8(3), 294-304.
- Cook, D.J., Cusimano, M.D., Tator, D., Chipman, M., & Macarthur, C. (2003). Evaluation of the ThinkFirst Canada, Smart Hockey, brain and spinal cord injury prevention video. *Injury Prevention*, 9(4) 361-366.
- Delaney, J.S., Lacroix, V.J., Leclerc, S., & Johnston, K.M. (2000). Concussions during the 1997 Canadian Football League season. *Clinical Journal of Sport Medicine*, 10(1), 9-14.
- Echlin, P.S., Johnson, A.M., Riverin, S., Tator, C.H., Cantu, R.C., Cusimano, M.D., et al. (2010). A prospective study of concussion education in 2 junior ice hockey teams: Implications for sports concussion education. *Neurosurgical Focus*, 29(5), E6.
- Echlin, P.S., Tator, C.H., Cusimano, M.D., Cantu, R.C., Taunton, J.E., Upshur, R.E., et al. (2010). A prospective study of physician-observed concussions during junior ice hockey: Implications for incidence rates. *Neurosurgical Focus*, 29(5), E4.
- Emery, C.A., Kang, J., Shrier, I., Goulet, C., Hagel, B.E., Benson, B.W., et al. (2010). Risk of injury associated with body checking among youth ice hockey players. *Journal of the American Medical Association*, 303(22), 2265-2272.
- Gessel, L.M., Fields, S.K., Collins, C.L., Dick, R.W., & Comstock, R.D. (2007). Concussions among United States high school and collegiate athletes. *Journal of Athletic Training*, 42, 495-503.
- Goodman, D., & Gaetz, M. (2002). Return-to-play guidelines after concussion: The message is getting through. *Clinical Journal of Sport Medicine*, 12(5), 265.
- Goodman, D., Gaetz, M., & Meichenbaum, D. (2001). Concussions in hockey: There is cause for concern. *Medicine and Science in Sports and Exercise*, 33(12), 2004-2009.
- Hoshizaki, T.B., & Brien, S.E. (2004). The science and design of head protection in sport. *Neurosurgery*, 55(4), 956-966; discussion 966-967.
- Macpherson, A., & Spinks, A. (2007). Bicycle helmet legislation for the uptake of helmet use and prevention of head injuries. *Cochrane Database of Systematic Reviews*, 2, CD005401.
- Macpherson, A.K., To, T.M., Macarthur, C., Chipman, M.L., Wright, J., Parkin, G. (2002). Impact of mandatory helmet legislation on bicycle-related head injuries in children: A population-based study. *Pediatrics*, 110(5), e60.
- McCrea, M., Hammeke, T., Olsen, G., Leo, P., & Guskiewicz, K. (2004). Unreported concussion in high school football players: Implications for prevention. *Clinical Journal of Sport Medicine*, 14, 13-17.
- McCrorry, P., Johnston, K., Meeuwisse, W., Aubry, M., Cantu, R., Dvorak, J., et al. (2005). Summary and agreement statement of the 2nd International Conference on Concussion in Sport, Prague 2004. *British Journal of Sports Medicine*, 39(4), 196-204.
- McCrorry, P., Meeuwisse, W., Johnston, K., Dvorak, J., Aubry, M., Molloy, M., & Cantu, R. (2009). Consensus statement on concussion in sport 3rd International Conference in Sport, (held in November 2008). *British Journal of Sports Medicine*, 43(Suppl 1), i76-90.

- McKee, A.C., Cantu, R.C., Nowinski, C.J., Hedley-Whyte, E.T., Gavett, B.E., Budson, A.E., et al. (2009). Chronic traumatic encephalopathy in athletes: Progressive tauopathy after repetitive head injury. *Journal of Neuropathology and Experimental Neurology*, 68(7), 709-735. doi: 10.1097/NEN.0b013e3181a9d503.
- Meehan, W.P., & Bachur, R.G. (2009). Sport-related concussion. *Pediatrics*, 123(1), 114-123.
- Mueller, F., Zemper, E.D., & Peters, A. (1996). American football. In D.J. Caine, C.G. Caine, & K.J. Lindner (Eds.), *Epidemiology of sports injuries* (pp. 41-62). Champaign, IL: Human Kinetics.
- Mueller, F.O. (2001). Catastrophic head injuries in high school and collegiate sports. *Journal of Athletic Training*, 36(3), 312-315.
- Pless, I.B., Magdalinos, H., & Hagel, B. (2006). Risk-compensation behavior in children: Myth or reality? *Archives of Pediatric and Adolescent Medicine*, 160(6), 610-614.
- Provvidenza, C.F., & Johnston, K.M. (2009). Knowledge transfer principles as applied to sport concussion education. *British Journal of Sports Medicine*, 43(Suppl 1), i68-75.
- Roberts, W.O., Brust, J.D., Leonard, B., & Hebert, B.J. (1996). Fair-play rules and injury reduction in ice hockey. *Archives of Pediatric and Adolescent Medicine*, 150(2), 140-145.
- Smith, A.M., Jorgenson, M., Sorenson, M.C., Margenau, D., Link, A.A., MacMillan, M., & Stuart, M. (2009). Hockey Education Project (HEP): A statewide measure of fair play, skill development, and coaching excellence. *Journal of ASTM International*, 6(4), 291-310. doi: 10.1520/JAI101857
- Tator, C.H. (Ed.). (2008). *Catastrophic injuries in sports and recreation, causes and prevention: A Canadian study*. Toronto: University of Toronto Press.
- Tator, C.H. (2009a). Concussions are brain injuries and should be taken seriously. *Canadian Journal of Neurological Sciences*, 36(3), 269-70.
- Tator, C.H. (2009b). Injury prevention in the classroom. You only get one brain. *Canadian Journal of Neurological Sciences*, 36(6), 675-676.
- Tator, C.H. (2009c). Let's standardize the definition of concussion and get reliable incidence data. *Canadian Journal of Neurological Sciences*, 36(4), 405-406.
- Tator, C.H. (2009d). Recognition and management of spinal cord injuries in sports and recreation. *Physical Medicine and Rehabilitation Clinics of North America*, 20(1), 69-76.
- Tator, C.H., Provvidenza, C., & Cassidy, J.D. (2009). Spinal injuries in Canadian ice hockey: An update to 2005. *Clinical Journal of Sport Medicine*, 19(6), 451-456.