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On

The Impact of Concussions on High School Athletes

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About Children's National Medical Center

Children's National Medical Center, a 283 bed not-for-profit academic medical center in Washington, DC, has provided hope to sick children and their families throughout the metropolitan region for nearly 140 years. The mission of Children's National is to improve health outcomes for children regionally, nationally and internationally; to be a leader in creating innovative solutions to pediatric healthcare problems; and to excel in care, advocacy, research and education to meet the unique needs of children, adolescents and their families. Children's National is ranked among the best pediatric hospitals in America by *U.S. News & World Report* and the Leapfrog Group. It is a Magnet recognized pediatric hospital, one of a handful of elite healthcare facilities nationwide.

Children's Safe Concussion Outcome, Recovery & Education Program

Children's National has long been an advocate for child safety and injury prevention. Safe Kids Worldwide, the first national advocacy organization solely dedicated to pediatric injury prevention, was founded by Children's National in 1987. With respect to concussions, Children's Safe Concussion Outcome, Recovery & Education (SCORE) Program is the first and only program in the greater Baltimore-Washington region that specializes in the clinical evaluation and treatment of concussions in children, as well as conducting research and delivering public health education and advocacy nationally and internationally. The SCORE program evaluates and treats children and adolescents with concussions (also known as a mild traumatic brain injury or mTBI). In 2009-2010, the SCORE program at Children's National treated more than 1,000 children in its concussion clinics.

Pediatric Acquired Brain Injury (PABI) Plan

Pediatric Acquired Brain Injury (PABI), of which concussions are a large component, is a significant national issue for our youth. Because a brain injury is typically "invisible," it remains unrecognized or under-recognized, thereby markedly increasing the burden of care in all aspects of society. The effects of a PABI are complex and require the integration of medical, educational, judicial and social service systems. A large number of brain injury professionals and family members have come together within the Sarah Jane Brain Foundation committed to develop a seamless, standardized, evidence-based system of care universally accessible for all children/young adults and their families regardless of where they live in the nation. This system of care is called the National Pediatric Acquired Brain Injury Plan (PABI Plan). The PABI Plan has been developed into seven overlapping "Categories of Care" for treating brain injuries in children and young adults: 1) Prevention, 2) Acute Phase, 3) Mild TBI Assessment / Treatment, 4) Reintegration / Long-term care, 5) Adult Transition Phase, 6) Rural / Telehealth and 7) The Virtual Center. For each Category of Care, the PABI Plan establishes a nationwide standard for collecting translational data, a standard set of training, education and dissemination of information, and the ability to monitor and develop basic science research. I serve as the National Lead for the Mild TBI Category of Care and a member of the Steering Committee of the Sarah Jane Brain Foundation's PABI Plan.

Introduction

Recent national media coverage has shined a bright light on sport related concussions and their effects on college and professional athletes, but less attention has been given to the effects of concussions on the developing brains of children and adolescents. As a sports medicine clinician, I am very much in favor of our nation's 40+ million children and adolescents participating in sports. I have three children who have been active student-athletes – and they have gained tremendous benefit in their physical, social, emotional, and cognitive maturity as a result of their participation in sports. But it is critical that we balance these significant benefits with careful attention to safety issues – especially when it involves the precious resource of the student-athlete's brain.

The current state of affairs in addressing mild traumatic brain injury in our student-athletes is largely one of under-identification and arbitrary treatment. A concussion is an injury to the brain as a result of a traumatic force applied directly or indirectly to the head. Many prefer to use the more comforting term “concussion” – but make no mistake – a concussion is an injury to the brain. Improving care systems for these brain injuries, and thus reducing risk to the lives of children and adolescents, is an attainable goal if we can direct proper attention, effort, and resources to the appropriate places and persons.

About Concussion/Traumatic Brain Injuries

A concussion involves a strong, violent force applied to the brain that, in most people, changes the brain's electrochemistry (i.e., software); in some people it may alter the brain's structure (i.e., hardware). We know from the work with repeated concussions that if this injury goes unchecked, the brain's hardware can be permanently damaged with dire consequences for the individual's long-term cognitive, social, and emotional quality of life.

The incidence of traumatic brain injuries (TBI) occurring to children annually is significant, but the full extent of the problem is as yet unknown. The existing epidemiologic methods are not yet developed to precisely identify the number of concussions. With current figures as likely underestimates, the Centers for Disease Control and Prevention (CDC) studied emergency department visits, hospitalizations and deaths between 2002-2006 and reported 1.7 million people sustain TBI annually, of which 52,000 died, 275,000 were hospitalized, and 1.365 million were treated and released from the Emergency Department.¹ These data do not include, however, concussions diagnosed in primary or specialty care office settings, or concussions that go unreported. Children aged 0 to 4 years and older adolescents aged 15-19 years, together with senior citizens over 75 years of age, are most likely to sustain a TBI.

Other data sources tell us that the majority of TBIs (80-90%) are of a “mild” nature. With respect to sports, recent data (Yard & Comstock, 2009) indicates an estimated 400,000 sport related concussions reported to athletic trainers at the high school level in five major male sports and four female sports. The true figures, though, are significantly higher as many other sports (e.g., ice hockey, field hockey, lacrosse, equestrian, rugby,

¹ Blue Book, March 2010 www.cdc.gov/traumaticbraininjury

cheerleading) were not included in these estimates, nor were non-scholastic high school or younger-age youth sports. In addition, a significantly higher rate of sport related concussion occurs than what is formally reported to the athletic trainer.

The developing brain of children and adolescents is much more vulnerable to injury than that of adults. In fact, according to recently published consensus recommendations by the *International Concussion in Sport Group (CISG)* – an international panel of experts of which I am a member - differences in identifying and treating concussions in children and adolescents versus adults must be recognized. The CISG guidelines, published in the May 2009 issue of *The British Journal of Sports Medicine*, recommend that children and teens:

- be removed from play if any sign or symptom of concussion is exhibited,
- Be strictly monitored; and
- be restricted from activities until they're fully healed. The important roles of parents and the school were also highlighted.

When managing concussions in children and adolescents, the guidance strongly reiterates several key points for coaches, parents, and physicians:

- Injury to the developing brain, especially repeat concussions, may increase the risk of long term effects in children, so no return-to-play until completely symptom free.
- No child or adolescent athlete should ever return to play on the same day of an injury, regardless of level of athletic performance.
- Children and adolescents may need a longer period of full rest and then gradual return to normal activities than adults.

Academic Consequences of Sport Related Concussion

There are significant threats to the child and adolescent as a result of an injury to the developing brain from concussion. Today we focus on the all-important consequences of a concussion on the academic learning and performance of the student-athlete. The effects of a concussion are quite significant and potentially wide ranging, with an adverse impact on the student-athlete's ability to think and learn (e.g., concentration, memory, speed of thinking - and therefore school performance), and his or her social and emotional functioning (e.g., irritability, depression). The student-athlete also typically experiences physical pain and/or significant fatigue. This is debilitating and disabling for a child's learning and social interactions. The length of time for a full recovery following a concussion – and of functional impairment – varies from days to months. For most, it takes at least several weeks. For others, the effects can be long-term. Second injuries result in a significantly longer period of recovery and in some instances may result in permanent disability and even death.

The nature of the academic problems associated with sport related concussions is an understudied problem. Clinically, these problems can be viewed in two categories: short- or medium-term, and long-term. Clinically, we observe that the majority of concussed student athletes recover fully with no long-term academic problems. Nevertheless, almost all student-athletes experience significant short- to medium-term challenges in their

academic performance during their period of recovery. Many experience direct neurocognitive dysfunction in their attention/concentration, memory, and speed of processing and performance. Others experience cognitive difficulties secondary to the effects of post-concussion fatigue or other somatic or emotional symptoms. As such, much of the time spent with concussed student-athletes and their families in our clinics is associated with managing school learning issues.

A smaller subgroup of student-athletes - the numbers of which we do not know - report persisting problems with attention and memory, or significant headaches and fatigue that adversely affect school learning for longer periods of time. The underlying reasons for these prolonged post-concussion learning difficulties are not fully understood, and need further study to identify the best treatment.

Why does the academic learning and performance of the student-athlete suffer after a concussion? The primary organ for learning is the brain. The brain is a very complex biological computer that requires properly working software and hardware systems. Concussions render the biological software systems dysfunctional, which produces functional deficits and symptoms, and consequently impair the learning process. Students with concussions experience difficulties focusing their attention, maintaining information process and learn actively in mind to, performing multi-step tasks, putting new information into their memories, and processing information and completing tasks at a normal speed. Without these neurocognitive abilities functioning properly, school learning and performance becomes significantly compromised. Academic problems can also have significant downstream effects, especially for the high school student-athlete. For example, concussions at the end of a semester can significantly reduce performance and grades on a final exam, reducing the student-athlete's grade point average. Taking the SAT prior to recovery from a concussion can also have a significant adverse impact on the student-athlete's future college options.

To further compound the academic difficulties, a high percentage of student-athletes experience "cognitive exertional effects", which are defined as an increase or re-emergence of symptoms following a period of cognitive activity (e.g., concentrating on a lecture, reading a textbook, performing math calculations). The reality is that the school learning environment places significant physiological demands on the recovering brain of the student-athlete.

In a recently completed study with concussed student-athletes seen in our clinics at Children's National Medical Center, over 80% reported a significant worsening of symptoms over the first four weeks as they attempted school learning activities. Half of this group was still experiencing the cognitive exertional effects 6 weeks post-injury. The typical concentration and memory requirements of school place significant demands on the brain's biological software. When these cognitive demands are placed on a brain in an impaired state, the result is an increase in post-concussion symptoms. Interestingly, symptom increase occurred less frequently with physical activity (37%) relative to cognitive/ learning activities. We believe that if the brain continues to over-exert in this way during recovery, the length of time to recovery will be delayed. For example,

attempting to do an academic task with a worsening headache further impairs school performance.

In addition to these cognitive challenges, students' poorly controlled emotions, such as irritability and a heightened emotional response to stress, have a direct and adverse effect on school performance. As student-athletes experience ongoing challenges with school learning and performance, they can experience secondary emotional effects such as feelings of nervousness or sadness. Finally, the physical/somatic post-concussion symptoms of headache, fatigue, and sensitivity to light and noise can contribute to impairments in learning due to adverse effects on sustained schoolwork. Thus, academic challenges following a concussion can result from a variety of sources.

The medical provider treating the concussed student needs to work closely with school personnel as a team to carefully manage the school learning activities. Thus, the majority of time spent in our clinics is related to planning academic treatment accommodations – both to assist effective learning and to facilitate appropriate recovery. With active management, our research demonstrates gradual reduction of cognitive exertional effects helping the student-athlete achieve an appropriate recovery.

Our clinical work also highlights that fact that schools are not adequately prepared with the necessary knowledge and skills to properly support the return of the concussed student-athlete. Several excellent tools are now available to help schools transition the concussed student athlete back into the classroom. In 2005, Dr. Micky Collins and I developed the Acute Concussion Evaluation (ACE) Care Plan, to provide the family, student-athlete, and school team with a written plan of specific academic accommodations each stage of recovery. This ACE Care Plan is updated regularly at each clinic appointment with new recommendations based on the recovery progress of the student-athlete. The ACE Care Plan is available to download within the Centers for Disease Control and Prevention's (CDC) "Heads Up: Brain Injury in Your Practice" physician's toolkit (www.cdc.gov/concussion).

While this Care Plan is useful in assisting the individual student-athlete, often school personnel are not prepared with the necessary knowledge and skill to easily implement the student's recommended accommodations. Increasing the knowledge and skill of school personnel is the focus of the CDC's May 2010 release of a school concussion toolkit called "Heads Up to Schools: Know Your Concussion ABCs." This toolkit provides key information for school nurses, counselors, school psychologists, teachers, parents, and student-athletes to assist students with concussions in their return to school.

To fully address the problem of concussion/ mild TBI and reduce risk for long-term academic and social problems, clinical, research and public health program development at Children's National and the PABI Plan focus in three areas:

1. Prevention of the injury;
2. Early, acute identification of the injury and protection of the youth athlete from further injury; and

3. Active, early treatment to promote the fastest recovery possible and reduce the period of impaired function, including an active plan to implement effective training of school personnel with the CDC's "Heads Up to Schools: Know Your Concussion ABCs" toolkit.

Conclusion

Sport related concussion to the student-athlete is an injury to the developing brain that presents a unique set of risks and challenges for their future. Specifically, learning in school is the job of the child and adolescent, and is particularly challenged by this injury given: (1) the direct effects of the concussion on neurocognitive functioning, and (2) the adverse effects of the cognitive/ learning demands on the brain's dysfunctional biological software. A portion of students have persisting problems with school learning and performance long after the acute effects of the concussion. We do not yet understand the reasons for these poor long-term outcomes, and must study them further. A high percentage of student-athletes with concussion/ mild TBI experience short- and medium-term problems with school learning and performance. These academic problems, even if temporary, can have potential negative consequences for the student down the road. And, if unidentified and untreated, these problems can have significant long-term consequences for the student. To address this problem, it is essential that we implement a national system of care for student-athletes with concussion/ mild TBI - as outlined in the national PABI Plan and supported by public health efforts at the CDC. This system must include directed efforts at prevention, education of key stakeholders, early acute identification and treatment, and effective reintegration of the student-athlete into the school system.