

[Editorial]

Banging Heads

Concussion, or mild traumatic brain injury (MTBI), continues to occupy the center stage in sports medicine. The relationship between contact sports and degenerative central nervous system diseases—such as dementia, amyotrophic lateral sclerosis, depression, and chronic traumatic encephalopathy (CTE)—remains unclear and thus deserves focused investigation as researchers probe for clinical answers.

Contact sports are an integral part of American life due to their popularity at all levels of play, from the school yard to the professional ranks. America's interest in sports that can cause high-velocity trauma continues to grow and is evident on most weekends in the fall and winter. Drastic measures to change the games have been and, understandably, will continue to be resisted by most participants, coaches, and viewers for fear of altering the nature of the competition. However, for parents, many of the recent findings are alarming. Former players cautiously review the recent reports as they ponder their own fates. Some of the more recent findings are worth review.

When all causes are considered, children have the highest incidence of MTBI.¹ Recent reports estimate that MTBI occurs in 692 of 100 000 children younger than 15 years.⁵ Up to 16% of children require medical attention for a head injury by age 10.³ One of the difficulties in isolating the lasting effects of head injury in children and teenagers is that preinjury factors, including age, education, alcohol, drug use, neuropsychiatric history, stress, and litigation, all contribute to postmorbidity disabilities.^{2,7}

One of the consequences of MTBI is postconcussion syndrome (PCS), which is a collection of cognitive, physical, emotional, and behavioral symptoms lasting from weeks to years. Studies have estimated that between 6% and 35% of children suffer PCS after MTBI.³

A recent prospective study of children¹ questioned a consecutive cohort of families of emergency room admissions with MTBI (n, 670) or extracranial injury (n, 197). Three months after injury, 11% of the children with MTBI were still symptomatic, compared with less than 1% with extracranial injury. The impact of PCS on school performance and social functioning in children and adolescents is unknown but may be an important factor in their neurological development.

Current estimates indicate that 1.2 million high schoolers play football in the United States and sustain up to 68 000 concussions per year.¹¹ Players experience approximately 3000

hits per season, with some hits generating forces in excess of 100 g's.¹² The participation numbers dramatically decrease from the high school level to the college level, but the risk increases with the size, speed, and collision forces. At present, the force threshold to interrupt cerebral functioning is unknown. A newly developed magnetic resonance imaging technique may soon be able to detect that danger level. Diffusion tensor imaging, which measures the directional preference of water molecules in cerebral white matter, is currently being used to study retired National Football League (NFL) players.⁶

At the professional level, Roger Goodell, commissioner of the NFL, has faced batteries of questions regarding the NFL's research and management of concussions. Goodell testified at a congressional hearing in October 2009, after new NFL guidelines were issued instructing teams to sideline players with suspected concussions in games or practice. Although this seems like common sense, many players in the past were not removed from play, due to a lack of understanding about the consequences of concussion.

One of the most concerning possible outcomes of concussion is CTE. First described by pathologist Harrison Martland in 1928,⁸ this progressive degenerative brain disease is being investigated by a research group at the Center for Study of Traumatic Encephalopathy in Boston, Massachusetts. Chris Nowinski, a concussion safety proponent, is spearheading this effort to expose the risks of contact sports. The hallmark of CTE is the deposition of tau protein in the brain. These deposits have been found in several former NFL players who have died prematurely from other causes. Three of 12 prematurely deceased athletes showed tau protein deposition, whereas 10 of 12 demonstrated a second abnormal protein (TDP-43).⁹ Separating the effects of comorbidities in these individuals is not currently possible, justifying a cautious approach to drawing conclusions about the dangers of these deposits. Most recent reports suggest that CTE is similar to amyotrophic lateral sclerosis and is 8 times more common in NFL players.⁹ CTE's hypothesized cause is that repeated head trauma produces toxic proteins that migrate to the spinal cord and affect motor neuron function.

The concern over this possible neurodegenerative process of the brain and spinal cord has generated focused clinical research on concussions. One of the more contentious studies was funded by the NFL and conducted at the University of Michigan's Institute for Social Research.¹⁰ Its findings, reported

in September 2009, were quite controversial. Memory-related disorders (Alzheimer disease) were reported to occur at 19 times the normal rate in former NFL football players between the ages of 30 and 49. In players who are over the age of 50, 6.1% had memory-related disorders, whereas the national average is approximately 1.2%. Surprisingly, the diagnoses were never confirmed; that is, the data were obtained through phone conversations with former players and their caregivers. This report generated concern and skepticism. Because testing to confirm the diagnosis was never performed, this study was justifiably criticized and its diagnoses called into question.

The critical need for diligent basic science and clinical studies of concussion is obvious. To its credit, the NFL has made extensive efforts along these lines. The study by Casson et al,⁴ which appears in this issue of *Sports Health*, appears to be the most comprehensive clinical assessment of concussion to date. This study compares 2 consecutive 6-year periods in the NFL (1996–2001 and 2002–2007) to determine changes in the environment associated with concussion, the patterns of concussion signs and symptoms, and comparison of the player's time loss from participation. The findings are quite interesting: Injury frequency remains quite low (0.38 concussions per game). Quarterbacks and wide receivers actually experienced a decline in their concussion frequency, no doubt due to increased protection efforts, whereas tight ends saw a whopping 54% increase. This increase, as the authors point out, is most likely due to the changing role of the tight end from, primarily, a blocker at the line of scrimmage to a downfield receiver subject to high-speed collisions. The mean number of days lost with concussion has increased from 1.92 to 4.73, reflecting increased caution and concern among coaches, medical staffs, and players. The number of individual players out for more than 7 days doubled to 16.5%, whereas those out for more than 14 days increased to 5.9% from 1.8%. The most common concussion symptoms were headache (56.1%) and dizziness (40.6%), with information processing (20.2%) and immediate recall (18.3%) also being frequently affected. Photophobia occurred with concussion in 6.9% of players, suggesting that more severe concussions may be related to migraine headaches. Overall, less than 10% of all those concussed had a documented loss of consciousness.

Repeat concussions, which did not increase in frequency in the NFL study, are more likely to lead to chronic

functional problems. The median time between reported concussions continues to be about 1 year. Most interesting is the table of rule changes,^{4(p***)} that have occurred in the NFL since 1995. All appear to be good common sense and probably overdue.

The concussion problem is very worrisome because, at this point, we do not know what dangers athletes face or who is susceptible. No doubt, preliminary evidence indicates that chronic degenerative problems of the brain and spinal cord are present at a higher rate in former players. Yet, it is clear that most individuals who play contact sports do not develop these pathologies. Nevertheless, there are enough disturbing data to justify our utmost efforts in prevention: identifying those at high risk, optimizing protective gear, strictly enforcing rules, providing adequate training and supervision, and implementing the most diligent medical surveillance.

—Edward M. Wojtyś, MD
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REFERENCES

1. Barlow KM, Crawford S, Stevenson A, Belanger F, Dewey D. Epidemiology of postconcussion syndrome in pediatric mild traumatic brain injury. *Pediatrics*. 2010;126(2):e374–e381.
2. Bernstein DM. Recovery from mild head injury. *Brain Inj*. 1999;13(3):151–172.
3. Burton LJ, Quinn B, Pratt-Cheney JL, Pourani M. Headache etiology in a pediatric emergency department. *Pediatr Emerg Care*. 1997;13(1):1–4.
4. Casson IR, Viano DC, Powell JW, Pellman EJ. Twelve years of National Football League concussion data. *Sports Health*. 2010;2(6):xxx–xxx.
5. Guerrero JL, Thurman DJ, Sniezek JE. Emergency department visits associated with traumatic brain injury: United States, 1995–1996. *Brain Inj*. 2000;14(2):181–186.
6. <http://www.diagnosticimaging.com/MRI/content/article/113619/1522620>
7. Kibby MY, Long CJ. Minor head injury: attempts at clarifying the confusion. *Brain Inj*. 1996;10(3):159–186.
8. Martland HS. Punch drunk. *JAMA*. 1928;91:1103–1107.
9. McKee AC, Gavett BE, Stern RA, et al. TDP-43 Proteinopathy and motor neuron disease in chronic traumatic encephalopathy. *J Neuropathol Exp Neurol*. 2010;69(9):918–929.
10. Mitchell D. Alzheimer's disease, memory problems common among NFL players. eMaxhealth.com. <http://www.emaxhealth.com/1275/91/33938/Alzheimers-disease-memory-problems-common-among-nfl-players.html>. Submitted September 30, 2009. Accessed September 17, 2010.
11. Montgomery W. Coaches, players tackling brain concussions head-on. *The Record*. <http://www.troyrecord.com/articles/2010/09/02/sports/doc4c800225f3a1c129115140.txt>. Published September 2, 2010. Accessed September 17, 2010.
12. NPR. NFL: Dodging the concussion discussion? <http://www.npr.org/templates/story/story.php?storyId=112219425>. Published August 26, 2009. Accessed September 17, 2010.