Long-term Consequences of Multiple Impacts and Concussions: How Many is Too Many?

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Trends in Ambulatory Care for Children with Concussion and Minor Head Injury from Eastern Massachusetts between 2007 and 2013

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Objective To characterize trends in health care utilization and costs for children diagnosed with concussion or minor head injury within a large pediatric primary-care association.

Study design We conducted a retrospective cohort analysis from 2007 through 2013 examining all outpatient medical claims related to concussion and minor head injury from 4 commercial insurance companies for children 6-21 years of age who were patients within a large pediatric independent practice association located throughout eastern Massachusetts.

Results Health care visits for concussion and minor head injury increased more than 4-fold during the study period, with primary-care and specialty clinics experiencing the greatest increases in the rate of visits while emergency department visits increased comparatively less. These increases were accounted for by both the proportion of children diagnosed with concussion or minor head injury (1.3% of all children in 2007 vs 3.3% in 2013) and the number of encounters per diagnosed patient (1.0 encounters per patient in 2007 vs 1.7 in 2013). Although the overall population costs devoted to care for concussion or minor head injury increased 34%, the cost per individual diagnosed child decreased 31%.

Conclusions Over the past 7 years, health care encounters for children diagnosed with concussion or minor head injury increased substantially in eastern Massachusetts. Care for these injuries increasingly shifted from the emergency department to primary-care and specialty providers. *(J Pediatr 2015; ■: ■-■).*

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Table. Sample characteristics and costs associated with concussion or minor head injury

	2007	2008	2009	2010	2011	2012	2013	P*
Total population								
Number of unique patients	71 329	73 760	75 766	75 063	81 231	72 518	75 683	
Female sex, number (%)	35 146 (49.3)	36 362 (49.3)	37 353 (49.3)	36 981 (49.3)	40 007 (49.3)	35 555 (49.0)	37 070 (49.0)	.4
Age, mean (SD)	12.4 (4.4)	12.5 (4.4)	12.6 (4.5)	12.7 (4.5)	12.8 (4.5)	12.9 (4.6)	12.9 (4.6)	<.001
Head injury related cost per 1000 patient-years, US$†	13 264	13 587	17 093	16 853	18 556	17 969	17 774	.009
Patients with concussion or minor head injury								
Number of unique patients (% of total population)	902 (1.3)	954 (1.3)	1252 (1.7)	1368 (1.8)	1873 (2.3)	2102 (2.9)	2491 (3.3)	<.001
Female sex, number (%)	317 (35.1)	342 (35.8)	489 (39.1)	542 (39.6)	737 (39.3)	881 (41.9)	1047 (42.0)	<.001
Age, mean (SD)	13.3 (3.8)	13.4 (3.8)	13.4 (3.8)	13.4 (3.7)	13.6 (3.6)	13.5 (3.5)	13.5 (3.4)	.045
Cost per unique patient, S$, mean (SD)†	790 (415)	786 (354)	817 (404)	690 (285)	705 (338)	604 (296)	543 (238)	<.001
Clinician visits per patient, mean (SD)	1.0 (0.70)	1.2 (0.9)	1.2 (1.1)	1.3 (1.1)	1.5 (1.3)	1.6 (1.3)	1.7 (1.4)	<.001

*P value reflects linear trend by year.
†Costs adjusted to 2013 US dollars.

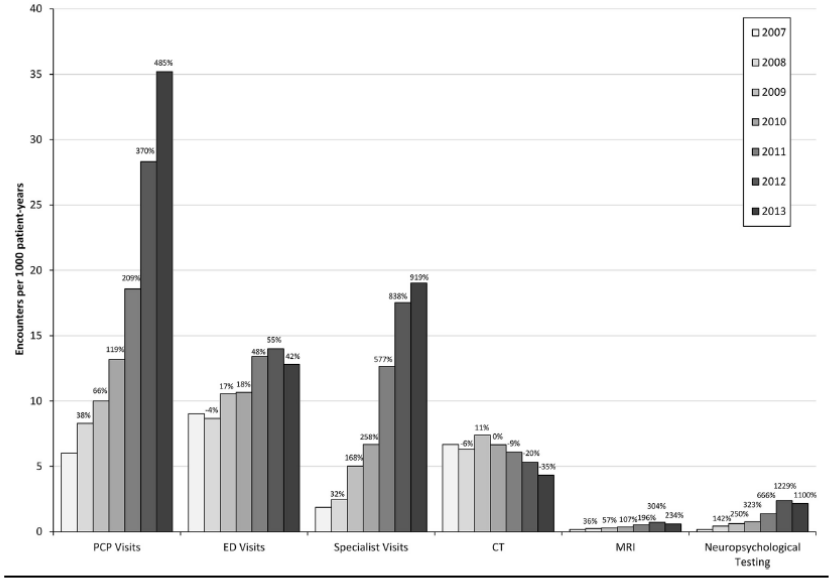

Figure 2. Utilization of services for concussion and minor head injury 2007-2013; percentages reflect change from 2007.

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CONCUSSION

Prague 2004 and Zurich 2008, 2012 Consensus—Common Features

- Concussion may be caused by a direct blow to the head, face, neck, or elsewhere on the body with an “impulsive” force transmitted to the head.
- Concussion typically results in the rapid onset of short lived impairment of neurological function that resolves spontaneously.
- Concussion may result in neuropathological changes, but the acute clinical symptoms largely reflect a functional disturbance rather than structural injury.
- Concussion results in a graded set of clinical syndromes that may or may not involve loss of consciousness. Resolution of the clinical and cognitive symptoms typically follows a sequential course.
- Concussion is typically associated with grossly normal structural neuroimaging studies.

Br J Sports Med 2005;39:196-204
Br J Sports Med 2009;43 (suppl I):i76-i84
PM & R 2013;19:255-79

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ORIGINAL ARTICLES

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The Diagnosis of Concussion in a Pediatric Emergency Department

Kathy Boutis, MD, MSc[1], Kirstin Weerdenburg, MD[1], Ellen Koo, MSc[1], Suzan Schneeweiss, MD, MEd[1], and Roger Zemek, MD[2]

Objectives To compare the proportion of children diagnosed with a concussion by pediatric emergency physicians vs the proportion who met criteria for this injury as recommended by Zurich Fourth International Conference on Concussion consensus statement and to determine clinical variables associated with a physician diagnosis of a concussion.

Study design This was a prospective, cross-sectional study conducted at a tertiary care pediatric emergency department. We enrolled children ages 5 through 17 who presented with a head injury and collected data on demographics, mechanism of injury, head injury-related symptoms/signs, physician diagnosis, and discharge advice.

Results We identified 495 children whose mean age was 10.1 years (SD 3.4 years); 308 (62.2%) were male. Emergency physicians diagnosed concussion in 200 (40.4%; 95% CI 36.1, 44.7) children, and 443 (89.5%; 95% CI 86.8, 92.2) met criteria for concussion in accordance with the Zurich consensus statement ($P < .0001$). Age ≥10 years (OR 1.8), presentation ≥1 day after injury (OR 2.4), injury from collision sports (OR 5.6), and symptoms of headache (OR 2.2) or amnesia (OR 3.4) were the variables significantly associated with an emergency physician's diagnosis of concussion.

Conclusions Pediatric emergency physicians diagnosed concussion less often relative to international consensus-based guidelines and used a limited number of variables to make this diagnosis compared with current recommendations. Thus, pediatric emergency physicians may be missing cases of concussion and the corresponding opportunity to provide critical advice for cognitive and physical management. *(J Pediatr 2015;166:1214-20)*.

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CONCUSSION

How Many Concussions Should End a Career?

- We don’t know
- No two concussions are the same
- No two athletes are the same

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INSTITUTE OF MEDICINE REPORT 10/31/13

Sports-Related Concussions in Youth: Improving the Science, Changing the Culture

http://www.iom.edu/Reports/2013/Sports-Related-Concussions-in-Youth-Improving-the-Science-Changing-the-Culture.aspx

"…while some existing studies provide useful information, much remains unknown about the extent of concussions in youth; how to diagnose, manage, and prevent concussions; and the short- and long-term consequences of concussions as well as repetitive head impacts that do not result in concussion symptoms."

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IOM REPORT

- Studies of repetitive head impacts (sometimes called "subconcussive" impacts) have had mixed findings, with some showing an association between such impacts and functional impairments, and others not. Preliminary imaging research suggests that there are changes in brain white matter following repetitive head impacts. This finding is supported by the animal literature.

- Though studies of the effects of multiple concussions on cognitive function and symptom presentation have had mixed results, more studies report unfavorable changes than do not. The most commonly observed neurocognitive impairments have been in the areas of memory and processing speed. In some studies, symptom load (i.e., the number and severity of concussion symptoms) has been found to be increased in athletes with a history of two or more concussions.

IOM REPORT

- Athletes with a history of concussion may have more severe subsequent concussions and may take longer to recover. Preliminary evidence suggests that, in addition to the number of concussions an individual has sustained, the time interval between concussions may be an important factor in the risk for and the severity of subsequent concussions.

- Surveys of retired professional athletes provide some evidence of a positive association between the number of concussions an individual has sustained and risk for depression. There has thus far been very little research on the relationship between multiple concussions and suicidal thoughts and behaviors.

HOW MANY HITS ARE TOO MANY?

Cognitive effects of one season of head impacts in a cohort of collegiate contact sport athletes

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ABSTRACT

Objective: To determine whether exposure to repetitive head impacts over a single season negatively affects cognitive performance in collegiate contact sport athletes.

Methods: This is a prospective cohort study at 3 Division I National Collegiate Athletic Association athletic programs. Participants were 214 Division I college varsity football and ice hockey players who wore instrumented helmets that recorded the acceleration-time history of the head following impact, and 45 noncontact sport athletes. All athletes were assessed prior to and shortly after the season with a cognitive screening battery (ImPACT) and a subgroup of athletes also were assessed with 7 measures from a neuropsychological test battery.

Results: Few cognitive differences were found between the athlete groups at the preseason or postseason assessments. However, a higher percentage of the contact sport athletes performed more poorly than predicted postseason on a measure of new learning (California Verbal Learning Test) compared to the noncontact athletes (24% vs 3.6%; $p < 0.006$). On 2 postseason cognitive measures (ImPACT Reaction Time and Trails 4/B), poorer performance was significantly associated with higher scores on several head impact exposure metrics.

Conclusion: Repetitive head impacts over the course of a single season may negatively impact learning in some collegiate athletes. Further work is needed to assess whether such effects are short term or persistent. *Neurology*® 2012;78:1777–1784

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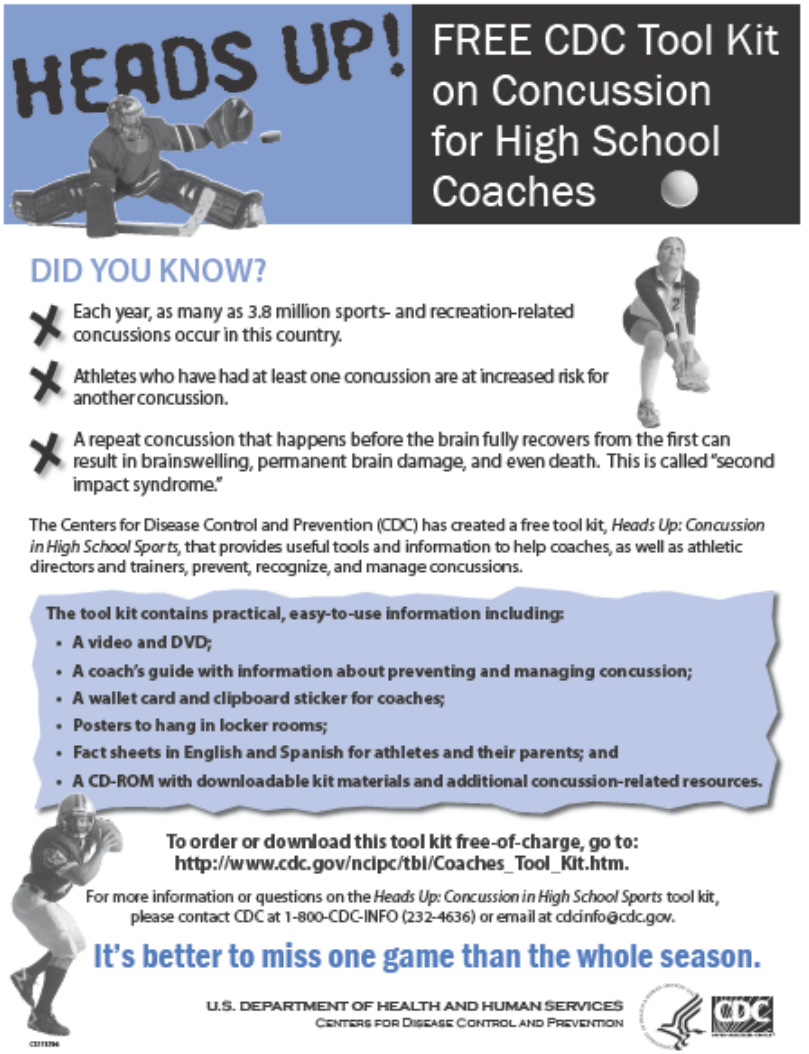
Heads Up: Brain Injury in Your Practice



www.cdc.gov/traumaticbraininjury

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