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The Prevalence of Undiagnosed Concussions in Athletes

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Abstract

Objective—Previous studies suggest athletes underreport concussions. We sought to determine whether athletes in our clinics have sustained previous concussions that went undiagnosed.

Design—Multi-centered, cross sectional study.

Setting—Two sport concussion clinics.

Patients—Patients diagnosed with sport-related concussions or concussions with injury mechanisms and forces similar to those observed in sports were included.

Main Outcome Measures—The proportion of patients that answered “yes” to the following question were defined as having a previously undiagnosed concussion: “Have you ever sustained a blow to the head which was **NOT** diagnosed as a concussion but was followed by one or more of the signs and symptoms listed in the Post Concussion Symptom Scale.”

Results—Of the 486 patients included in the final analysis, 148 (30.5%) reported a previously undiagnosed concussion. Athletes reporting previously undiagnosed concussions had a higher mean Post Concussion Symptom Scale score (33 v. 25; $p < 0.004$) and were more likely to have lost consciousness (31% v. 22%; $p = 0.038$) with their current injury than athletes without previously undiagnosed concussions.

Conclusions—Nearly one third of athletes have sustained previously undiagnosed concussions, defined as a blow to the head followed by the signs and symptoms included in the post concussion symptom scale. Furthermore, these previously undiagnosed concussions are associated with higher post concussion symptom scale scores and higher loss of consciousness rates when future concussions occur.

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Keywords

Mild traumatic brain injury; loss of consciousness; sports injury

Introduction

Previous studies have suggested that athletes often neglect to report their concussions to medical personnel. In a 2004 study published by McCrea et al., less than half (47.3%) of US high school football players sustaining a concussion reported their symptoms.¹ The authors defined a concussion as, “a blow to the head followed by a variety of symptoms that may include any of the following: headache, dizziness, loss of balance, blurred vision, ‘seeing stars,’ feeling in a fog or slowed down, memory problems, poor concentration, nausea or throwing up.”¹

In 2005, a study by LaBotz et al. found that only 17% of collegiate athletes reported sustaining a concussion, even though 48% reported sustaining a head injury that was followed by the signs and symptoms of concussion.² Williamson et al. found similar results in amateur hockey,³ both retrospective surveying of players and diagnosing concussions by direct observation of players revealed substantially higher incidence rates than those officially reported. In a survey of all college athletes attending the University of Akron between 1995 and 2001, Kaut et al. reported that 32% of collegiate athletes had suffered a direct blow to the head resulting in dizziness, but only 20% had been diagnosed with a concussion.⁴

Recently, there has been an effort to reach a consensus on the definition of concussion. Specifically, the Third International Conference on Concussion in Sport defined concussion as:

Concussion is defined as a complex pathophysiological process affecting the brain, induced by traumatic biomechanical forces. Several common features that incorporate clinical, pathologic, and biomechanical injury constructs that may be utilized in defining the nature of a concussive head injury include

1. 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.
2. Concussion typically results in the rapid onset of short-lived impairment of neurologic function that resolves spontaneously.
3. Concussion may result in neuropathologic changes, but the acute clinical symptoms largely reflect a functional disturbance rather than a structural injury.
4. Concussion results in a graded set of clinical symptoms that may or may not involve loss of consciousness. Resolution of the clinical and cognitive symptoms typically follows a sequential course; however, it is important to note that in a small percentage of cases, postconcussive symptoms may be prolonged.
5. No abnormality on standard structural neuroimaging studies is seen in concussion.

We sought to determine whether athletes cared for in our clinics have sustained previously undiagnosed concussions.

Materials and Methods

Participants

We conducted a cross sectional study of patients seen in 2 sport concussion clinics, the Sports Concussion Clinic at Children's Hospital Boston and the University of Pittsburgh Medical Center Sports Medicine Concussion Program, Bethel Park location. All patients seen between October 1, 2009 and September 30, 2010 were considered for enrollment. We included all sport-related concussions. In addition, patients with injury mechanisms and forces similar to those observed in sports, such as falling from a standing position or fist-fighting, were also included. We excluded patients with more severe injury mechanisms and forces, such as motor vehicle accidents and falls from above ground level.

Definition of concussion

We used the definition of concussion proposed by the international consensus on concussion in sport.⁵ Thus, athletes experiencing a traumatic acceleration of the brain followed by the onset of symptoms of concussion, signs of concussion, or decreases in neurocognitive function were diagnosed as a concussion.

Definition of undiagnosed concussion

Standardized intake and follow-up visit forms were used at each location. Patients entered demographic information (e.g. date of birth, gender), and clinical data (e.g. day of injury, sport played at time of injury, score on the post-concussion symptom scale). In addition, each patient was given a copy of the Post Concussion Symptom Scale (PCSS) included in the consensus statement on concussion in sport,⁵ and asked to answer the following question: "Have you ever sustained a blow to the head which was **NOT** diagnosed as a concussion but was followed by one or more of the signs and symptoms listed in the Post Concussion Symptom Scale." Patients answering "yes" to this question were defined as having a previously undiagnosed concussion.

The PCSS is a symptom inventory containing a total of 22 symptoms that athletes rank on a scale from 0, when an athlete is not experiencing a given symptom, to 6, when the athlete describes the symptom as "severe." The PCSS is part of the SCAT 2, which was proposed by the 3rd international consensus on concussion in sport. The total score on the PCSS is the sum of the athlete's severity score (0-6) for each of the 22 symptoms. Thus, the maximum possible score on the PCSS is 132 (6 × 22).

A history of previous concussions is associated with an increased likelihood of loss of consciousness (LOC), increased scores on symptom inventories, and increased symptom duration with a recurrent injury.⁶⁻⁸ Thus, we compared the rates of LOC, the mean symptom scores, and duration of concussion symptoms between athletes with previously undiagnosed concussions, and those without previously undiagnosed concussions as a way of validating the self-reported history of previously undiagnosed concussions.

The mean values for continuous variables were compared between the 2 groups using Student's t-test; proportions between the two groups were compared using chi-square test. All analyses were done with PASW Statistics 18.0 (SPSS Inc., Chicago, IL). This study was approved by the institutional review board of Boston Children's Hospital.

Results

A total of 731 patients met inclusion criteria and were enrolled between the two clinics during the study period. Two hundred and twenty seven patients (31%) did not answer the

question. An additional 18 were removed for incomplete or inaccurate data. Thus, 486 patients were included in the final analysis with a mean age of 15.5 years (SD 3.5 years). Most participants (63%) were male.

A total of 148 patients (30.5%) reported that they had sustained a previous blow to the head that resulted in one or more of the signs and symptoms listed on the PCSS, but were not diagnosed with a concussion. There were no significant differences in gender, mean age, or mean number of previously diagnosed concussions, between participants with previously undiagnosed concussions and those without (table 1).

Athletes who reported sustaining a previously undiagnosed concussion were more likely to have lost consciousness and have a higher mean PCSS score with their current injury than athletes without previously undiagnosed concussions (table 2).

Discussion

Our study shows that nearly one third of athletes seen in our clinics have sustained previously undiagnosed concussions, defined as a blow to the head followed by the signs and symptoms on the PCSS. Furthermore, these previously undiagnosed concussions are associated with higher post concussion symptom scale scores and higher LOC rates when future concussions occur. Failure to diagnose concussions in athletes can lead to further insults to the brain prior to full recovery, exposing these athletes to the cumulative effects of injuries and an increased risk of second impact syndrome.^{6, 9-13}

Our rate of undiagnosed concussions is moderately lower than that reported by McCrea et al.¹ and LaBotz et al.² This decrease in unreported concussions may be due to increased awareness and understanding of concussion resulting from increased media attention. Outspoken former athletes have publically described how playing through concussions has negatively impacted their future health.¹⁴ Perhaps this awareness is resulting in more athletes reporting their injuries to medical personnel.

The differences between our findings and that of McCrea et al. might also be explained by the different methods between the 2 studies. Our definition, which included the 22 signs and symptoms of the PCSS, was more inclusive than both McCrea et al.'s, which only included a limited number of symptoms, and LaBotz et al.'s which included 15 signs and symptoms. We would expect, however, that our more inclusive definition of concussion would result in a higher proportion of athletes with previously undiagnosed concussions. Another possible explanation for the differences in our findings is the study populations. We included all sports played by the athletes in our clinics, while McCrea studied exclusively high school football players. It is possible that football players are less likely to report concussion symptoms than participants in other sports. Similarly, LaBotz et al. studied National Collegiate Athletic Association Division 1 athletes while we included all ages and levels of athletes.

Limitations

Our findings must be interpreted in light of several limitations. Although it did not reach statistical significance, there appeared to be a difference between the proportion of male and female athletes reporting previously undiagnosed concussions (26% vs. 33%, $p=0.17$). Given the number of participants, however, we were underpowered to detect such a difference. In addition, we defined “previously undiagnosed concussion” using historical data only. Thus, we could not confirm that the signs and symptoms experienced by the athletes after these previous blows to the head were, in fact, due to concussion. We did show, however, that athletes meeting our definition of “previously undiagnosed

concussions,” complained of higher PCSS scores with their current injuries. This outcome is associated with a history of previous concussions, suggesting that our definition was valid. Furthermore, athletes with previously undiagnosed concussions appeared more likely than those without to lose consciousness with their current injuries (30.6% vs. 21.8%; $p=0.038$). Since, however, we made 3 comparisons (proportion with loss of consciousness, mean PCSS score and mean symptom duration) the threshold for statistical significance should be adjusted downward to $p<0.017$. Therefore, we cannot confidently say that this finding was statistically significant. Finally, our results are possibly affected by recall bias; perhaps athletes with more severe concussion symptoms were more likely to remember previous blows to the head resulting in the signs and symptoms of concussion. If, however, this were the case, we would expect recall bias to also affect the number of recalled diagnosed concussions as well, a variable that was similar between the two groups.

Conclusions

Nearly one third of athletes have sustained a blow to the head that resulted in the signs and symptoms of concussion, but was not diagnosed as a concussion. Failure to diagnose concussions in athletes can lead to further, potentially devastating, insults to the brain. A prospective study designed to determine the reasons behind the under-diagnosis of concussions may allow us to effectively encourage these athletes to seek proper medical attention.

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Abbreviations

PCSS	post concussion symptom scale
LOC	loss of consciousness

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Clinical Relevance

Many athletes have sustained previous blows to the head that result in the signs and symptoms of concussion, but have not been diagnosed with a concussion. These injuries are associated with increased rates of loss of consciousness and higher symptom scale scores with future concussions.

Table 1

Characteristics of participants

	Participants with previously undiagnosed concussions (N=148)	Participants without previously undiagnosed concussions (N=338)	p-value
Mean Age	15.4 years	15.5 years	0.68
Mean number of previously diagnosed concussions	3.5	3.0	0.33
Proportion male	69%	60%	0.17
Number playing a given sport at time of current injury*† n(%)			
Football	32 (22%)	66 (20%)	
Ice hockey	25 (17%)	58 (17%)	
Soccer	20 (14%)	49 (14%)	
Basketball	13 (9%)	31 (9%)	
Lacrosse	7 (5%)	24 (7%)	0.58

Table 2

Factors previously associated with a history of prior concussions *

	Patients with previously undiagnosed concussions	Patients without previously undiagnosed concussions	p-value
Loss of consciousness n/N (%)	41/134 (30.6)	69/317 (21.8)	0.038
Mean PCSS[†] score at initial visit	33	25	0.004
Mean symptom duration (days)	44	30	0.177

* PCSS = Post-Concussion Symptom Scale from the international consensus on concussion in sports (total score at initial visit)