Contact Sport Concussion Incidence

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Clinical Question: What is the incidence of concussion in various contact sports?

Data Sources: Studies for the review were found through a MEDLINE search (1985–2000) and by gathering and reviewing older articles referenced in the searched articles. The main terms that were included in the search were brain injuries, brain concussion, and incidence. Text words that were also included were mild traumatic brain injury, concussion, incidence, injury, and head injury, along with the names of 8 contact sports (American football, boxing, ice hockey, judo, karate, tae kwon do, rugby, and soccer).

Study Selection: For this review, concussion was defined as “a mild brain injury resulting from a direct blow to the head resulting in physiological changes in brain function.” Cohort studies with documented incidence of concussion in athletes from 8 identified contact sports were the target of the search. All studies of male and female athletes in any of the 8 contact sports, including practices and games and regardless of level of competition, were included in the study search. Possible articles for review were identified through a 3-step screening process. Article titles were initially screened by one of the authors. If the title seemed to be relevant to the purpose of the review, the abstract of the article was then screened for inclusion/exclusion criteria as the second step. To be included, studies had to relate to the incidence of injury to the head and brain, report results relevant to concussion, involve 1 of the 8 identified contact sports, and be published between 1985 and 2000. All systematic reviews about mild traumatic brain injury (TBI) or concussion were also included. Studies were excluded if they discussed concussion due to whiplash injury or concussion associated with spinal cord injury, facial bone fracture, or soft tissue injuries; if they reported prevalence, rather than incidence, of concussion; if they addressed chronic TBI; if they comprised case reports or letters to the editor; or if they lacked a denominator to determine risk rates. Finally, relevant and unknown articles from the abstract screening were reviewed again for the inclusion and exclusion criteria by an independent, outside party.

Data Extraction: A general methodologic criteria design was used to critically appraise all articles that met the inclusion and exclusion criteria. This design appraised 11 study design and reporting criteria. In order for an article to be accepted into the systematic review, it had to meet at least the 5 mandatory criteria: description of the source population, appropriate description of inclusion and exclusion criteria, verifiable results from the raw data, differentiation of the incidence of injury between practice and game settings, and adequately measured denominator of population or person-time at risk. For each individual study, the 5 mandatory criteria listed above were rated with regard to whether they were included or addressed in the paper (yes), were missing from the paper (no), or were included but not described fully or in a way characterized by sound quality (substandard). If any of the 5 mandatory criteria were rated no, the article was not evaluated any further. Data taken from these articles included sex, types of sessions in which concussion occurred, and numbers defining incidence of concussion within a contact sport. In some studies, rates were recalculated from the raw data in order to check accuracy, or if they were not presented in the published material, rates were calculated. These rates were recalculated with the denominator presented in the original study, athletes at risk for injury or time at risk for injury. Athlete-exposure was not defined in the review but is commonly used as the denominator in epidemiologic studies and represents one time in which an athlete takes part in a game or practice that exposes him or her to a risk for injury.

Main Results: The overall search identified 559 publications with possible relevance to the incidence of concussion in contact sports. After the titles were screened, 213 articles remained, and their abstracts were reviewed. The abstract screening for relevance yielded 127 articles to which the inclusion and exclusion criteria were applied. The investigators then critically reviewed 63 articles that fit the inclusion criteria. During this critical review, 40 articles did not meet the 5 mandatory criteria listed above and were not evaluated further. After final screening, 23 articles were included in the study. Review of these 23 articles revealed that among team sports for high school males, ice hockey athletes demonstrated the highest incidence of concussion (3.6 per 1000 athlete-exposures [AEs], 95% confidence interval [CI] = 0.99–9.29) and soccer athletes the lowest incidence of concussion (0.18 per 1000 AEs, 95% CI = 0.14–0.22). At the professional level, similar concussion incidence rates were found in both ice hockey (6.5 per 1000 player-games, 95% CI = 4.8–8.6) and rugby (9.05 per 1000 player-games, 95% CI = 4.1–17.1) players. When compared with other individual male sports (karate and tae kwen do), boxing had the highest incidence of concussion in professional (0.8 per 10 rounds, 95% CI = 0.75–0.95) and amateur (7.9 per 1000 man-minutes, 95% CI = 5.45–11.09) athletes. Only 6 included studies (5 dealing with tae kwen do and 1 with soccer) addressed concussion incidence in females. Tae kwen do had the
highest incidence of concussion (8.77 per 1000 AEs, 95% CI = 0.22–47.9).

**Conclusions:** The information presented in the article offers helpful insight into the rate of concussion in athletes from 8 contact sports. Ice hockey seemed to have the greatest incidence of concussion for males, whereas taekwondo had the highest incidence rate for females. Relatively few rigorous epidemiologic studies on the incidence of concussion exist. Specifically, 63% of the identified studies did not meet the methodologic criteria to be included in this systematic review. In addition, limited information exists on the risk of concussion for females in contact sports. Future authors should address the limitations in reporting incidences, including the lack of adequately measured denominators (person-time at risk), vague definitions of concussion, combining game and practice injuries, and history of concussive injury. Future researchers should also include at least the 5 mandatory methodologic criteria used in the critical appraisal of articles for this review to allow for better reporting of concussion incidence and comparison among various studies. Concussion incidence in females should also be explored.

**Key Words:** head injury, brain injury, epidemiology

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**COMMENTARY**

This systematic review provides information on the incidence of concussion in athletes from various team and individual sports through a review of methodologically sound original research articles. Epidemiologic studies such as this may provide an overview of injury rates that can aid clinical athletic training practice and also serve as an initial stepping stone to further research that can aid clinicians. Understanding the incidence rates of concussion in certain contact sports may help the clinician to identify areas in which additional preventive measures can be taken to ensure adequate coverage of these sports. This may be accomplished through the implementation of a comprehensive concussion management protocol, proper training of all medical personnel in the emergency action plans for the various sports, altering return-to-play progressions for sports with higher incidences of injury, and educating athletes in high-risk sports about the signs and symptoms associated with concussion and the proper reporting of concussions to medical personnel.

Comprehensive concussion management protocols have been advocated in several consensus statements and should include baseline cognitive and postural stability testing, especially for athletes in high-risk sports. In settings such as high schools, where staff and other resources are often limited, knowing the concussion incidence rates in various sports may assist the athletic trainer in determining which athletes should undergo baseline testing. Additionally, training coaches and other medical personnel involved in high-risk sports in the steps of the emergency action plan for a suspected head injury is an appropriate preventive practice.

Once an athlete reports to the athletic trainer as asymptomatic and scores on adjunct tests have returned to baseline, a progressive return-to-play protocol is recommended. This progression should begin with general exertional tests, such as running or riding a stationary bicycle, and progress to restricted sport-specific skills and finally to unrestricted participation. Based on the information provided in this review, athletes in high-risk sports such as ice hockey and boxing may benefit from a slower return-to-play progression because of the increased risk of concussions in their respective sports. A slower progression could involve taking 2 to 3 days for each phase of the progression instead of moving from one phase to the next on consecutive days.

Using injury incidence rates to educate athletes, coaches, and parents involved in high-risk sports is important, because underreporting of concussive injuries at all levels of athletics is substantial. In a postseason survey, McCrea et al found that more than 50% of high school football players did not report their concussions. The reasons for not reporting their concussions included not thinking the injury was serious enough (66%) and not knowing they had suffered a concussion (36%). Similarly, 56% of collegiate athletes reported no knowledge of concussion consequences, 28.2% reported playing while dizzy, and 30.4% reported continuing to play with a headache after a blow to the head.

The education of high-risk athletes is also important in possibly preventing repeat concussions. Recent authors have identified discrepancies between concussion history as reported on the preparticipation examination (PPE) and history of symptoms after previous head injuries. LaBotz et al found that 71% of athletes who reported concussion symptoms on a concussion symptom survey did not report a concussion history on their PPE. Similarly, only 8.1% of a sample of high school athletes reported a concussion history on the PPE; however, 55.0% reported having concussion symptoms after a head injury. Of those reporting concussion symptoms, 86.4% did not report a concussion history in sport on their PPEs. These studies highlight the need to educate athletes, especially those in high-risk sports, about concussion symptoms, consequences of concussion, and the importance of reporting suspected concussions to medical personnel.

This systematic review provides important information regarding the incidence of concussion across team and individual sports; however, it has several limitations that readers should take into account when reviewing the results. First, the authors defined concussion as resulting from direct or blunt trauma to the head. This is a narrow definition and does not take into account concussions that result from being hit elsewhere on the body with resultant acceleration or deceleration of the brain. The International Conference on Concussion in Sports included direct blows to the face, neck, or other body areas that transmit impulsive forces to the head in its definition of concussion. The limited definition used in this review may have affected the selection of relevant articles and may have caused many of the original articles found in the search to be rejected. Because concussion results from mechanisms other than direct blows to the head, future investigators should include all mechanisms when looking at the incidence of concussive head injury.

Second, this article alone does not provide any insight into risk factors for sport-related concussion. An understanding of the factors that may predispose athletes to concussion may help clinicians recognize at-risk athletes in various sports. The authors did not study repeat concussions, which have been implicated as a risk factor for subsequent injuries. Gusiewicz et al observed a dose-response relationship between history of previous concussions and risk for sustaining a repeat injury (3 or more previous concussions, adjusted risk ratio = 3.0, 95% confidence interval [CI] = 1.6–5.6; 2 previous concussions, adjusted risk ratio = 2.5, 95% CI = 1.5–4.1; 1 previous concussion, adjusted risk ratio = 1.4, 95% CI = 1.0–
2.1). Similarly, a history of previous concussions more than doubled the concussion rate in high school athletes (adjusted rate ratio = 2.28, 95% CI = 1.24–4.19). Further study of the incidence of recurrent concussions may lead to a better understanding of the risks of repeat injuries and the potential for cumulative effects of recurrent concussions.

The finding of few studies addressing concussion in female athletes warrants attention. Although many authors have focused on the contact sports of ice hockey and football, which tend to be male dominated, sports such as women’s field hockey have largely been ignored. Sex-related injury incidence patterns have been discovered in certain high school sports and should be explored further. Tools such as the National Collegiate Athletic Association Injury Surveillance System can be used to further examine rates of concussions in female athletes. This tool has shown that females sustain a higher incidence of concussions in game situations than their male counterparts, which further supports the need for more studies regarding female athletes. However, the use of the Injury Surveillance System is not without its own limitations, such as including time loss as a qualification for injury and not recording data on high school or club sport athletes.

The findings stemming from this review are interesting, but they seem to lead to further questions and the need for future studies. Authors of future systematic reviews should focus on repeat concussions, concussions resulting from all types of mechanisms, and age differences. The conclusions (1) that not many well-designed studies exist regarding the incidence of concussion and (2) that very few studies address females also indicate the need for future epidemiologic studies in this area. The examination of these issues may aid in preventing concussion in sports and may lead to a better understanding of this complex injury.

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REFERENCES