A Heads-up on Concussions

Are there sex-related differences?

XUAN LUO, MD, EMILY CURRY, BA, AND ELIZABETH MATZKIN, MD

The number of sports-related concussions in the United States has risen significantly over the years. Available data from the 1990s indicated that approximately 300,000 concussions were incurred annually. Currently, a more generous estimate of all sports-related concussions, including those that do not result in loss of consciousness, may be closer to 1.6 million—and may be as high as 3.8 million each year.

Furthermore, this number may be a gross underestimate because many concussions remain unreported. Approximately 5 percent of high school athletes will sustain a concussion each year. The number and severity of concussions sustained by young athletes also may depend on their sex, as well. With an ever-increasing number of females participating in high school and collegiate sports, recognizing possible concusion differences between sexes is important for team physicians.

Concussion in female athletes

Large epidemiologic studies find that female athletes sustain significantly more concussions than male athletes; in some studies, the number of concussions sustained by female athletes was double the number sustained by male athletes. These differences were most commonly seen in basketball, soccer, and volleyball.

Female athletes may also sustain more severe concussions with greater deficits in cognitive function and a longer recovery period.

Why the differences?

Several theories have been postulated for the differences between male and female athletes with regard to concussion, primarily centered on biomechanical differences. Women have more slender necks and smaller heads and thus experience greater reactive forces during head trauma. In biomechanical studies, women can experience nearly 50 percent more head acceleration during head trauma.

In addition to the mechanical differences, hormonal differences between males and females may also play a role. Estrogen may play a role in the effects on the brain after trauma, with animal studies suggesting a greater detrimental effect of estrogen in females.

Table 1 summarizes several concussion incidence studies and the potential sex-related differences noted. However, this is not an open-and-shut case. Some studies failed to find significant differences in concussions between the sexes and directly contradict those that do. In a large prospective cohort of 15,802 high school athletes in North Carolina, male soccer players reported more concussion incidents than females, while female basketball players reported more concussion incidents than males. It may be argued that currently documented differences between the sexes with regard to concussion may be the product of reporting bias. Male athletes may be more likely than female athletes to hide concussions and fail to report them for fear of not being able to continue playing or to participate in sports.

However, several other reasons could explain the lack of a uniform consensus on the sex predominance of concussions. The most likely reason could be differences between study populations (elite versus recreational athletes and sport types). In addition, many of the studies were performed retrospectively with a variety of measurement tools and indications.

Ultimately, a team physician should have a high index of suspicion for concussion with any head trauma sustained in sports, regardless of the athlete’s sex. Further research to determine the differences in the incidence of concussion in men and women, as well as differences in symptoms and return to play criteria, is still necessary.

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References for the studies cited in this article may be found in the online version available at www.aaosnow.org

Putting sex in your orthopaedic practice

This quarterly column from the AAOS Women’s Health Issues Advisory Board and the Ruth Jackson Orthopaedic Society provides important information for your practice about issues related to sex (determined by our chromosomes) and gender (how we present ourselves as male or female, which can be influenced by environment, families and peers, and social institutions). It is our mission to promote the philosophy that male and female patients experience and react to musculoskeletal conditions differently; when it comes to patient care, surgeons should not have a one-size-fits-all mentality.

**Table 1: Incidence of Concussion Studies**

<table>
<thead>
<tr>
<th>Primary author</th>
<th>Year of publication</th>
<th>Study design</th>
<th>Patients studied</th>
<th>Evaluation tools</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marar 2010</td>
<td>Descriptive epidemiology</td>
<td>1,936 high school athletes</td>
<td>Reported concussions</td>
<td>Female athletes had a higher rate of concussions than male athletes.</td>
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<tr>
<td>Lincoln 2011</td>
<td>Descriptive epidemiology</td>
<td>158,430 high school athletes</td>
<td>Electronic medical record keeping</td>
<td>Female athletes had double the risk of concussions than male athletes.</td>
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<tr>
<td>Barnes 1998</td>
<td>Retrospective, interviews</td>
<td>137 elite soccer players</td>
<td>Interview related to concussion</td>
<td>No differences between sexes, female athletes had a lower odds ratio of concussion than male athletes.</td>
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<tr>
<td>Schulz 2004</td>
<td>Prospective cohort</td>
<td>15,802 high school athletes</td>
<td>Customized medical record and participation forms</td>
<td>No differences between sexes, risk of concussion was mixed and sport-dependent</td>
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