First-Time Sports-Related Concussion Recovery: The Role of Sex, Age, and Sport

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Background: Concussion is one of the most common injuries in athletes. Current concussion consensus statements propose that female sex may be a modifying factor in concussion management and recovery.

Objective: To determine whether female athletes in middle school and high school with a first-time, sports-related concussion remained symptomatic longer than their male counterparts.

Methods: A retrospective medical record analysis was performed among athletes who sustained a concussion between 2011 and 2013. Inclusion criteria consisted of age between 11 and 18 years and diagnosis of first-time concussion sustained while playing organized sports. Using the documented notes in the medical record, length of time that each athlete was symptomatic from his or her concussion was calculated.

Results: A total of 110 male and 102 female athletes (N=212) met the eligibility criteria for the study. A significant difference was found in the median number of days female athletes remained symptomatic (28 days) when compared with male athletes (11 days) (P<.001). No statistically significant difference was found in symptom duration between age groups. When matched for sex, no statistically significant differences were found in symptom duration between the type of sports played.

Conclusion: Female athletes aged 11 to 18 years with first-time, sports-related concussions remained symptomatic for a longer period when compared with male athletes of similar age, regardless of sport played. The mechanism behind this difference needs to be further elucidated.


Keywords: athlete, concussion, head injury, sports

Concussions represent almost 9% of all injuries in high school athletics.1,2 Since 2001, emergency department visits for sports-related concussions among children and adolescents increased by 60%, possibly reflecting the increased number of participants, increased incidences of sports-related concussions, or increased concussion awareness.1

Certain studies propose that female athletes are at greater risk for concussion than their male counterparts.1,3-6 Newer published consensus statements suggest that female sex may be a modifying factor in concussion recovery.5,6 Most early studies state that the majority (80%-90%) of concussions resolve in a 7- to 10-day period.5,7-10 Nonetheless, the majority of these initial studies involved male collegiate or professional athletes. The consensus statement on concussion issued by the 4th International Conference on
Concussion in Sport held in Zurich in November 2012 “accepted that sex may be a risk factor for injury and/or influence injury severity” but did not list female sex as a possible modifier in the management of concussions because there was no “unanimous agreement that the current published research evidence is conclusive.”

The most recent consensus statement on concussion issued by the 5th International Conference on Concussion in Sport in October 2016 went on to state that “there is some evidence that the teenage years, particularly the high-school years, might be the most vulnerable time period to have persistent symptoms—with greater risk for girls than boys.” They reported “that a sizeable minority of youth, high school and collegiate athletes take much longer than 10 days to clinically recover and return to sport.”

The purpose of the current study was to determine whether a sex difference exists in the resolution of symptoms in first-time sports-related concussion among middle school and high school athletes.

Methods

Design

We conducted a retrospective medical record analysis of athletes who sustained a concussion between 2011 and 2013 and were seen at a single sports medicine practice in southern New Jersey. Athletes were seen by 1 of 3 primary care physicians (including J.M.N. and D.B.G.) with a Certificate of Added Qualifications in sports medicine. This study was deemed exempt by the Cooper University Hospital Institutional Review Board.

Criteria

Inclusion criteria consisted of middle school and high school athletes who sustained a first-time concussion while playing organized sports. Athletes who sustained a concomitant injury with concussion (eg, nasal fracture, intracranial bleed) were excluded from the study. Athletes who sustained a concussion outside of organized sports (eg, gym class, backyard play, motor vehicle accident) were excluded from the study. Athletes lost to follow-up or with incomplete forms were also excluded.

Collected Data

The intake forms for all 3 physicians were identical with regard to initial evaluation of athletes presenting with concussion. The following data were recorded: demographic information (age, sex, and sport); presence of loss of consciousness and retrograde or anterograde amnesia as assessed during the initial office visit; medical history of migraines/frequent headaches, learning disability, visual problems, or mental illness; and postinjury total ImPACT (Immediate Post-Concussion Assessment and Cognitive Testing; ImPACT Applications, Inc) symptom score using the 7-point Likert symptom scale (Figure 1). Each of the 22 items is rated on a scale of 0 (not present) to 6 (severe). The length of time that each athlete was symptomatic was calculated using the documented medical record information from follow-up office visits. The criterion for resolution of symptoms was documentation that the athlete returned to baseline symptoms (before concussion). Owing to an inconsistency of baseline ImPACT symptom scores, baseline levels were determined through patient self-reporting.

Data Analysis

All statistical tests were performed using SPSS (IBM). Independent t tests were used to compare the mean age between the sexes, and the Mann Whitney U test was used to compare the ranks of asymptomatic days and ImPACT score. Medians were evaluated rather than means for asymptomatic days and ImPACT score because the data were not normally distributed and assessing the means would skew the results. $\chi^2$ tests were used to compare the type of sport, presence of amnesia, and loss of consciousness between the sexes. $P$ values <.05 were considered statistically significant.

Results

Of 549 medical records reviewed, 212 athletes (110 male and 102 female) met the inclusion criteria.
History of previous concussion and concussion sustained outside of organized sports were the most common reasons for exclusion from the study.

Comparisons by sex are reported in Table 1. Within the sex groups, no significant difference was found in mean age (male, 14.8 years, vs female, 14.5 years; \( P = .3 \)). No statistically significant difference was found in the presence of retrograde amnesia between the sexes. However, a statistically significant difference was found between sexes regarding associated loss of consciousness and anterograde amnesia. Male athletes had a higher incidence of both loss of consciousness and anterograde amnesia compared with female athletes. No statistically significant difference was found in history of learning disability or visual problems between male and female athletes before injury. Female athletes had a significantly greater incidence of preinjury history of migraines/frequent headaches compared with male athletes (13.8% vs 3.6%, respectively; \( P = .005 \)). No significant difference was found in preinjury history of mental illness between male and female athletes (0.9% vs 4.6%, respectively; \( P = .08 \)). Initial median postinjury ImPACT symptom scores were similar between male and female athletes (14 vs 17, respectively; \( P = .589 \)). This similar initial median symptom score suggests that there was no difference in initial concussion severity between the sexes.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Male (n=110)</th>
<th>Female (n=102)</th>
<th>( P ) Value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean (SD) Age, y</td>
<td>14.8 (1.82)</td>
<td>14.5 (1.58)</td>
<td>.3</td>
</tr>
<tr>
<td>Loss of Consciousness, %</td>
<td>16.4</td>
<td>5.5</td>
<td>.016</td>
</tr>
<tr>
<td>Amnesia, %</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Retrograde</td>
<td>11.8</td>
<td>4.6</td>
<td>.071</td>
</tr>
<tr>
<td>Anterograde</td>
<td>20.9</td>
<td>6.4</td>
<td>.003</td>
</tr>
<tr>
<td>Medical History, %</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Migraines/frequent headaches</td>
<td>3.6</td>
<td>13.8</td>
<td>.005</td>
</tr>
<tr>
<td>Visual problems</td>
<td>4.5</td>
<td>4.6</td>
<td>&gt;.99</td>
</tr>
<tr>
<td>Learning disability</td>
<td>18.2</td>
<td>11.9</td>
<td>.275</td>
</tr>
<tr>
<td>Mental illness</td>
<td>0.9</td>
<td>4.6</td>
<td>.08</td>
</tr>
<tr>
<td>Initial ImPACT</td>
<td>14</td>
<td>17</td>
<td>.589</td>
</tr>
<tr>
<td>Symptom Score, Median</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of Days</td>
<td>11</td>
<td>28</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Reporting Symptoms, Median</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* \( P < .05 \) was considered statistically significant.

Abbreviation: ImPACT, Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT Applications, Inc).
As i g n i
cant difference was found between males
and females in duration of symptoms (median, 11 days
vs 28 days, respectively; \( P < .001 \)). Our data revealed
that 82 of 110 male athletes (75%) experienced recov-
ery of concussion symptoms by 3 weeks compared
with 43 of 102 female athletes (42%) (Figure 2).

When comparing middle school and high school ath-
hletes, no statistically signi
fi
cant differences were found
in length of reported symptoms between age groups
(Table 2). When matched for sex, no statistically signi-
cificant differences were found between sports played and
athletes’ resolution of concussion symptoms (Figure 3).

Discussion
Multiple review articles involving sports-related con-
cussion call for more research regarding sex and its
role in the recovery from concussion.\(^4\,5\,11-13\) The
current study seems to be the first to suggest a statisti-
cally significant difference in length of recovery between
male and female athletes in middle school and high
school with first-time, sports-related concussions.

A preponderance of current literature states that 80%
to 90% of sports-related concussion symptoms resolve
in 7 to 10 days.\(^5\,10\) However, many of these studies
involved male collegiate or professional football
players. A 2014 study looking at patients with an
average age of 14.3 years showed concussion symp-
toms to last a median of 13 days.\(^14\) However, this
study did not evaluate data by sex, and its sample was
57.4% male. Kadyan et al\(^15\) found no differences
between sexes in duration or frequency of symptoms;
however, their population differed, consisting of

<table>
<thead>
<tr>
<th>Age, y</th>
<th>n</th>
<th>No. of Days Reporting Symptoms, Median</th>
<th>( P ) Value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11-13</td>
<td>26</td>
<td>10.5</td>
<td>.053</td>
</tr>
<tr>
<td>14-18</td>
<td>84</td>
<td>12.0</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11-13</td>
<td>31</td>
<td>22.0</td>
<td>.167</td>
</tr>
<tr>
<td>14-18</td>
<td>71</td>
<td>30.0</td>
<td></td>
</tr>
</tbody>
</table>

* \( P < .05 \) was considered statistically significant.
patients with traumatic brain injury in an acute rehabilitation setting with a mean age of 35 years, whereas the present study involved patients aged 11 to 18 years. In a retrospective medical record review, Cantu et al\textsuperscript{16} found no differences in recovery from concussion between sexes. The average age of the participants in that study was approximately 19 years. The current study’s findings that male and female athletes reported symptoms for a median of 11 and 28 days, respectively, are in agreement with the most recent consensus statement from the 5th International Conference on Concussion in Sport: “[T]he large majority of injured athletes recover, from a clinical perspective, within the first month of injury.”\textsuperscript{16}

In another retrospective medical record review, Kostyun and Hafeez\textsuperscript{17} showed that adolescent female athletes had a longer recovery course than adolescent male athletes (75.6 [73.0] and 49.7 [62.0] days, respectively [\textit{P}=0.002]) and required more interventions after concussion. The only major difference between their study and the current study was that we focused on first-time concussion, whereas Kostyun and Hafeez\textsuperscript{17} included athletes with a history of multiple concussions. Also, we looked at medians instead of means.
because of the skewing effect of outliers. These differences could explain the longer recovery reported in their sample compared with ours.

To our knowledge, no definitive research has provided an explanation for sex differences in concussion recovery. We think that these differences are complex and multifactorial, including biomechanical and biological differences between the sexes.11,18-20 Biomechanically, females may be at higher risk for concussions because their necks are smaller and do not absorb shock as well as the necks of males. One study of collegiate soccer players found that females had 26% less total mass in their head and neck, and displayed significantly greater head-neck segment peak angular acceleration and displacement.18 Biologically, it has also been suggested that females have a greater basal rate of glucose metabolism.19 Broshek et al20 suggested that as a result of increased demands for glucose after a concussion, female athletes might exhibit prolonged impairments compared with male athletes because females have a greater basal rate of glucose metabolism. The prevalence of other medical conditions, such as migraines and mood disorders, in men and women may also potentially explain differences in concussion recovery.21-23 Migraine is more than twice as common in females than in males, and females experience more frequent, longer-lasting, and more painful attacks.21 In addition, history of migraine has been associated with prolonged concussion recovery.6,22 Our research showed a statistically significant difference in preinjury history of migraine/frequent headaches in females compared with males. However, we found no statistically significant difference between females with a history vs those without a history of migraines/frequent headaches in median time being symptomatic after concussion (26 days vs 28 days, respectively; P= .806). The lack of a significant difference may have been because physicians adjust their management of concussion based on an athlete’s medical history.

After puberty, females experience major depression at roughly twice the rate of males.23 The lifetime prevalence of generalized anxiety disorder is also higher in females than in males (6.6% vs 3.6%, respectively).24 and females may have greater anxiety sensitivity than males.25 A recent consensus statement6 indicates that such psychological factors may increase concussion symptom recovery and contribute to risk of persistent symptoms of concussion.

Mental stress could certainly play a role in concussion recovery, and adolescent girls may have higher levels of stress than boys.28,29 The effects of stress include headache, nausea, fatigue, anxiety, irritability, difficulty sleeping, and difficulty concentrating. These effects are also concussion symptoms and thus could potentially account for a longer recovery in females with concussion.

Children, adolescents, and young adults with a history of headache disorder or mental health problems seem to be at greater risk of having concussion symptoms for more than 1 month.6 We theorize that it is a possibility that some first-time concussions in adolescent athletes with persistent symptoms are due to preexisting medical conditions or psychosocial complications, regardless of sex. In other words, it is possible that the concussion has resolved and the “persistent concussion symptoms” could possibly be better attributed to another medical condition or psychosocial dysfunction. The most recent consensus statement6 on concussion in sport goes on to state that, “Persistently symptomatic’ does not reflect a single pathophysiological entity, but describes a constellation of non-specific posttraumatic symptoms that may be linked to coexisting and/or confounding factors, which do not necessarily reflect ongoing physiological injury to the brain.” Considering medical history is often dependent on the patient self-reporting, it is certainly possible that the current study contained an incomplete dataset with respect to preinjury diagnoses. Psychosocial problems can also be ambiguous and difficult for physicians to assess if not conveyed by patients.

When matched for sex, the current study found no statistically significant difference in length of recovery when comparing sports. The incidence was highest in football players for males and soccer players for females, consistent with preexisting data.1,2
Little concussion research has been performed in children younger than 13 years.6 We found no significant difference in length of recovery between middle school athletes (aged 11-13 years) and high school athletes (aged 14-18 years). Interestingly, although not statistically significant, we found the middle school athletes recovered more quickly than the high school athletes. Lee et al30 found no statistically significant difference in symptom presence after a sports-related concussion when comparing 92 high school athletes with 92 collegiate athletes matched for sex and number of previous concussions. Conversely, a study by Zuckerman et al31 showed that adolescents aged 13 to 16 years took longer to return to their neurocognitive and symptom baselines than adults aged 18 to 22 years.31 The findings of Cantu et al16 suggest that participants aged 18 years or older are more likely to report symptoms that last longer than 90 days than participants younger than 18 years.16 The most recent consensus statement recognizes that pediatric populations in general take more time to recover from a concussion than adults, and they recommend that the diagnosis of “concussion with persistent symptoms” not be used in children until symptoms have been present for longer than 4 weeks.6 Further research needs to be done when it comes to concussion recovery and age, considering the present conflicting data and lack of data on persons younger than 13 years.

Limitations
This study took place at a southern New Jersey sports medicine practice with expertise in sports-related concussion. This type of specialization possibly encourages referral of more difficult concussion cases, biasing the data to longer periods of being symptomatic. However, because of the New Jersey state law passed in 2011, this selection bias is partially mitigated. According to this law, “A student-athlete who is removed from competition or practice shall not participate in further sports activity until he/she is evaluated by a physician or other licensed health care provider trained in the evaluation and management of concussions.”32 The New Jersey law further clarifies that only a physician (osteopathic or allopathic) may clear an individual with a concussion, including one who recovers quickly, to return to play.32

Because of the nature of a retrospective medical record review, the timeline for scheduling initial postinjury concussion evaluations could not be standardized, nor could follow-up appointments. The appointment scheduling variable was not constant and may have altered the true length of recovery.

Another limitation of this study lies within the diagnosis of concussion. That physicians must rely on patients to self-report their symptoms adds a subjective nature to the condition. This subjectivity can interfere with the monitoring and assessment of a patient’s concussion, thereby altering the dataset. This limitation is a concern with most concussion research.

Future concussion research will be helpful in providing health care professionals more knowledge regarding the role of sex and recovery. Prospective studies that allow for more uniformity in follow-up could be helpful. Future research and development on concussion biomarkers and advanced imaging could also help provide more objectivity in true length of concussion recovery.

Conclusion
Current research states that the majority of adolescents with concussions recover within 4 weeks.6 The findings of the current study suggest that with first-time sports-related concussions in middle school and high school athletes, female athletes remain symptomatic longer when compared with male athletes, regardless of the sport played. The reason for this sex difference is complex and probably multifactorial in nature.

Author Contributions
All authors provided substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data; all authors drafted the article or revised it critically for important intellectual content; all authors gave final approval of the version of the article to be published; and all authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.
References


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