Concussion Among Female Middle-School Soccer Players

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**IMPORTANCE** Despite recent increased awareness about sports concussions, little research has evaluated concussions among middle-school athletes.

**OBJECTIVES** To evaluate the frequency and duration of concussions in female youth soccer players and to determine if concussions result in stopping play and seeking medical care.

**DESIGN, SETTING, AND PARTICIPANTS** Prospective cohort study from March 2008 through May 2012 among 4 soccer clubs from the Puget Sound region of Washington State, involving 351 elite female soccer players, aged 11 to 14 years, from 33 randomly selected youth soccer teams. Of the players contacted, 83.1% participated and 92.4% completed the study.

**MAIN OUTCOMES AND MEASURES** Concussion cumulative incidence, incidence rate, and description of the number, type, and duration of symptoms. We inquired weekly about concussion symptoms and, if present, the symptom type and duration, the event resulting in symptom onset, and whether the player sought medical attention or played while symptomatic.

**RESULTS** Among the 351 soccer players, there were 59 concussions with 43 742 athletic exposure hours. Cumulative concussion incidence was 13.0% per season, and the incidence rate was 1.2 per 1000 athletic exposure hours (95% CI, 0.9-1.6). Symptoms lasted a median of 4.0 days (mean, 9.4 days). Heading the ball accounted for 30.5% of concussions. Players with the following symptoms had a longer recovery time than players without these symptoms: light sensitivity (16.0 vs 3.0 days, \( P = .001 \)), emotional lability (15.0 vs 3.5 days, \( P = .002 \)), noise sensitivity (12.0 vs 3.0 days, \( P = .004 \)), memory loss (9.0 vs 4.0 days, \( P = .04 \)), nausea (9.0 vs 3.0 days, \( P = .02 \)), and concentration problems (7.0 vs 2.0 days, \( P = .02 \)). Most players (58.6%) continued to play with symptoms, with almost half (44.1%) seeking medical attention.

**CONCLUSIONS AND RELEVANCE** Concussion rates in young female soccer players are greater than those reported in older age groups, and most of those concussed report playing with symptoms. Heading the ball is a frequent precipitating event. Awareness of recommendations to not play and seek medical attention is lacking for this age group.
Sports-related concussions account for 1.6 to 3.8 million injuries in the United States annually,\(^1\) with approximately 50,000 soccer-related concussions occurring annually among high school (HS) players.\(^2\) US Youth Soccer reports 3 million players registered between ages 5 and 15 years, 48% of whom are female.\(^3\) While HS athletes are represented in the concussion literature,\(^2,4-7\) youth players traditionally lack injury tracking systems and are largely unstudied, which is concerning since younger age and female sex are risk factors for sports-related concussion.\(^8,9\)

Symptom checklists are a primary tool used to diagnose concussion.\(^10-15\) Randolph et al,\(^11\)(p220) reviewing concussion symptom scales, concluded that “self-report subjective symptom checklists . . . have repeatedly been demonstrated to be sensitive to the effects of concussion” and are “the primary decision-making factor in the most commonly used guidelines for return to play.” Expert consensus states that athletes with concussion symptoms should stop play and be medically evaluated.\(^16\) Furthermore, concussed athletes should not return to play until asymptomatic and cleared by medical personnel.\(^16\) The purpose of our study was to describe the incidence rate, frequency, and duration of concussion symptoms in female youth soccer players and determine if these symptoms resulted in stopping play and seeking medical care.

Methods

We performed a prospective cohort study, enrolling 351 female youth soccer players aged 11 to 14 years (U13-U15 [under 13 years of age to under 15 years of age]). We randomly selected (using standard-sized paper drawn from a container) 36 of 72 elite (select and premier) teams from 4 youth soccer clubs in the Puget Sound region of Washington State. Of the 36 teams we contacted, 33 (91.7%) agreed to participate, and we recruited 83.1% (351 of 422) of their players. The top 2 teams in each age group are designated premier, and the next-level teams are classified as select. We enrolled 8 teams each during 3 seasons (2008-2009, 2009-2010, and 2010-2011) and 9 teams during the 2011-2012 season, observing each team for at least 1 yearlong season. We evaluated 6 teams for 2 seasons. We had complete follow-up on 92.4% of players. Preseason, all participants (including those observed previously) provided age, race, length of soccer career, and previous history of soccer-related concussions, defined as a hit to the head resulting in symptoms (listed in the next paragraph) regardless of subsequent medical evaluation. All participants provided assent and their parents provided informed consent. This study was approved by the University of Washington Institutional Review Board.

We implemented a validated injury surveillance system,\(^17\) sending a weekly e-mail to each player’s parent with a link to an Internet-based survey to report if his or her daughter experienced a hit to the head resulting in symptoms consistent with the diagnosis of concussion. Concussion symptoms identified by the 3rd International Conference on Concussion in Sport\(^46\) were memory loss, difficulty concentrating, confusion or disorientation, dizziness, drowsiness, headache, more emotional than usual, irritability, losing consciousness, nausea, ringing in the ears, sensitivity to light or blurry vision, and sensitivity to noise. The e-mail system sent an automated reminder after 2 days of nonresponse, and study staff telephoned all e-mail nonresponders.

Players reporting concussion symptoms were telephoned by trained study personnel using a standardized, written interview form within 1 week of the injury. Concussion was defined as a blow to the head that resulted in symptoms, regardless of loss of playing time, and the interviewers confirmed the temporal association between the injury and subsequent concussion symptoms. The player was asked from a list of soccer-specific activities what caused the injury and if she continued to play with symptoms, was evaluated by a qualified health care professional (QHP), had a concussion diagnosis given by a QHP if evaluated, and reasons for limiting her return to play. A QHP was defined as a physician, nurse practitioner, physician assistant, or certified athletic trainer because they were identified in the Washington State concussion law as authorized to evaluate and clear concussed athletes to return to play. Weekly interviews assessing the length of symptoms and length of each individual symptom occurred through recovery. Recovery was defined as complete resolution of symptoms and return to full participation in soccer. At the final interview, we obtained the date of return to play without symptoms. Our sports medicine physician (J.W.O.) reviewed interviews weekly, confirming the temporal association between head injury and symptoms and that the symptoms were sufficient and consistent with the diagnosis of concussion. In a few instances, a symptom report of specifically headache only that resolved quickly or was not clearly associated with an appropriate mechanism of injury was not classified as a concussion.

The weekly Internet survey collected the number of athletic exposure hours (AEH) in practice and the number of practices per week. Trained parent volunteers collected the number of game minutes for each player using a game timing sheet. We received timing data for 96.6% of games.

Since some soccer players were enrolled for 2 successive seasons, we compared baseline demographic and soccer characteristics by player-seasons among those with and without a concussion. A player-season is defined as 1 player’s soccer participation for 1 season. Among concussed players, we assessed number of concussions; length of symptoms (days) using the mean, median, and categories of less than 1 day, 1 to 7 days, 8 to 14 days, 15 to 21 days, and more than 21 days; frequency of each symptom; event classification (practice or game); object contacted (person, playing surface, or ball); activity during injury; and if a foul was called. We used the Wilcoxon rank sum test to compare the median number of days that concussion symptoms lasted among those with and without each specific symptom. We used the 2-sample t test to compare the mean number of symptoms among those with symptoms lasting more than 1 week with those who had symptoms lasting 1 week or less.

We calculated the proportion of players who played with symptoms, were assessed before their initial injury interview, and were ever evaluated by a QHP. Among those evalu-
ated by a QHP, we calculated the proportion receiving a concussion diagnosis. We calculated the difference in the likelihood of playing with symptoms and median concussion duration between those examined by a QHP and those not evaluated using Wilcoxon rank sum and χ² testing, respectively. We calculated cumulative incidence for concussion symptoms as the number of players with incident symptoms for the season divided by the number of player-seasons. We estimated the incident concussion rate using the number of incident concussions divided by the number of AEH. We also calculated an all-concussion symptom rate (incident and repeat events combined) and compared rates by game vs practice; age groups U13, U14, and U15; and select vs premier level using Poisson regression, reporting the relative risks and 95% CIs. Analyses were carried out with use of Stata (StataCorp LP) and R (R Foundation for Statistical Computing). All tests were 2-sided with an α level of 0.05.

Results

Of the 36 eligible teams, 33 (91.7%) participated, and we recruited 83.1% (351 of 422) of their players. We observed 288 players (82.0%) for 1 season and 63 (18.0%) for 2 seasons, resulting in 414 player-seasons and 43 742 AEH. Most played at the premier level, had played for soccer for 6 to 7 years, and participated in other sports besides soccer. Concussed players were more likely to be black or mixed race compared with nonconcussed players (Table 1), although these differences were not statistically significant (P = .05). A nonsignificant consider-
Most (58.6%) reported playing soccer while symptomatic (Table 4). Before the first interview, a coach assessed 8.5% and a QHP evaluated 33.9% of those diagnosed with a concussion by study personnel from their history. More than half (55.9%) of the players reporting concussion symptoms were never evaluated by a QHP. Among the 44.1% who were examined by a QHP, 76.9% were diagnosed with a concussion. Players evaluated by a QHP were symptomatic significantly longer (median, 11.5 vs 2.0 days; \( P < .001 \)) and were less likely to play with symptoms (42.3% vs 71.9%; \( P = .03 \)) compared with those not evaluated. Players who did not play cited concern for making symptoms worse (39.0%) and advice from a health care provider (28.8%), parent (35.6%), or coach (28.8%).

Cumulative incidence of concussions was 13.0% per season. The rate of incident and all concussions was 1.2 per 1000 AEH (95% CI, 0.9-1.6) and 1.3 per 1000 AEH (95% CI, 1.0-1.7), respectively (Table 5). The rate of concussions diagnosed by a QHP was 0.4 (95% CI, 0.2-0.7). The concussion incidence in games was 22.9-fold (95% CI, 10.7-55.8) greater than that in practices. The U15 players had the highest rate (1.6 per 1000 AEH; 95% CI, 0.9-2.5) and the U14 players the lowest (1.2 per 1000 AEH; 95% CI, 0.7-1.9), although these differences were not statistically significant. Rates did not differ significantly by level of play.

### Discussion

Concussions are common in female youth soccer players, with a significantly higher incidence in games. Player contact accounts for 54.3% of concussions, and 30.5% occur from heading the ball. Median concussion length was 4.0 days (mean, 9.4 days), with symptom type and number of symptoms associated with time to full recovery. Most players participated with symptoms, and less than half sought medical attention.

Our rate of 1.3 concussions per 1000 AEH is greater than those previously reported. Earlier studies of girls’ soccer\(^{12,18} \) noted rates of 0.23 to 0.85 per 1000 athletic exposure at the HS level and 0.35 to 0.85 per 1000 athletic exposure\(^{2,19} \) at the college level. To our knowledge, no youth soccer concussion rates are reported in the literature for comparison. The high concussion rate in this population could be explained by differences in method (prospective data collection with weekly interviews in this study) and underreporting of concussions in previous studies\(^{10,13,14,20,21} \) that captured concussions only in athletes seeking medical attention. Other studies in HS and college athletes have found that one-third to one-half of players report previous concussion symptoms for which they did not seek medical attention largely because they did not appreciate the significance of injury or feared being withheld from play.\(^{10,13,14} \) In our study, only 44.1% of athletes identified through our weekly interviews sought QHP evaluation for their concussion symptoms, and the concussion rate considering only those diagnosed by a QHP was 0.4 per 1000 AEH. We suspect that underreporting in previous studies explains the lower rates observed.

Soccer is unique among sports in that the players use their heads to intentionally strike the ball. In our study, players cited contact with another person in 54.3% and heading the ball in 30.5% of the concussions. Studies of HS athletes report that head-to-head collisions occurring while heading often result in concussion.\(^{2,22} \) In the collegiate and professional literature, debate exists over concussion risk from heading alone vs contact with another player or object during heading. Several studies\(^{23,24} \) found that purposeful heading did not result in neurocognitive deficits, including among 13- to 18-year-old players. Barnes et al\(^{25} \) reported that more than half of the elite
women players experienced headaches after heading, some lasting up to 25 days, and 2 reported amnesia. Male professional players with greater heading exposure had poorer performance on neuropsychologic testing compared with those with less heading exposure.26 Jordan et al27 found no evidence of long-term brain injury from heading in US male national team players, and Schmitt et al28 studied college players after bouts of heading and discovered no change in postural control but increases in reported concussion symptoms following heading that resolved in less than 24 hours. A recent study of college players using a more sensitive balance measurement tool found deficits in postural control from 24 to 48 hours following bouts of heading.29 Less neck strength, less mature brains, and poor heading technique may contribute to the relatively high percentage of concussions from heading in our younger players, although no studies have evaluated these hypothesized explanations.25,30

Our finding that games were 23-fold riskier than practices for concussion is consistent with studies noting an 11.5- to 13.7-fold increased risk during games in older age groups.4,6 This increased risk may be due to more aggressive play in games or more attempts to use the head in games when the stakes are higher.

The mean length of concussion was 9.4 days with symptom resolution by 3 weeks in 91.6% of the players, consistent with previous studies of HS players. Mararet al6 found that 50% of players returned at 7 to 9 days and 80% by 3 weeks. Meehan et al7 reported that 27% of HS athletes had resolution of symptoms by 1 day and 15% had symptoms lasting longer than 1 week. The type and prevalence of symptoms reported by our athletes was also similar to those in HS athletes.4,7 Symptoms associated with longer recovery are similar to those reported by HS athletes, including light and noise sensitivity, dizziness, nausea, concentration problems, amnesia, and confusion.31-33

Panels of experts have recommended that concussed athletes discontinue participation and be evaluated by a QHP before returning to play.26-34 Despite this, 58.6% of our players reported playing with concussion symptoms, with less than half (44.1%) evaluated by a QHP. A previous study of concussed HS athletes35 found that 15% returned to play prematurely. A focus group study36 found that although HS football and soccer players understood the symptoms and potentially severe complications from playing with a concussion, most would continue to play despite symptoms. Some evidence suggests that concussion education can be helpful. Bramley et al36 found that HS athletes receiving concussion education were more likely to report symptoms to coaches compared with those with no education (72% vs 36%), although 28% with education did not report symptoms.

Our study had several limitations. It is unclear how many of our participants reporting concussion symptoms might have received a different diagnosis if formally evaluated. Symptom misclassification using an in-depth telephone interview may have occurred (identifying a headache that was unrelated to soccer), but we minimized this by using a standardized definition of concussion and having an experienced sports medicine physician review all reports. A 2009 review15 of studies using concussion symptom scales found that for athletes aged 13 to 22 years, 24 of 25 studies demonstrated high validity in discriminating concussed vs nonconcussed groups. Conversely, the number and rates of concussion may have been underreported because our Internet surveillance system required parents to be aware of their daughters’ symptoms to be able to report them. Our previous study17 demonstrated that our Internet-based injury surveillance system was equivalent to a certified athletic trainer reporting system, although the system was primarily designed to track musculoskeletal injuries. It is also possible that our assessment of recovery may be premature in some cases. For example, concussion symptoms may have resolved while an objective assessment of balance may have revealed persisting deficits.
Table 5. Comparison of Rates of Incident and All Concussions Among Female Soccer Players Aged 11 to 14 Years, Puget Sound Region, 2008 Through 2012

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>No.</th>
<th>AEH</th>
<th>Rate/1000 AEH (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incident</td>
<td>51</td>
<td>42 702</td>
<td>1.2 (0.9-1.6)</td>
</tr>
<tr>
<td>All, incident and repeat</td>
<td>59</td>
<td>43 742</td>
<td>1.3 (1.0-1.7)</td>
</tr>
<tr>
<td>Concussion diagnosed by qualified health professional</td>
<td>20</td>
<td>43 742</td>
<td>0.4 (0.2-0.7)</td>
</tr>
<tr>
<td>Event</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Practice</td>
<td>8</td>
<td>34 215</td>
<td>0.2 (0.1-0.5)</td>
</tr>
<tr>
<td>Game</td>
<td>51</td>
<td>9527</td>
<td>5.3 (4.0-7.0)</td>
</tr>
<tr>
<td>Age group, y*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>U13 (11-12)</td>
<td>23</td>
<td>17 307</td>
<td>1.3 (0.8-2.0)</td>
</tr>
<tr>
<td>U14 (13)</td>
<td>19</td>
<td>15 610</td>
<td>1.2 (0.7-1.9)</td>
</tr>
<tr>
<td>U15 (14)</td>
<td>17</td>
<td>10 825</td>
<td>1.6 (0.9-2.5)</td>
</tr>
<tr>
<td>Level of play</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Select</td>
<td>20</td>
<td>17 859</td>
<td>1.1 (0.7-1.7)</td>
</tr>
<tr>
<td>Premier</td>
<td>39</td>
<td>25 883</td>
<td>1.5 (1.1-2.1)</td>
</tr>
</tbody>
</table>

Abbreviation: AEH, athletic exposure hours.

* U13 through U15 indicates under 13 years of age to under 15 years of age.

Conclusions

Concussions are common in pre–high school female soccer players, with a concussion rate higher than that reported among older athletes. Head ing the ball is associated with symptom onset, and the presence of specific symptoms predicts a longer recovery. Most of those with symptoms report playing before symptom resolution, with less than half seeking evaluation from a QHP. Future studies are needed to develop education strategies to ensure players understand and report concussion symptoms and that parents and coaches ensure appropriate medical evaluation and clearance before returning to play. Future studies should also compare short- and long-term outcomes for those who seek medical care and return to play according to recommended guidelines vs those who do not seek medical care and/or return to play prematurely.

REFERENCES