Sex-Based Differences as a Predictor of Recovery Trajectories Using ImPACT

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This is an abbreviated version of an article that is currently in press in the *American Journal of Sports Medicine*.

**Purpose of Study**
To date, there have been relatively few studies that have described clear sex-based differences in symptom resolution following sports-related concussion (SRC). Furthermore, it is unclear whether sex-based differences exist on baseline assessments. The majority of studies have indicated that female athletes experience poorer neurocognitive performance, increased post-concussive symptoms, and protracted recovery following a concussion, when compared to male athletes. Other concussion studies, however, have revealed no significant sex-based differences in baseline assessment and SRC recovery of symptoms.
The purpose of the current study was to assess whether female athletes displayed more symptoms at baseline and prolonged recovery following a SRC, compared to male athletes.

**Methodology and Results**

The current study assessed 135 male and 41 female athletes (10–18 years in age) who participated in high impact sports in metro Atlanta middle- and high-schools. All athletes completed baseline assessment and at least one post-concussion assessment from the Immediate Post-Concussive Assessment and Cognitive Testing (ImPACT) battery. Longitudinal hierarchical linear modeling was employed to examine individual-level variables and their associations with adolescents’ rates of recovery in concussive symptoms, after controlling for age and number of prior concussions. Aggregate symptoms were rated as higher in female athletes compared to male athletes at baseline and immediately following a concussion (p<.01). There were no group differences in slope of recovery between male and female athletes, indicating generally similar trajectories of change for both groups. Post-hoc analyses revealed higher levels of migraine and neuropsychological symptoms in females at baseline.

**Conclusion and Implications of Study**

Results from our study revealed that male and female adolescent athletes recover (e.g., when symptoms return to baseline levels) at the same rate and exhibit the generally similar recovery patterns. However, results indicated that female athletes experience higher rates of symptoms at baseline and throughout return to baseline (i.e., recovery), particularly for somatic and emotional symptoms (e.g., migraine and neuropsychology clusters). The latter finding is consistent with results from previous research, which has demonstrated elevated symptom severity and poorer cognitive performance at baseline in female athletes when compared to male athletes. While several researchers examining SRC recovery have found that increased symptomatology, including cognitive, physical, and emotional problems is related to protracted recovery, the current study is the first to suggest that recovery difference between the sexes is better explained by concussion symptomatology rather than recovery rate or pattern.

These findings emphasize the importance of acquiring baseline scores for adolescent athletes, as sex-based differences at baseline appear to impact their overall recovery pattern. Furthermore, results highlight the importance of sex-normed comparison data for future directions of ImPACT. Future research will require researchers to focus on the factors that best explain variation and influence on neurocognitive computerized testing. For example, baseline levels of headache frequency and the influence of sleep on performance are both active areas of consideration for the clinician working with adult athletes but more importantly the pediatric population as well. As sports become more structured and intense at younger age levels, it will be important to address the developmental considerations that have an effect on test performance.

**Commentary** by Mark Lovell, Ph.D., FACP

This is a timely and interesting study that examines potential differences in symptoms pre and post-concussion in males and females. The authors examine both baseline and post-concussion self-report of symptoms on the ImPACT Symptom Inventory and employed a sophisticated statistical approach to examining sex differences. They found a higher rate of symptom reporting in female athletes compared to males both at baseline and following concussion but no significant differences between...
groups with regard to change in symptom reporting from baseline to post-concussion. Of particular interest was the finding of a higher base rate of migraine-type symptoms in female athletes. This is consistent with the higher known incidence of migraines in the female (18 percent) population compared to 6 percent in males (Weitzel et al, 2001). The authors correctly emphasize the importance of baseline testing in younger athletes to optimize accurate assessment of any changes that occur post-injury.

References from Article


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