

A Heads Up On Concussions: Are There Sex-Related Differences?

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Overview

•A **concussion** is “a complex pathophysiological process affecting the brain, induced by biomechanical forces.” A concussion can be caused by a direct blow to the head or neck that results in a rapid onset of symptoms.¹

•Title IX legislation, passed in 1972, has afforded females the equal opportunity to compete in athletics at all levels of play. Female participation in sport at the high school and collegiate level has skyrocketed as a result.

•Concussions are becoming a common injury at all types and levels of athletic competition. Incidence has increased from 300,000 reported concussions per year in 1998, to 1.6-3.8 million concussions per year in 2006. Incidence continues to rise in specific sports.²⁻⁴

•Previous research suggests a sex-related difference. Several studies have indicated that in sports like soccer and basketball, females have a higher incidence of concussions than males.⁵⁻⁸ Female athletes may also sustain more severe concussions with greater cognitive deficits and a longer recovery period.⁹⁻¹¹

Methods

•This present study is a review of all current literature pertaining to sex-related differences of concussion.

•Search terms included combinations of “concussion and sex”, “concussion and gender”, “incidence”, “symptoms”, “recovery”, and “neurologic deficit”.

•The literature search was performed using PubMed and included articles from 1993 to present. The majority of articles used were published in the last 15 years.

•Articles pertaining to sex-related differences of incidence, number of symptoms, symptom constellation, neurologic deficit, and recovery rates were used in this review.

Results

•Several articles compared the incidence, severity of neurological deficit, constellation of symptoms, and length of recovery post-concussion in males and females. (Table 1)

Primary Author	Year of Publication	Study design	Patients studied	Evaluation tools	Findings
Biomechanical Differences of Head/Neck Mechanics					
Tierney et al.	2008	Cross-sectional design	15 male, 29 female college soccer players	Anthropometrics, isometric strength, linear head acceleration, superficial neck muscle electromyography	Female soccer players experienced greater head impact acceleration
Mansell et al.	2005	Pretest and posttest control group	17 male, 19 female collegiate soccer players	Head-neck kinematics and stiffness, EMG, isometric strength	Females had less head-neck segment length and mass than males
Tierney et al.	2005	Three-factor research design with repeated measures	20 males, 20 females	EMG, isometric strength, anthropometrics, kinematics, stiffness	Females had increased head-neck angular acceleration and earlier neck muscle activation. Also less head-neck mass, girth, isometric strength, stiffness than males.
Role of Hormonal Influence					
Wunderle et al.	2014	Nested cohort study	144 females aged 16-60	Rivermead post concussion questionnaire and EQ5D	Menstrual cycle phase and progesterone concentration affect quality of life and neurologic outcomes after a mTBI
Reporting Bias					
Kerr et al.	2015	Cross sectional	797 former collegiate athletes	Online questionnaire- concussion history	Concussion nondisclosure was more prevalent in males than females.
Granito et al.	2002	Retrospective; interviews	31 intercollegiate athletes	Interviews related to injury	Male athletes may feel additional peer pressure to not report symptoms of injury
Concussion Prevalence					
Marar et al.	2012	Descriptive epidemiologic	1,936 high school athletes	Reported concussions	Females sustained twice as many concussions than males in soccer, females sustained 30% more concussions in volleyball
Lincoln et al.	2011	Descriptive epidemiologic	158,430 high school athletes	Electronic medical record keeping	Females had double the risk of concussions than male athletes
Gessel et al.	2007	Descriptive epidemiologic study	100 high schools, 180 colleges	Reported concussions, electronic medical record keeping	In high school sports played by both sexes, females sustained a higher rate of concussions
Schulz et al.	2004	Prospective cohort	15,802 athletes	Customized medical record and participation forms	No differences between sexes; risk of concussion was mixed and sport-dependent
Covassin et al.	2003	Cohort study	882 collegiate athletes reporting a concussion	NCAA Injury Surveillance System	Female basketball players had an increased risk for concussion. Females sustained a higher percentage of concussions than male athletes in games
Barnes et al.	1998	Retrospective; interviews	137 elite soccer players	Interview related to concussion	No differences between sexes; female athletes had a lower odds ratio of concussion than male athletes
Boden et al.	1998	Prospective	701 collegiate soccer players	Reported concussions	Males sustained more concussions than females over a 2 year period
Number and Severity of Symptoms					
Baker et al.	2015	Retrospective	147 high school athletes	SCAT2, ANAM or ImPACT, Buffalo Concussion Treadmill Test	Females reported more symptoms initially and took longer to be asymptomatic compared to males
Dougan et al.	2014	Meta-analysis	91 studies	----	Females demonstrated greater post-concussion deficits
Frommer et al.	2011	Descriptive epidemiologic	100 high schools	Electronic medical record keeping	Females experienced different symptoms than males, but RTP and time to symptom resolution was the same
Preiss-Farzanegan et al.	2009	Prospective nested cohort	215 patients with sport-related mTBI	Rivermead post concussion symptom questionnaire	Adult females experienced greater neurologic deficits and post-concussion symptoms
Covassin et al.	2007	Prospective dependent-sample cohort	79 collegiate athletes	ImPACT	No sex-related difference in number of symptoms reported. Females reported a different constellation of symptoms than males
Broshek et al.	2005	Prospective cohort	155 high school and collegiate athletes	Concussion resolution index (CRI)	Females experienced worse reaction times, increased symptoms and had increased cognitive impairment post-concussion compared to males
Kraus et al.	2000	Prospective cohort	795 patients with moderate to severe TBI	Glasgow outcome scale	Females had higher mortality and poor outcomes in moderate and severe TBI than males
Neurocognitive testing					
Zuckerman et al.	2012	Prospective cohort	80 soccer players	ImPACT	No sex-related differences in any facet of ImPACT testing
Covassin et al.	2010	Retrospective	188 NCAA athletes	ImPACT	Females with a history of 2-3 concussions performed better in visual memory, motor processing speed, and reaction time compared to males with a history of 2-3 concussion
Colvin et al.	2009	Cohort study (prognosis)	234 soccer players	ImPACT	Females exhibit worse reaction times, memory, and report more symptoms compared to males post-concussion
Covassin et al.	2006	Prospective cohort	1209 collegiate athletes	ImPACT	Females reported more concussion symptoms, but there was no sex-related difference in reaction time, verbal memory, or processing speed
Weiss et al.	2003	Prospective cohort	97 college students	Mental rotation tasks in fMRI	Females scored higher on verbal memory tasks while males scored higher on visual-spatial tasks

Table 1. A summary of all articles addressing a sex-related difference in sports-related concussion. Appendix: electromyography (EMG), mild traumatic brain injury (mTBI), National Collegiate Athletic Association (NCAA), sport concussion assessment tool 2 (SCAT2), automated neuropsychological assessment metrics (ANAM), immediate post-concussion assessment and cognitive testing (imPACT), traumatic brain injury (TBI), fMRI (functional magnetic resonance imaging).

Areas of Interest

Biomechanical Differences

•Women have less head and neck mass, resulting in greater reactive forces and more acceleration during head trauma.^{12,13}

Hormonal Differences

•A recent study found that females with TBI and high levels of progesterone in the luteal phase of the menstrual cycle had worse outcomes and a longer recovery.¹⁴

Conclusions

•Current literature is suggestive of a sex-related difference, but there is conflicting data.

•The disparity could be attributed to: Different populations studied (i.e. different sport type and level of competition)

Reporting bias (retrospective studies)

Male athletes may be more likely not to report a concussion

•Currently, there is not enough data to support a hallmark difference between a female concussion and a male concussion. Research is suggestive of a difference, but more research needs to be done to confirm a difference.

Future Directions

•Future research should be directed at a large collaborative study that minimizes the disparity of populations studied, bias, and evaluation tools.

•The development of sideline testing to assess concussion immediately should be continued, the Balance Error Scoring System (BESS) and King-Devick tests have both shown promising potential for a sideline assessment tool. Research should also be conducted on any sex-related differences in sideline assessment tools.^{15,16}

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