

[Physical Therapy]



Sex Differences in Time to Return-to-Play Progression After Sport-Related Concussion

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Background: Recently, female sports participation has increased, and there is a tendency for women to experience more symptoms and variable presentation after sport-related concussion (SRC). The purpose of this study was to determine whether sex differences exist in time to begin a return-to-play (RTP) progression after an initial SRC.

Hypothesis: After initial SRC, female athletes (11-20 years old) would take longer to begin an RTP progression compared with age-matched male athletes.

Study Design: Retrospective cohort study.

Level of Evidence: Level 3.

Methods: A total of 579 participants (365 males [mean age, 15.0 ± 1.7 years], 214 females [mean age, 15.2 ± 1.5 years]), including middle school, high school, and collegiate athletes who participated in various sports and experienced an initial SRC were included and underwent retrospective chart review. The following information was collected: sex, age at injury, sport, history of prior concussion, date of injury, and date of initiation of RTP progression. Participants with a history of more than 1 concussion or injury sustained from non-sport-related activity were excluded.

Results: Despite American football having the greatest percentage (49.2%) of sport participation, female athletes took significantly longer to start an RTP progression after an initial SRC (29.1 ± 26.3 days) compared with age-matched male athletes (22.7 ± 18.3 days; $P = 0.002$).

Conclusion: On average, female athletes took approximately 6 days longer to begin an RTP progression compared with age-matched male athletes. This suggests that sex differences exist between athletes, aged 11 to 20 years, with regard to initiation of an RTP progression after SRC.

Clinical Relevance: Female athletes may take longer to recover after an SRC, and therefore, may take longer to return to sport. Sex should be considered as part of the clinical decision-making process when determining plan of care for this population.

Keywords: concussion; sex; return-to-play progression

In the past 10 years, sports-related concussions (SRCs) have been placed at the forefront of the media, sports, and health care due to increased incidence with greater sports participation as well as improved methods of detection. According to the Centers for Disease Control and Prevention,⁷ the number of reported concussions has doubled to 3.8 million

from 2002 to 2012. Over a 16-year period, participation in National Collegiate Athletic Association championship sports has increased by 80% for women and 20% for men.¹⁶ For female athletes, the majority of concussions have been found to occur in basketball,²³ volleyball,^{5,23} softball,²³ field hockey,^{5,23} cheerleading,⁵ gymnastics,⁵ lacrosse,²⁴ and soccer.^{23,24}

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Table 1. Descriptive data

	Male	Female	P Value
N	365	214	—
Age, y, mean \pm SD	15.0 \pm 1.7	15.2 \pm 1.5	0.101

The majority of SRCs resolve in a 7- to 10-day period,^{10,14,19,21,23} but athletes who are younger,²¹ have a history of repeated concussions,²¹ and present with retrograde amnesia,^{1,19,21} loss of consciousness,^{1,21} headache, and difficulty concentrating lasting longer than 3 hours¹ are more likely to have a protracted recovery period. Although the evidence is inconclusive, additional factors may contribute to protracted recovery, including sex.

Currently, research is limited with regard to sex differences in recovery post-SRC. With regard to SRCs, when comparing sex-matched sports, women have greater incidence rates^{12,15,16,18,20,23} and risks^{18,24} compared with men. After traumatic brain injury (TBI), women have poorer outcomes, including increased incidence of somatic symptoms and greater mortality rates.^{13,17} Many studies suggest that women present with a greater number of total postconcussive symptoms,^{3,5,8,9,10,24,25} specifically neurobehavioral and somatic symptoms.¹⁴ In addition, after SRC, women have increased reaction times⁸ and difficulty with visual memory tasks^{9-11,17} on ImPACT testing compared with men.

The purpose of this study was to determine whether sex differences exist in the time to begin a return-to-play (RTP) progression after an initial SRC. The hypothesis is that after SRC, female athletes (11-20 years of age) will take longer to begin an RTP progression compared with age-matched male athletes.

METHODS

Participants

The institutional review board of Texas Health Resources approved the research procedures. This was a retrospective study that included 579 middle school, high school, and collegiate athletes (365 males, 214 females) who participated in various sports and experienced an initial SRC. The mean age for the male group was 15.0 \pm 1.7 years and that for the female group was 15.2 \pm 1.5 years ($P = 0.101$). Table 1 summarizes the complete demographic characteristics. Participants were identified during regularly scheduled visits to the participating fellowship-trained, board-certified primary care sports medicine physician (D.B.). Inclusion criteria for study participation included the following: (1) the athlete was between 11 and 20 years of age, (2) the athlete experienced a primary concussion during a sport-related injury (defined by ICD-9/ICD-10 codes 310.2, 784.0, 307.81, 847.0, 386.50, 850.0, 850.1, 850.2, and 850.3), and (3) the athlete was treated during the time frame of August 2012 through December 2014. Exclusion criteria

included the following: (1) athlete was not between the ages of 11 and 20 years, (2) the athlete was not diagnosed with a concussion caused by a sports-related injury, (3) the athlete had a history of prior concussion, and (4) the athlete was not treated between August 2012 and December 2014. Participants were cleared for initiation of RTP progression by a fellowship-trained, board-certified primary care sports medicine physician, at which point participants were no longer required to follow up. If, after a patient was enrolled in the study, it was discovered that they did not meet the aforementioned criteria, the patient was removed from data collection.

Testing

For all study participants, the following information was collected from patient charts once they were determined to have met the inclusion and exclusion criteria: sex, age at injury, sport, history of prior concussion, date of injury, and date of initiation of RTP progression. Data collected during chart review were taken as part of standard of care during initial and follow-up visits with the participating physician.

Statistical Analysis

A priori statistical analysis was performed using time in days to initiate an RTP progression as the primary outcome and determined that a total of 200 patients per group (males and females) would be needed to detect statistical significance based on an 80% power calculation. An independent-samples *t* test was used to determine significant differences between groups for mean days to initiate an RTP progression after a concussion. Additionally, a separate independent-samples *t* test was performed to determine any potential differences between groups when football was removed from the sample and to provide details of demographics of the participants. Statistical significance was set at $P < 0.05$.

RESULTS

There was no statistically significant difference for subject age between male and female athletes (Table 1; $P = 0.101$). Data for number of days from time of injury to start of RTP progression and sport participation are included in Figure 1 and Table 2, respectively. Despite American football having the greatest percentage (49.2%) of sport participation, female athletes took significantly longer to start an RTP progression after an initial SRC (29.1 \pm 26.3 days) compared with age-matched male athletes (22.7 \pm 18.3 days; $P = 0.002$).

In a separate subanalysis, when football players were removed from the data, female athletes (29.1 \pm 26.3 days) continued to take significantly longer to begin an RTP progression than male athletes (18.6 \pm 44.7 days; $P = 0.040$).

DISCUSSION

This study demonstrates that women take significantly longer to begin an RTP progression after SRC compared with age-matched men. However, in a study involving 100 high schools

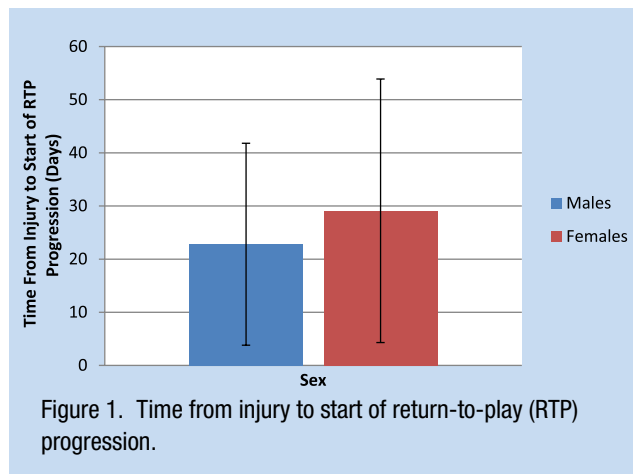


Figure 1. Time from injury to start of return-to-play (RTP) progression.

and 812 concussions across 9 sports, symptoms varied between sexes but there was no difference in time of symptom resolution or RTP.¹⁴ Additionally, no sex differences were found in number or time to recovery of SRC symptoms in a study of 215 concussions.⁶ Several recent studies report that female athletes tend to have increased severity and number of symptoms, as well as varying symptom presentation,^{3,5,8,9,10,24,25} more neurobehavioral and somatic symptoms,¹⁴ increased reaction times,⁸ and difficulty with visual memory tasks on ImPACT testing^{9-11,26} compared with males after SRC. Individuals with increased severity and symptoms may require a longer time to return to baseline after SRC. With regard to time to RTP, a study of 100 SRCs found no differences between males and females.¹ In a study of 170 SRCs, male basketball players took longer to RTP compared with female basketball players, while female hockey players took longer to RTP than male hockey players.⁴ In the current study, a subanalysis without American football players (49.2%) showed that female athletes still took significantly longer to RTP after SRC ($P < 0.05$).

More recent literature supports the current study's results that sex differences may exist in recovery time after SRC.^{2,25} In a meta-analysis of TBI, women fared worse than men on 17 of 20 outcome variables, such as mortality, length of hospitalization, presence of somatic and psychiatric symptoms, and overall injury severity.¹³ In moderate to severe TBI specifically, women were 1.57 times more likely to experience poorer outcomes and have a 1.75 times higher mortality rate compared with men.¹⁷ In 16,000 pediatric patients, no significant differences were found for hospital mortality, intensive care unit length of stay, total length of stay, discharge to home versus rehabilitation, and functional status at discharge.²²

There are limitations to this research. First, it is retrospective and dependent on accurate record keeping. Furthermore, confounding variables such as prolonged recovery, learning disabilities, anatomical differences, and regional differences in sport participation could affect the results.

Table 2. Sports participation of subjects

Sport	Total Sport Participation, %
American football	49.2
Soccer	17.6
Basketball	9.8
Cheer	6.0
Volleyball	5.4
Softball	4.1
Baseball	1.6
Hockey	1.6
Wrestling	0.7
Swim	0.7
Field hockey	0.7
Rugby	0.7
Gymnastics	0.5
Equestrian	0.2
Ski	0.2
Track and field	0.2

CONCLUSION

This study suggests that female athletes take 6 days longer to begin an RTP progression after initial SRC compared with age-matched male athletes. Sex should be considered as part of the clinical decision-making process after SRC in this population.

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