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Frequency and Outcomes of a Symptom-Free Waiting Period After Sport-Related Concussion

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Abstract

Background: Guidelines and practices for the management of sport-related concussion (SRC) have evolved swiftly over the past 2 decades. Despite common recommendations for a symptom-free waiting period (SFWP) before returning to sport, past reports have suggested poor utilization rates for this intervention.

Purpose: To obtain current estimates of the utilization and characterization of SFWPs with high school and collegiate athletes.

Study Design: Descriptive epidemiology study.

Methods: Data were extracted from a larger prospective study that followed athletes with SRC across 13 institutions in southeastern Wisconsin from 2012 to 2014. Participants included 143 contact and collision sport athletes who were followed serially through their recoveries after SRCs.

Results: In the current study sample, 99.3% of athletes used an SFWP. The mean self-reported symptom duration was 6.35 days (median, 5 days), with 72.7% reporting symptom recovery within 1 week of injury, 93.7% within 2 weeks, and 99.3% within 30 days. Rate of same-season repeat concussion was low (3.8%) and was similar to or lower than the overall rate of concussion (4.3%). Five same-season repeat concussions occurred at a range of 8 to 42 days after initial injuries.

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[i]Nine of these study subjects were lost to attrition; for 13 subjects, their seasons ended before they reached recovery and were able to return to competition; 2 did not have complete return-to-play and recovery data due to examiner error. Separate analysis showed that these athletes were similar demographically and on acute injury characteristics but had longer self-reported symptoms than did the athletes included in the current sample.

Conclusion: In comparison with prior published data collected from 1999 to 2004, utilization and duration of SFWPs were higher in the current study samples (99.3% vs 60.3% of athletes reported an SFWP; mean duration, 6.1 vs 3.2 days), and athletes were withheld from sports for more days than previously reported (12.3 vs 7.4 days). Rate of same-season repeat concussion was equivalent to that of prior published data. The findings support improved adherence to clinical management guidelines through increased utilization of SFWPs after SRC.

Keywords

concussion; sports; head injury; mild traumatic brain injury; symptom-free waiting period; clinical management

Recommendations and guidelines for the management of sport-related concussion (SRC) have changed greatly over the past 2 decades. Historically, 3 prominent concussion grading scales were in use: the Cantu Evidence-Based Grading System for Concussion,[3] the Colorado Medical Society Guidelines,[5] and the American Academy of Neurology guidelines.[12] These grading scales relied heavily on loss of consciousness (LOC) and amnesia for determining concussion severity and clinical recommendations. In addition, each grading scale permitted concussed athletes to return to play on the same day in select situations. From 1996 to 2001, almost half of players in the National Football League who sustained a concussion returned to play in the same game.[27]

Since that time, there have been numerous developments in formal clinical management guidelines for concussion. The First International Conference on Concussion in Sport in Vienna, Austria, in November 2001[1] a consensus statement with 4 main recommendations: (1) Concussions should be managed on an individual basis, (2) athletes diagnosed with concussion should not be returned to participation on the same day, (3) diagnoses should not be made only in the presence of LOC, and (4) concussions should not be managed based on grading systems that rely on such acute characteristics.[1] Since that time, the International Conference on Concussion in Sport has updated its consensus statements 3 times,[19–21] and additional organizations have published position papers.[2,8,10] All 50 United States and Washington DC now have 1 or more laws in place regarding the management of youth concussion, and sporting organizations like the National Collegiate Athletic Association,[22] National Federation of State High School Associations,[23] and individual states' athletic associations[30] have guidelines in place. The Wisconsin state law, for example, dictates that concussed athletes may not return to play on the day of injury and recommends return-to-play protocols that include a symptom-free waiting period (SFWP).[6] In addition, youth athletes, parents, and coaches are required to sign forms documenting awareness of the law before the start of the athletic season.

A major change in guidelines and laws over time has been the implementation of an SFWP. Initially recommended at the First International Conference on Concussion in Sport,[1] an SFWP is now considered a central requirement for safe and effective return to play. The practice recommendation of an SFWP was derived from findings that the majority of repeat concussions occur within the acute (7–10 days) postinjury window, implying a window of cerebral vulnerability in which athletes may be more neurologically vulnerable to the effects

of further stress.[7,14] Yet it has likely taken some time for the recommended practice of an SFWP to be applied in the broader sports medicine community. In a retrospectively analyzed sample of high school and collegiate athletes enrolled in a prospective study of concussion from 1999 to 2004, an SFWP of any kind was employed in only 60.3% of cases.[14] But counterintuitively, an SFWP was unrelated to acute injury characteristics or clinical outcomes (symptom, cognitive, balance recovery). Furthermore, although most repeat concussions occurred within 10 days of injury, the SFWP group had a higher rate of repeat concussion than did the no-SFWP group. The finding implied that an SFWP does not speed clinical recovery or modify overall risk of reinjury but supported the concept of a general window of cerebral vulnerability during the acute postinjury period.

Given the numerous sociocultural and legal changes that have taken place in the context of SRC since this prior study, the goal of the current study was to obtain an updated account of SRC management practices. The major aims were to (1) characterize current concussion management practices using data collected from 2012 to 2014 and (2) examine current rates of same-season repeat injury. We then discuss these findings in the context of prior published data (collected from 1999–2004). We hypothesized that SFWP usage would be quite common in current practice and that same-season repeat injuries would be uncommon, especially within the acute postinjury period. We anticipated that concussions would be managed more conservatively (ie, that an SFWP would be more common and longer now than in 1999–2004) and that risk of same-season repeat injury would be low given more conservative clinical management practices. The findings shed light on the degree to which recent changes in guidelines, policy, and public awareness around SRC have changed routine clinical practice.

METHODS

Participants

As part of a larger prospective study on the assessment of SRC, 2148 student-athletes from 9 high schools and 4 colleges in Wisconsin participated from August 2012 through December 2014. Athletes at all participating schools had daily access to athletic trainers for SRC management. Within that larger sample, 143 athletes were followed after a sustained concussion, provided SFWP data, and were therefore targeted for analyses in this report. See Table 1 for additional sample characteristics. Adult athletes and parents of minor athletes provided informed consent, and minor participants completed assent forms before testing. The study was approved by the Institutional Review Board at the Medical College of Wisconsin.

Study Design

Before the season, athletes completed a baseline testing session that included the Sport Concussion Assessment Tool 3 (SCAT3) symptom checklist,[21] the Standardized Assessment of Concussion,[15,16] Balance Error Scoring System,[28] and 2 of 3 computerized neurocognitive assessment tools: Automatic Neuropsychological Assessment Metrics (ANAM v 4.3; Vista Life Sciences), Axon Sports (Axon/Cogstate Sport; Cogstate Ltd), and Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT, online version;

ImPACT Applications Inc). The protocol is described in more detail in prior publications from the study.[25,26] Athletes who went on to sustain a concussion completed follow-up evaluations within 24 hours of injury and at 8, 15, and 45 days after injury. Baseline and postinjury examinations were performed one- on-one by a certified research coordinator or research assistant at each athlete's school.

Acute injury variables recorded included LOC, retrograde amnesia (RGA), posttraumatic amnesia (PTA), and concussive symptom burden within 24 hours of injury as measured by the SCAT3 symptom checklist symptom severity score (range 0–132, with higher scores reflecting greater symptom burden). Primary recovery variables included total duration of self-reported symptoms, time lost from sport, and length of SFWP. The athletic trainers who diagnosed the concussions prospectively provided acute injury characteristics (LOC, RGA, and PTA) to the research team, which were subsequently confirmed with subjects at the 24-hour evaluations.

Definition of Injury

The definition of *concussion* used in this study was based on that of the study sponsor (US Department of Defense): "mTBI is defined as an injury to the brain resulting from an external force and/or acceleration/deceleration mechanism from an event such as a blast, fall, direct impact, or motor vehicle accident which causes an alteration in mental status typically resulting in the temporally related onset of symptoms such as headache, nausea, vomiting, dizziness/balance problems, fatigue, insomnia/sleep disturbances, drowsiness, sensitivity to light/noise, blurred vision, difficulty remembering, and/or difficulty concentrating."[9] However, all subjects sustained an SRC and were diagnosed by a certified athletic trainer.

Data Analyses

Although 167 concussed athletes were followed in the larger study protocol, data on the primary outcome variable for this study were missing for 24,[i] yielding 143 athlete injuries used in these analyses. Repeat injuries occurred for 10 of these subjects during the study period (n = 10; 5 in the same-season and 5 in a subsequent season at least 7 months after the initial concussion) and were not included in these analyses to ensure independent observations for statistical analyses.

Descriptive statistics were computed to characterize the sample, injuries, and clinical management variables (eg, SFWP frequency and duration). Independent-samples t tests, 1-way analysis of variance, and Pearson correlations were used to determine the relationship between length of SFWP (in days) and demographic and injury characteristics. Independent-samples *t* tests were also used to compare levels of competition and sex-based differences in clinical recovery and management metrics. Statistical analyses were conducted using SPSS (version 21.0; IBM SPSS Statistics for Windows; IBM Corp).

RESULTS

Clinical Management of SRCs

Overall sample characteristics, as well as injured athlete characteristics, are summarized in Table 1. The acute injury characteristics of the sample were 5.7% LOC, 9.9% PTA, and 9.2% RGA. Table 2 provides descriptive statistics on recovery and clinical management of the concussed athletes. Mean symptom recovery took 6.35 days, with 72.7% of athletes reporting a full recovery within 1 week, 83.9% within 10 days, and 93.7% within 2 weeks. Only 0.7% of athletes reported symptoms for longer than 1 month. Mean time lost from sports participation after injury was 12.31 days. Only 26.6% of athletes returned to play within 1 week, but 74.1% of athletes returned to competition within 2 weeks, and 97.9% of athletes returned to sports participation within 1 month.

Mean ± SD symptom duration was equivalent between high school and collegiate athletes (6.43 ± 4.75 versus 6.30 ± 5.41 days; $t(141) = .14$, $P = .89$). Similarly, mean time lost from sports participation was equivalent between levels of competition (high school vs collegiate: 12.98 ± 7.03 vs 11.87 ± 6.92 days; $t(141) = .93$, $P = .354$). Mean symptom duration and mean time lost from sports participation were also unrelated to sex (females vs males: 5.70 ± 4.61 vs 6.48 ± 5.25 days [symptom duration]; $t(141) = -.67$, $P = .505$; 11.91 ± 6.76 vs 12.38 ± 7.02 days [time lost from sports]; $t(141) = -.30$, $P = .768$).

An SFWP was reported in 99.3% of athletes with the average SFWP being 6.07 days. Table 3 displays additional information regarding the distribution of SFWP categories across subjects. Length of SFWP was not associated with any participant characteristics or injury characteristics. In particular, length of SFWP was not associated with age ($P = .292$), sex ($P = .868$), race ($P = .802$), sport (football vs soccer, $P = .693$), diagnosis of attention deficit/hyperactivity disorder ($P = .604$), learning disability ($P = .521$), grade point average ($P = .624$), Wechsler Test of Adult Reading standard score ($P = .323$), history of SRC ($P = 644$), household socioeconomic status (Hollingshead score, $P = .675$), institution ($P = .258$), 24-hour postconcussive symptoms (SCAT3 symptom severity score, $P = .451$), total duration of symptoms (self-reported in days, $P = .351$), LOC ($P = .972$), PTA ($P = .184$), or RGA ($P = .882$). Although the association between length of SFWP and level of competition was not significant, there was a small trend toward longer SFWPs in high school versus collegiate athletes (6.87 ± 4.85 vs 5.57 ± 4.18 days; $P = .092$, Cohen $d = .29$).

Rates of Same-Season Repeat Concussion

Five athletes (2 male football players, 2 male soccer players, and 1 female soccer player) experienced a same-season repeat concussion. Repeat concussions occurred at 8, 21, 25, 35, and 42 days after injury (mean, 26.2 days). The rate of repeat concussion (3.81%) was similar to the overall rate of concussion (4.25%) ($P = .984$). There was no significant difference in the average duration of symptoms, SFWP, or time withheld from sport between the athletes who sustained a same-season repeat concussion and those who did not go on to sustain a same-season repeat concussion.

DISCUSSION

The current study findings, collected on SRCs occurring between 2012 and 2014, imply nearly ubiquitous (99.3%) use of an SFWP in high school and collegiate athletes with SRC. These findings, compared with those previously published on an earlier sample (1999–2004),[14] indicate that SFWPs are more commonly utilized now (99.3% vs 60.3%) and, when utilized, are longer in duration (6.1 vs 3.2 days) than they were as part of concussion management practices from 1999 to 2004. (Statistical support for discussion points made regarding differences between the prior and current study samples and findings can be found in the Appendix, available in the online version of this article and at http://ajsm.sagepub.com/supplemental.) Combined with somewhat longer symptom duration reported by athletes in the current study sample, athletes are being withheld from competition approximately 5 days longer than they were previously (12.3 vs 7.4 days). As a result, athletes are more often returning to play outside the purported window of cerebral vulnerability during the first 7 to 10 days after concussion.

Consequently and consistent with expectation, the rate of same-season repeat concussion in this study was low (3.8%), with only 1 of the 5 same-season repeat concussions occurring within 10 days of the initial concussion. Interestingly, this is equivalent to the rate of same-season repeat concussion reported in the prior sample (ie, both 3.8%), although repeat concussions more frequently occurred in the acute postinjury time period in that prior sample (79.2% within 10 days of initial injury vs only 1 in 5 of the current repeat injuries). To the degree that a window of cerebral vulnerability exists early after injury, this implies reduced risk of repeat injury during that critical time in recovery. Similarly, the findings imply safer clinical practice in the context of concerns (albeit controversial) for potentially rare but catastrophic outcomes that have reportedly occurred when athletes are concussed a second time within the acute recovery phase of an initial injury.[4,17,18]

Given that athletes with a history of concussion are at greater risk of sustaining another concussion,[7] our finding of a similar rate of same-season repeat concussion compared with overall concussion incidence suggests that concussed athletes are being managed in accordance with current clinical practice guidelines and, therefore, are at no greater risk for concussion than they would be through routine participation. As suggested earlier, we suspect that these practice changes have resulted from several factors, most notably the development and dissemination of clinical management recommendations by a number of expert groups and sports medicine organizations (eg, the International Conference on Concussion in Sport, American Academy of Neurology, National Athletic Trainers Association, American College of Sports Medicine) and the passing of state laws related to youth concussion management. These factors, as well as increased media attention to concussion, have increased public awareness of concussion and changed the culture of reporting and managing injuries for many groups of athletes,[13] further allowing recommendations to be realized in practice.

Another key finding was that symptom recovery was equivalent for high school and collegiate athletes in the current study sample. This is consistent with prior published findings from the historical sample compared with the current data and implies that clinical

management practice need not differ between athletes at these levels of competition.[24] With only a trend toward more conservative clinical management in the high school sample, our data largely supported that this is occurring in practice in the geographic region followed for this study. Similarly, we found no association between sex and either symptom duration or clinical management, implying that concerns about sex differences in response to injury within the cohorts studied here may not be warranted.

It can be inferred that there is a greater rate of reported concussion overall now than there was in the previous study. This finding is supported by another analysis[13] that found similar rates of concussion between 1999–2002 and 2013 but increased concussion reporting in 2013. As a result of greater attention and legislation, athletes now may be more likely to report concussions, while health care providers, coaches, and parents may be more cognizant of concussion signs and symptoms. Stigma associated with reporting concussions may be reduced as symptoms (vs traditionally recognized acute injury characteristics such as LOC) are more widely recognized as a brain injury. As a result, athletes may be more likely to report concussions with less severe acute injury characteristics, a conjecture supported by less frequent PTA and RGA in the current cohort who also self-reported symptoms for a longer period of time.

Some limitations to this study exist. First, the measures used in the study are based on athlete self-report. Although it was specified in the design and athletes were told that the research team would have no involvement in return-to-play decisions, athletes may not have been completely honest when reporting recovery and return- to-play information. Athletes may not have fully understood the injury and recovery questions they were being asked. Furthermore, this study may not have a representative sample of schools, and results may not be generalizable beyond the region of data collection. High schools and universities that agree to participate in a research study on concussions may adhere to guidelines more so than do schools that are not actively participating in such research. In addition, the schools in our study have athletic trainers at each school every day of the week, which is not consistent with all schools, especially those in rural communities. Finally, this study included only athletes who completed follow-up and provided complete recovery information. Athletes who were lost to attrition (5.4% of entire sample) may have had different symptom durations and clinical management than those of athletes who completed the study.

It is also important to be aware that the historical and current samples we compared in this discussion of findings were different from each other in several ways. For example, the current sample included a greater diversity of sports participation (65% vs 80% football), sampled from a narrower geographic region, and used slightly different operational definitions of concussion than those of the prior study. On the other hand, both studies included high school and collegiate athletes, were comparable in sex distribution (albeit heavily weighted toward male athletes), sampled from overlapping geographic regions (southeastern Wisconsin), and were conducted by a common investigative team, which facilitated highly similar protocols for collection of clinical management information between the 2 studies.

Findings from the current study suggest that concussions are being managed much more conservatively than they were from 1999 to 2004. The magnitude of changes between prior and current usage of an SFWP is remarkable and reflects significant progress over the past 10 to 15 years in clinicians' adoption of practice recommendations for SRC. A number of factors may contribute to this, including increased availability of and knowledge about professional practice guidelines and legislation about concussion management, increased media attention toward concussion, and other changes to the cultural milieu for those involved in recognizing, reporting, and managing injuries. While this is considered a positive outcome, a key question that remains is to what degree such clinical management decisions influence an athlete's short-term clinical recovery and longer term neurologic outcomes. This is especially important for future work to address in light of our finding that symptom recovery was longer in the current versus prior study samples, particularly when considering other recent work finding more prolonged symptom recovery with more conservative injury management.[11,29] Although intuitively reducing risk of acute repeat injury is advantageous, only with increased understanding of the neurobiological recovery course associated with concussion, as well as the interplay among clinical/behavioral and neurobiologic factors, will we know the mechanisms by which clinical management decisions influence athlete outcomes.

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REFERENCES

1. Aubry M, Cantu R, Dvorak J, et al. Summary and agreement statement of the First International Conference on Concussion in Sport, Vienna 2001: recommendations for the improvement of safety and health of athletes who may suffer concussive injuries. Br J Sports Med. 2002;36(1):6–10. [PubMed: 11867482]
2. Broglio SP, Cantu RC, Gioia GA, et al. National Athletic Trainers' Association position statement: management of sport concussion. JAthl Train. 2014;49(2):245–265. [PubMed: 24601910]
3. Cantu RC. Guidelines for return to contact sports after a cerebral concussion. Phys Sportsmed. 1986;14(10):75–83. [PubMed: 27432133]
4. Cantu RC, Gean AD. Second-impact syndrome and a small subdural hematoma: an uncommon catastrophic result of repetitive head injury with a characteristic imaging appearance. J Neurotrauma. 2010; 27(9):1557–1564. [PubMed: 20536318]
5. Colorado Medical Society School and Sports Medicine Committee. Guidelines for the management of concussion in sports. Colo Med. 1990;87:4.
6. Concussion and head injury. Wis Stat §118.2932012 (2012).
7. Guskiewicz KM, McCrea M, Marshall SW, et al. Cumulative effects associated with recurrent concussion in collegiate football players: the NCAA Concussion Study. JAMA. 2003;290(19): 2549–2555. [PubMed: 14625331]
8. Harmon KG, Drezner JA, Gammons M, et al. American Medical Society for Sports Medicine position statement: concussion in sport. Br J Sports Med. 2013;47(1):15–26. [PubMed: 23243113]

9. Helmick K, Guskiewicz K, Barth J, et al. Defense and Veterans Brain Injury Center Working Group on the Acute Management of Mild Traumatic Brain Injury in Military Operational Settings: Clinical Practice Guideline and Recommendations. Washington, DC: Defense and Veteran Brain Injury Center; 2006:1–11.
10. Herring SA, Cantu RC, Guskiewicz KM, et al. Concussion (mild traumatic brain injury) and the team physician: a consensus statement. 2011 update. Med Sci Sports Exerc. 2011;43(12):2412–2422. [PubMed: 22089299]
11. Howell DR, Mannix RC, Quinn B, Taylor JA, Tan CO, Meehan WP III. Physical activity level and symptom duration are not associated after concussion. Am J Sports Med. 2016;44(4):1040–1046. [PubMed: 26838933]
12. Kelly JP, Rosenberg JH. Practice parameter: the management of concussion in sports (summary statement): report of the Quality Standards Subcommittee. Neurology. 1997;48(3):581–585. [PubMed: 9065530]
13. LaRoche AA, Nelson LD, Connelly PK, Walter KD, McCrea MA. Sport-related concussion reporting and state legislative effects. Clin J Sport Med 2016:26(1):33–39. [PubMed: 25894530]
14. McCrea M, Guskiewicz K, Randolph C, et al. Effects of a symptomfree waiting period on clinical outcome and risk of reinjury after sport-related concussion. Neurosurgery. 2009;65(5):876–882. [PubMed: 19834399]
15. McCrea M, Kelly JP, Kluge J, Ackley B, Randolph C. Standardized assessment of concussion in football players. Neurology. 1997; 48(3):586–588. [PubMed: 9065531]
16. McCrea M, Kelly JP, Randolph C, et al. Standardized assessment of concussion (SAC): on-site mental status evaluation of the athlete. J Head Trauma Rehabil. 1998;13(2):27–35. [PubMed: 9575254]
17. McCrory P Does second impact syndrome exist? Clin J Sport Med. 2001;11(3):144–149. [PubMed: 11495318]
18. McCrory P, Berkovic SF. Second impact syndrome. Neurology. 1998;50(3):677–683. [PubMed: 9521255]
19. McCrory P, Johnston K, Meeuwisse W, et al. Summary and agreement statement of the 2nd International Conference on Concussion in Sport, Prague 2004. Br J Sports Med. 2005;39(4):196–204. [PubMed: 15793085]
20. McCrory P, Meeuwisse W, Johnston K, et al. Consensus statement on concussion in sport: the 3rd International Conference on Concussion in Sport held in Zurich, November 2008. Br J Sports Med. 2009;43(suppl 1):i76–i90. [PubMed: 19433429]
21. McCrory P, Meeuwisse WH, Aubry M, et al. Consensus statement on concussion in sport: the 4th International Conference on Concussion in Sport held in Zurich, November 2012. Br J Sports Med. 2013;47(5):250–258. [PubMed: 23479479]
22. National Collegiate Athletic Association. Concussion guidelines: diagnosis and management of sport-related concussion. https://www.ncaa.org/health-and-safety/concussion-guidelines. Accessed August 12, 2015.
23. National Federation of State High School Associations. Recommendations and guidelines for minimizing head impact exposure and concussion risk in football. Report from the July 2014 NFHS Concussion Summit Task Force. https://www.nfhs.org/media/1014079/2014-nfhs-recommendations-and-guidelines-for-minimizing-head-impact-final-october-2014.pdf Accessed May 16, 2016.
24. Nelson LD, Guskiewicz KM, Barr WB, et al. Age differences in recovery after sport-related concussion: a comparison of high school and collegiate athletes. J Athl Train. 2016;51(2):142–152. [PubMed: 26974186]
25. Nelson LD, LaRoche AA, Pfaller AY, et al. Prospective, head-to-head study of three computerized neurocognitive assessment tools (CNTs): reliability and validity for the assessment of sport-related concussion. J Int Neuropsychol Soc. 2016;22(1):24–37. [PubMed: 26714883]
26. Nelson LD, Pfaller AY, Rein L, McCrea MA. Rates and predictors of invalid baseline test performance for three computerized neurocognitive tests (CNTs): ANAM, Axon, and ImPACT. Am J Sports Med. 2015;43:2018–2026. [PubMed: 26059178]

27. Pellman EJ, Viano DC, Casson IR, Arfken C, Feuer H. Concussion in professional football: players returning to the same game. Part 7. Neurosurgery. 2005;56(1):79–90; discussion 90–92.

28. Riemann BL, Guskiewicz KM. Effects of mild head injury on postural stability as measured through clinical balance testing. J Athl Train. 2000;35(1):19–25. [PubMed: 16558603]

29. Thomas DG, Apps JN, Hoffmann RG, McCrea M, Hammeke T. Benefits of strict rest after acute concussion: a randomized controlled trial. Pediatrics. 2015;135(2):213–223. [PubMed: 25560444]

30. Wisconsin Interscholastic Athletic Association. WIAA Concussion Policy. http://www.wiaawi.org/Health/Concussions.aspx. Accessed August 13, 2015.

TABLE 1

Sample Characteristics[a]

Characteristic	Baseline Sample (N = 2144)	SRC Sample (n = 143)
Sex, male (vs female)	77.0	83.9
Age, y	17.8 ± 1.9	17.6 ± 2.0
College (vs high school)	61.3	60.8
Race		
White	83.5	86.7
Black	12.0	11.2
Asian	1.3	1.4
Other/not reported	3.2	0.7
ADHD	8.0	11.2
Learning disability	3.2	2.8
GPA	3.3 ± 0.5	3.2 ± 0.5
WTAR standard score	101.5 ± 12.5	101.0 ± 12.7
No. of prior concussions		
0	60.0	51.7
1	23.3	35.0
2	8.8	9.8
≥3	7.9	3.5
Sport		
Football	49.3	65.0
Soccer	32.2	25.2
Lacrosse	7.2	4.9
Wrestling	3.5	1.4
Ice hockey	3.7	1.4
Rugby	2.4	1.4
Field hockey	1.7	0.7

[a]Data are reported as either mean ± SD or percentage. The baseline sample size does not match the overall number of athletes enrolled in the study, as there was not perfect overlap in the baseline and injured samples. ADHD, attention deficit/hyperactivity disorder; GPA, self-reported cumulative grade point average; SRC, sport-related concussion; WTAR, Wechsler Test of Adult Reading.

TABLE 2

Summary of Recovery Duration and Time Lost From Competition

	Duration of Symptoms, d	Time Lost From Sports, d
Mean ± SD	6.35 ± 5.14	12.31 ± 6.96
Median (range)	5 (<1 to 35)	10 (3 to 40)
Recovery Time, d	% of Athletes (Cumulative %)	% of Athletes (Cumulative %)
0 to ≤7	72.7 (72.7)	26.6 (26.6)
8 to ≤14	21.0 (93.7)	47.5 (74.1)
15 to ≤30	5.6 (99.3)	23.8 (97.9)
>30	0.7 (100.0)	2.1 (100.0)

TABLE 3

Symptom-Free Waiting Period (SFWP) Usage and Duration

Duration of SFWP (mean ± SD), d	6.07 ± 4.48
Median (range)	5 (0–31)
SFWP category, %	
None	0.7
≤1 d	7.7
>1 and ≤7 d	67.8
>7 d	23.8