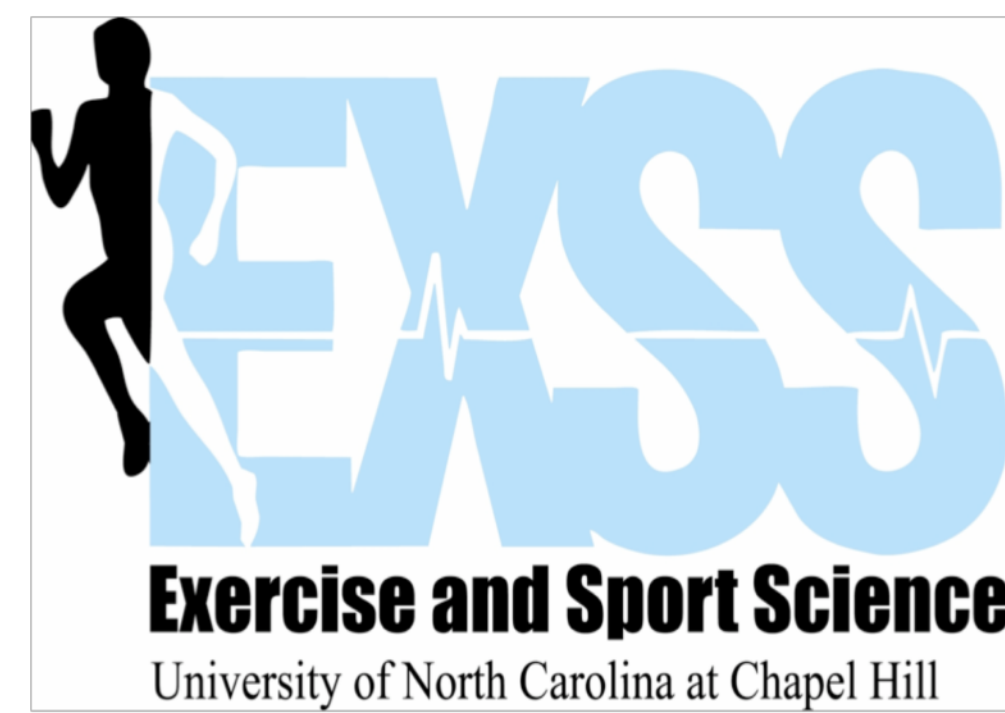


# Concussion symptom prevalence in 20 U.S. high school sports, 2013/14-2017/18 academic years

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## INTRODUCTION

- Sport-related concussions (SRCs) have been acknowledged to be a major public health concern in recent years.[1-4]
- While the existing literature has been helpful in guiding policy measures, there is a need continuously update the literature in order to capture the evolving landscape of SRCs in this population.
- Moreover, concussion symptom presentation is an important consideration in this population as SRCs present with an array of symptoms, and concussion diagnoses are not all the same.[5-8]
- Examining symptom presentation and the time courses of symptom resolution as well as recovery, will help make treatment protocols more nuanced.

## PURPOSE

- This study examined concussion symptomology, in 20 HS sports during the 2013/14-2017/18 academic years using data from the High School Reporting Information Online (HS RIO™) surveillance system.

## MATERIALS AND METHODS

- Study design:** Descriptive Epidemiologic Design.
- Data source:** National High School Sports-Related Injury Surveillance System - High School RIO™ (Reporting Information Online), an Internet-based sports injury surveillance system.[9]
  - Used a convenience sample of high school boys' and girls' soccer programs.
  - 2013/14-2017/18 school years
- Data collection:** Athletic trainers (AT) from participating high schools reported injuries and exposures through a Web-based injury surveillance platform.
  - Data were collected pertaining to the injury event (ex: body location injured, injury diagnosis) and injury outcome (ex: time loss from injury)
  - Concussion-related data included: concussion symptoms (dichotomous), symptom resolution time (ordinal)
- Injury definition:** A reportable injury had to meet 2 criteria: (1) occurred as a result of participation in a school sanctioned practice or competition; (2) required medical attention. No definition for concussion was provided as we relied upon the ATs' expertise to properly diagnose concussions.
- Statistical analysis:**
  - Symptom prevalence was estimated as the proportion of SRCs reported with a given symptom among all SRCs:  
 $Prevalence = (\# \text{ SRCs with a given symptom} / \# \text{ all SRCs}) * 100$
  - Overall symptom counts (out of the 14 possible symptoms) were calculated for each reported SRC.
  - The distributions of symptom resolution times (SRT) and time loss (TL) were also examined, and the proportions of SRCs reported with SRT, TL of < 7 days, and ≥ 22 days (among all SRCs) were estimated.
  - Symptom prevalence, SRT, RTP, and symptom count were compared across event type (practice/competition), injury mechanism (non-player-contact/player-contact), injury history (recurrent/new), sex, and contact level.
    - Sex-differences were examined in high contact, and low/no contact sports, while among boys SRCs in collision sports were compared with SRCs in all other sports.
  - Chi-square tests (or Fisher's exact tests when  $\chi^2$  assumptions were violated) compared symptom prevalence and differential proportions of SRT and RTP outcomes between groups; Wilcoxon rank sum tests compared symptom counts between groups.
  - Statistical significance was evaluated at the 0.001 level, and data were analyzed using SAS software (version 9.4; SAS Institute Inc.).

## ACKNOWLEDGEMENTS

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## RESULTS

Figure 1. Temporal trends in concussion symptom resolution time among high school athletes. Individual bars correspond to each year of data included within analysis, and bars partitioned by the proportion of all SRCs (within the year) that resulted in a specific symptom resolution times.

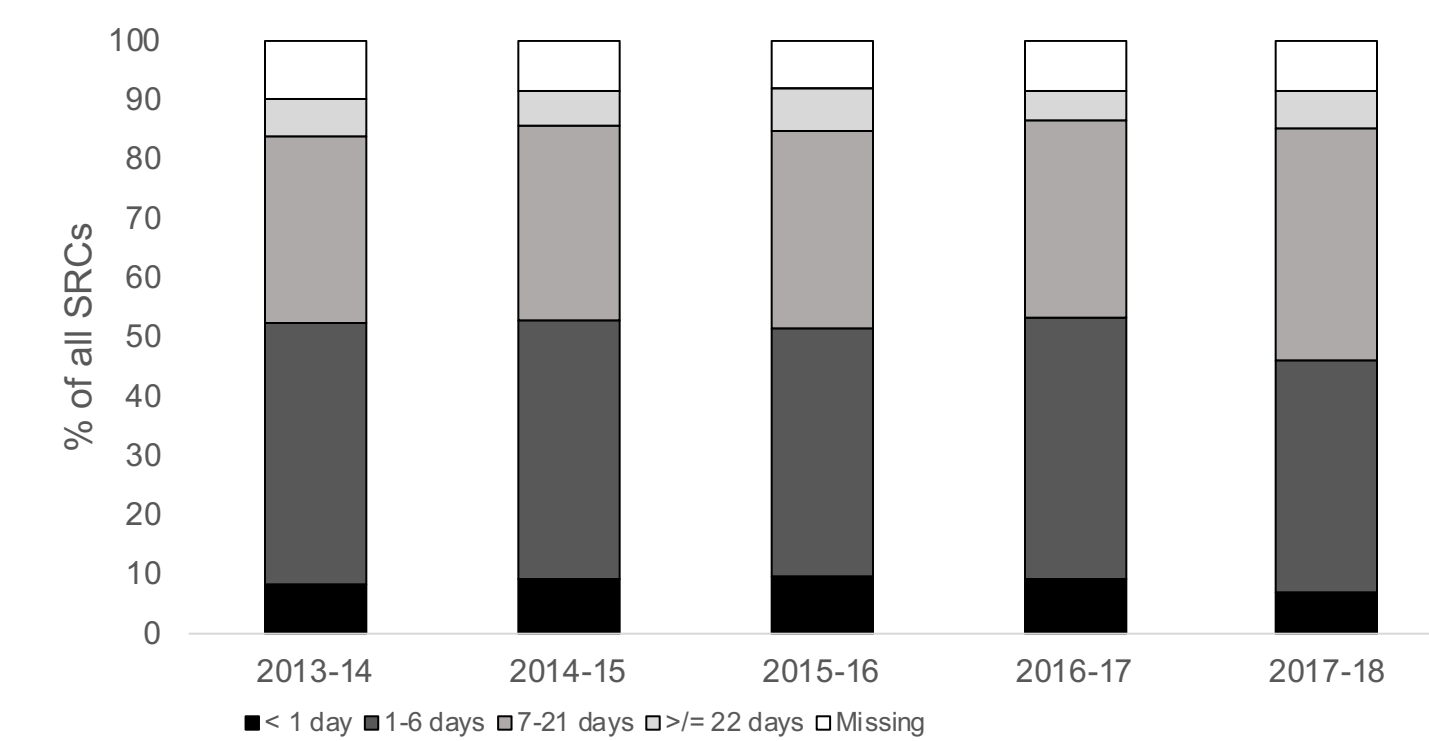


Figure 2. Temporal trends in time loss following SRCs among high school athletes. Individual bars correspond to each year of data included within analysis, and bars partitioned by the proportion of all SRCs (within the year) that resulted in a specific time loss values.

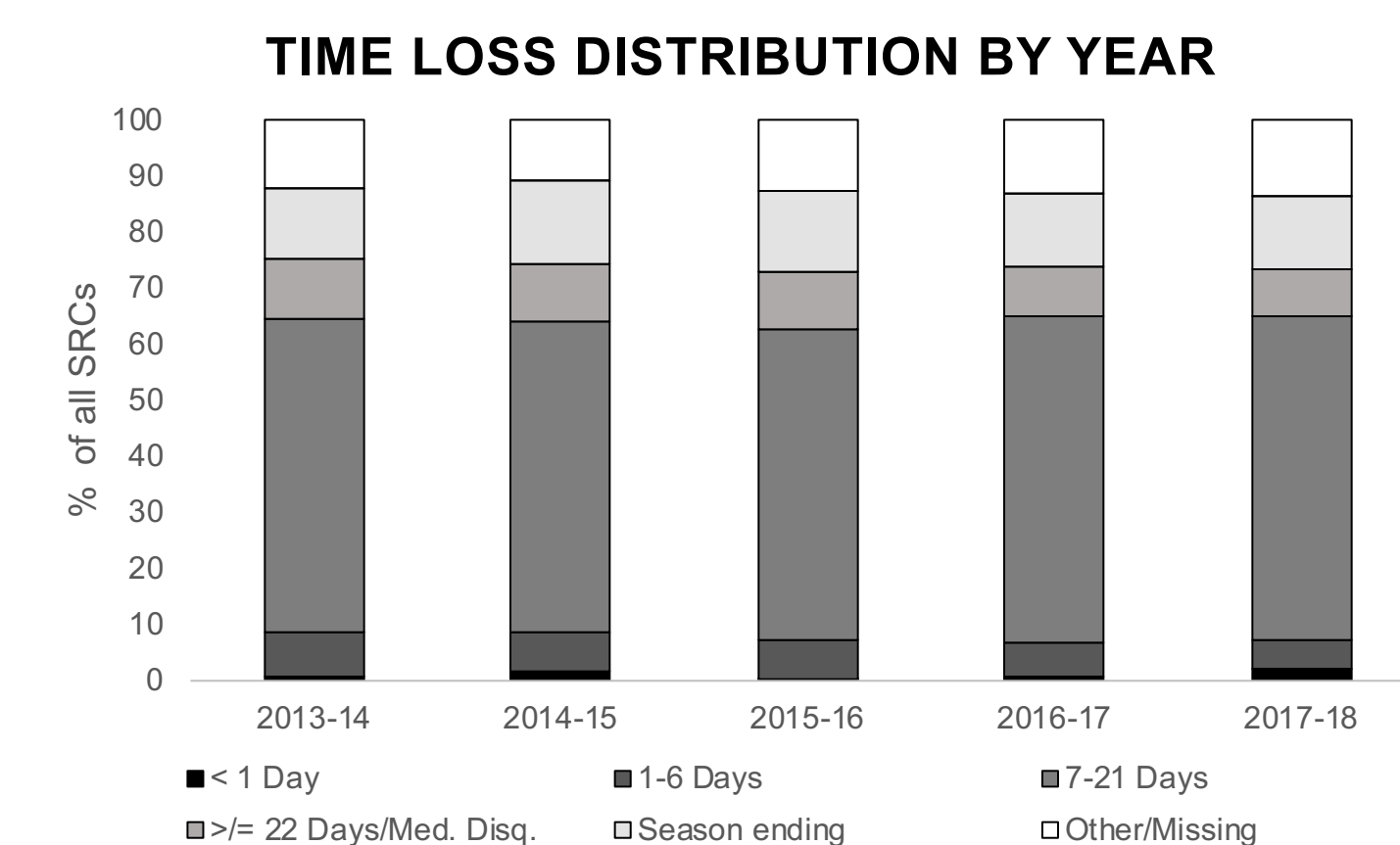


Table 1. Comparisons of concussion symptom prevalence, symptom resolution time, return-to-play time, and symptom counts between practice and competition-related SRCs among high school athletes in 20 sports, 2013/14 – 2017/18 academic years

Symptom Prevalence, % <sup>a</sup>	Event			p-value <sup>b</sup>
	Overall	Practice	Competition	
Amnesia	11.5	8.8	13.0	<0.001
Difficulty Concentrating	56.0	56.0	56.0	0.98
Confusion/Disorientation	37.2	36.4	37.6	0.25
Dizziness/Unsteadiness	73.8	74.8	73.2	0.10
Drowsiness	32.7	34.6	31.6	0.003
Headache	94.5	95.4	94.0	0.003
Hyperexcitability	2.1	1.5	2.5	0.001
Irritability	13.3	13.3	13.3	0.92
Loss of Consciousness	2.5	1.3	3.2	<0.001
Nausea	28.3	29.8	27.4	0.02
Tinnitus	6.4	6.6	6.3	0.51
Light Sensitivity	52.6	52.9	52.5	0.66
Noise Sensitivity	34.7	33.4	35.5	0.03
Foggy	19.2	18.6	19.5	0.27
Other	8.3	8.1	8.4	0.64
Symptom Resolution Time, %				
< 7 days <sup>c</sup>	51.3	49.8	52.1	0.04
≥ 22 days <sup>c</sup>	6.3	7.1	5.8	0.02
Time loss, %				
< 7 days <sup>d</sup>	7.9	7.3	8.2	0.09
≥ 22 days/Med. Disq. <sup>d</sup>	9.9	11.5	9.0	<0.001
Symptom Mean <sup>e</sup>	4.7	4.7	4.7	0.72
± SD	2.4	2.4	2.4	
Median	4.0	4.0	4.0	
IQR	3.0	3.0	3.0	
Total (n)	9542	3463	6079	n/a

Table 2. Comparisons of concussion symptom prevalence, symptom resolution time, time loss, and symptom counts between non-player-contact and player-contact-related SRCs among high school athletes in 20 sports, 2013/14 – 2017/18 academic years.

Symptom Prevalence, % <sup>a</sup>	Mechanism		p-value <sup>b</sup>
	Non-player-contact	Player-contact	
Amnesia	9.3	<0.001	<0.001
Difficulty Concentrating	54.1	57.0	0.009
Confusion/Disorientation	34.4	38.7	<0.001
Dizziness/Unsteadiness	74.7	74.0	0.47
Drowsiness	32.8	32.7	0.88
Headache	95.4	94.7	0.18
Hyperexcitability	1.7	2.4	0.03
Irritability	13.4	13.2	0.76
Loss of Consciousness	2.5	2.5	0.80
Nausea	28.6	28.3	0.72
Tinnitus	5.6	7.0	0.01
Light Sensitivity	53.2	52.8	0.71
Noise Sensitivity	35.9	34.1	0.08
Foggy	19.6	18.9	0.39
Other	7.3	8.6	0.03
Symptom Resolution Time, %			
< 7 days <sup>c</sup>	49.9	52.4	0.02
≥ 22 days <sup>c</sup>	6.7	5.9	0.15
Time loss, %			
< 7 days <sup>d</sup>	8.2	7.8	0.48
≥ 22 days/Med. Disq. <sup>d</sup>	10.2	9.7	0.50
Symptom Mean <sup>e</sup>	4.7	4.8	0.09
± SD	2.4	2.4	
Median	4.0	4.0	
IQR	3.0	3.0	
Total (n)	3177	5941	n/a

### Injury mechanism

- Compared with non-player-contact SRCs, a higher proportion of player-contact resultant SRCs were reported with the following symptoms: amnesia (12.7% vs. 9.3%; p< 0.001), and confusion/disorientation (38.7% vs. 34.4%; p< 0.001) (Table 2).

### Injury history

- As compared with new SRCs, a higher proportion of recurrent SRCs were seen with SRT of ≥ 22 days (12.0% vs. 5.8%; p< 0.001), as well as time loss of ≥ 22 days/medical disqualification (15.9% vs. 9.4%; p< 0.001) (Table 3).

For tables 1-3:

<sup>a</sup>Symptom prevalence expressed as a proportion of symptom presentation, among all SRCs in the category.  
<sup>b</sup>p-values correspond to  $\chi^2$  tests (or Fisher's exact tests when  $\chi^2$  assumptions were violated) comparing prevalence and proportions between practice and competition-related SRCs; and Wilcoxon Rank Sum tests comparing symptom counts between categories.  
<sup>c</sup>Symptom resolution time expressed as the proportion of SRCs reported with symptom resolution times of < 7 days, among all SRCs in the category.  
<sup>d</sup>Symptom resolution time expressed as the proportion of SRCs reported with symptom resolution times of ≥ 22 days, among all SRCs in the category.  
<sup>e</sup>Time loss expressed as a proportion of SRCs resulting in time loss of < 7 days, among all SRCs in the category.  
<sup>f</sup>Time loss expressed as a proportion of SRCs resulting in time loss of ≥ 22 days/medical disqualification (injuries resulting in medical disqualification, the athlete choosing not to continue, the athlete being released from team, and in rare cases, death); thus, this category included those injuries cause a premature end to an athlete's season or career, among all SRCs in the category.  
Average number of symptoms observed among all SRCs in the category.

## RESULTS

Table 4. Comparisons of concussion symptom prevalence, symptom resolution time, return-to-play time, and symptom counts by sex, and sport-type among high school athletes in 20 sports, 2013/14 – 2017/18 academic years.

Symptom Prevalence, % <sup>a</sup>	High contact sports <sup>b</sup>			Low/no contact sports <sup>b</sup>			Boys <sup>c</sup>			p-value <sup>d</sup>
	Girls	Boys	p-value <sup>e</sup>	Girl	Boys	p-value <sup>e</sup>	Collision	Rest	p-value <sup>e</sup>	
Amnesia	8.5	11.1	0.03	5.8	17.5	<0.001	13.4	12.1	0.25	
Difficulty Concentrating	54.6	53.4	0.57	53.9	53.0	0.82	57.8	53.4	0.008	
Confusion/Disorientation	32.6	34.7	0.26	33.6	42.6	0.02	40.0	36.1	0.02	
Dizziness/Unsteadiness	74.0	72.7	0.45	77.4	78.7	0.72	73.0	73.7	0.66	
Drowsiness	34.5	32.9	0.37	34.5	30.1	0.25	32.1	32.4	0.88	
Headache	95.2	95.5	0.34	96.7	95.1	0.30	93.3	95.4	0.01	
Hyperexcitability	1.6	1.8	0.81	1.0	2.7	0.07	2.5	1.9	0.25	
Irritability	15.3	9.7	<0.001	11.8	13.1	0.63	13.5	10.3	0.004	
Loss of Consciousness	1.2	4.0	<0.001	1.2	5.5	0.002	3.0	4.2	0.03	
Nausea	28.8	23.5	0.003	29.8	29.5	0.93	28.7	24.5	0.005	
Tinnitus	5.6	7.2	0.10	5.0	8.7	0.05	6.9	7.5	0.50	
Light Sensitivity	56.3	52.1	0.04	52.8	53.0	0.96	51.2	52.3	0.52	
Noise Sensitivity	38.0	35.7	0.24	40.3	29.5	0.007	32.7	34.7	0.20	
Foggy	18.2	18.5	0.87	19.0	18.6	0.90	19.6	18.5	0.41	
Other	7.7	8.1	0.74	8.4	7.7	0.75	8.5	8.0	0.57	
Symptom Resolution Time, %										
< 7 days <sup>f</sup>	47.7	58.5	<0.001	50.9	62.3	0.006	51.7	59.2	<0.001	
≥ 22 days <sup>f</sup>	7.3	3.7	<0.001	8.4	2.7	0.008	6.1	3.5	<0.001	
Time loss, %										
< 7 days <sup>g</sup>	7.8	9.9	0.06	9.5	7.7	0.44	7.6	9.5	0.04	
≥ 22 days/Med. Disq. <sup>g</sup>	9.8	6.0	<0.001	10.5	7.7	0.26	10.2	6.3	<0.001	
Symptom Mean <sup>h</sup>	4.7	4.6	0.11	4.7	4.9	0.58	4.8	4.7	0.07	
± SD	2.4	2.3		2.3	2.4		2.4	2.4		
Median	4.0	4.0		4.0	5.0		5.0	4.0		
IQR	3.0	3.0		3.0	4.0		3.0	3.0		
Total (n)	2009	904	n/a	727	183	n/a	5279	1087	n/a	

<sup>a</sup>Corresponds to comparisons of male and female SRCs in high contact sports (High contact: Boys/Girls-Soccer, and Basketball; Girls- Field Hockey, and Lacrosse).  
<sup>b</sup>Corresponds to comparisons of male and female SRCs in low/no contact sports (Low contact: Boys/Girls- Swim & Dive, Track & Field, and Cross Country; Boys- Baseball, Girls- Volleyball, and Softball).  
<sup>c</sup>Corresponds to comparisons between SRCs in collision (Collision: Boys- Football, Wrestling, Ice Hockey, and Lacrosse) and non-collision sports among boys.  
<sup>d</sup>p-values correspond to  $\chi^2$  tests (or Fisher's exact tests when  $\chi^2$  assumptions were violated) comparing prevalence and proportions between male and female SRCs in high contact sports, and Wilcoxon Rank Sum tests comparing symptom counts between categories.  
<sup>e</sup>p-values correspond to  $\chi^2$  tests (or Fisher's exact tests when  $\chi^2$  assumptions were violated) comparing prevalence and proportions between SRCs in low/no contact sports, and Wilcoxon Rank Sum tests comparing symptom counts between categories.  
<sup>f</sup>Symptom resolution time expressed as the proportion of SRCs reported with symptom resolution times of < 7 days, among all SRCs in the category.  
<sup>g</sup>Symptom resolution time expressed as the proportion of SRCs reported with symptom resolution times of ≥ 22 days, among all SRCs in the category.  
<sup>h</sup>Time loss expressed as a proportion of SRCs resulting in time loss of < 7 days, among all SRCs in the category.  
<sup>i</sup>Time loss expressed as a proportion of SRCs resulting in time loss of ≥ 22 days/medical disqualification (injuries resulting in medical disqualification, the athlete choosing not to continue, the athlete being released from team, and in rare cases, death); thus, this category included those injuries cause a premature end to an athlete's season or career, among all SRCs in the category.  
Average number of symptoms observed among all SRCs in the category.

### High contact sports

- Compared with female SRCs, a higher proportion of male SRCs were reported with SRT of < 7 days (58.5% vs. 47.7%; p< 0.001) (Table 4).
- Sex-differences were also noted in proportions of SRCs with symptoms resolving in ≥ 22 days, however, with a higher proportion of female SRCs falling in this category (7.3% vs. 3.7%; p< 0.001).
- Differential symptom prevalence was also observed between the sexes, with a higher proportion of female SRCs reported with irritability (15.3% vs. 9.7%; p< 0.001), and a higher proportion of male SRCs reported with loss of consciousness (4.0% vs. 1.2%; p< 0.001).

### Low/no contact sports

- Compared with female SRCs, a higher proportion of male SRCs were reported with amnesia (17.5% vs. 5.8%; p< 0.001) (Table 4).

## CONCLUSIONS

- Most prevalent symptoms observed (headaches, dizziness, and light sensitivity) were unsurprising considering the existing literature regarding SRCs in similar age cohorts.[10]
- In half of the SRCs reported, all symptoms resolved within a week, although in 10% of SRCs, the injury resulted in ≥ 22 days of time loss or medical disqualification. Those at risk of PCS require further study, though the lack of temporal trends related to time loss suggests stabilizing clinical practice.
- Differential symptom prevalence was most notable with regards to amnesia and loss of consciousness. As these symptoms require immediate referral, as well as serial monitoring, it is important to reconcile the observed patterns.
  - Considering the differential prevalence observed with regards to event type, and injury mechanism, interventions motivated by reducing the apparent severity of competition-related and player contact-resultant SRCs may particularly target coaching and refereeing education in high school sports.

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