

**Spring football concussion rates mimic the preseason:  
Findings from the CARE Consortium**

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## Acknowledgements

CARE Consortium Investigators include: Scott Anderson (University of Oklahoma), Holly Benjamin (University of Chicago), Kenneth L. Cameron and Steven Svoboda (United States Military Academy), James Clugston (University of Florida), Michael Collins and Anthony Kontos (University of Pittsburgh), Sara Chrisman (University of Washington), JT Eckner (University of Michigan), Luis Feigenbaum (University of Miami), Christopher Giza, Joshua Goldman, and John DiFiori (University of California at Los Angeles) April Hoy (Azusa Pacific), Jonathan Jackson (United States Air Force Academy), Thomas Kaminski and Thomas Buckley (University of Delaware), Louise Kelly (California Lutheran University), Justus Ortega (Humboldt State University), Jane McDevitt and Dianne Langford (Temple University), Christina Master (University of Pennsylvania), Jason Mihalik (University of North Carolina), Christopher Miles (Wake Forest University), Patrick O'Donnell (United States Coast Guard Academy), Nicholas Port (Indiana University), Margot Putukian (Princeton University), Steve Rowson (Virginia Tech), Adam Susmarski (United States Naval Academy).

This research was supported by the Grand Alliance Concussion Assessment, Research, and Education (CARE) Consortium, funded in part by the National Collegiate Athletic Association (NCAA) and the Department of Defense (DOD). This work was supported by the Office of the Assistant Secretary of Defense for Health Affairs, through the Combat Casualty Care Research Program, endorsed by the Department of Defense, under Award No. W81XWH1420151. Opinions, interpretations, conclusions and recommendations are those of the author and are not necessarily endorsed by the DOD.

The authors would also like to thank Jody Harland, Janetta Matesan, Michael Menser (Indiana University School of Medicine); Ashley Rettmann, Nicole L'Heureux, (University of Michigan); Melissa McEachern (Medical College of Wisconsin); Michael Jarrett, Vibeke Brinck, and Bianca Byrne, (Quesgen); Melissa Baker, Christy Collins, Will Felix, (Datalys Center for Sports Injury Research and Prevention); and the research and medical staff at each of the CARE participation sites. We are grateful for the participation of the student athletes without whom this research would not be possible

**1 ABSTRACT**

2 Increasing attention is directed on identifying aspects of football participation for targeted policy change  
3 that reduces concussion risk. Prior work evaluated concussion risk during the pre- and regular-seasons,  
4 leaving the spring season largely unexplored. This nationally representative observational investigation  
5 of 19 Division I collegiate football programs evaluated concussion rates and head impact exposure  
6 during the pre-season, regular season, and spring practices from 2014-2019. All participating programs  
7 recorded incidence concussions and a subset (n=6) also measured head impact exposure. Analyses by  
8 time of year and session type indicated concussion rates and head impact exposure during all practice  
9 sessions and contact only practices were significantly higher in the spring and pre-season compared to  
10 the regular season ( $p's < 0.05$ ). Concussion rates during the spring season and pre-season were  
11 statistically similar. This investigation identified comparable concussion risk between the spring and  
12 pre-seasons, highlighting the need for targeted policy intervention to protect athlete health and safety.

13  
14 **Key Words:** Head Impact Exposure, concussion risk

15 **Abstract word count:** 150

16 **Manuscript word count:** 1728

**17 Key points:**

- 18 • Concussion risk and head impact exposure during spring season football mimics the preseason
- 19 • This finding highlights the need for policy change to reduce injury risk and improve player health  
20 and safety.

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## 25 INTRODUCTION

26 Participation in football carries a known risk for concussion<sup>1</sup>. Over the previous decade,  
27 concussion researchers have strived to identify specific risk factors for injury and interventions to  
28 mitigate risk. Data-driven changes to game play aimed at reducing concussion risk include adjustments  
29 to the kickoff<sup>2</sup>, revisions to the pre-season contact practice rules<sup>3,4</sup>, and increased penalty severity (i.e.,  
30 player ejection) for intentional helmet-to-helmet contact (i.e., targeting). Of note, a recent study from  
31 the NCAA-DoD Concussion Assessment, Research and Education (CARE) Consortium indicated that 72%  
32 of football related concussions and 67% of all head impact exposure (HIE) occurred during practices.  
33 Further, concussion incidence and HIE were both disproportionately higher during pre-season training  
34 camp (i.e., August practices) than the regular season. In the same study, preseason accounted for nearly  
35 50% of all concussions (despite preseason accounting for only about 20% of the fall football season) and  
36 had HIE that occurred at twice the proportion of the regular season<sup>5</sup>. In response to this investigation,  
37 the NCAA altered pre-season football rules to allow 25 practices over a 29 day period with a maximum  
38 of eight days in full pads, eight days in helmets and shoulder pads, and nine days in helmets only. The  
39 revised rules also restricted contact practices to a maximum of two consecutive days.

40 In addition to rule changes related to pre-season and regular season activities, the spring  
41 football season represents another area for examination and possible change to guidelines to reduce  
42 incidence of concussion and HIE. At the NCAA Division I level, the spring football season includes up to  
43 15 days of team practices across 34 calendar days. During the 15 practices, 12 may be contact sessions,  
44 eight of which may involve tackling, although no more than three of the eight tackling sessions may be  
45 devoted to 11-on-11 scrimmages. Contact sessions on consecutive days are not permitted. Work by  
46 Dick et al<sup>6</sup> evaluating the NCAA Injury Surveillance System (ISS) data collected from Division I schools  
47 from 1988-2004 and noted that concussion rates during spring practices were 1.5x higher than pre-  
48 season practices (10.05 vs 7.05 injuries per 1000 Athlete Exposures (AE)). Conversely, a more recent

49 study by Houck and colleagues<sup>7</sup> from a single Division I football program collected from 2006-2015  
50 reported that pre-season practice concussion rates were nearly 2x that of spring practices.

51 With increasing attention on athlete health and safety, there is a notable dearth of literature  
52 examining concussion risk during these key points in the football season, specifically the spring season  
53 and from a nationally representative sample. This investigation made use of data collected from the  
54 CARE Consortium to estimate and compare incidence of concussion and HIE during the fall football pre-  
55 season, regular season, and spring season.

## 56 **METHODS**

57 The NCAA-DoD CARE Consortium is a multi-center study of the natural history of concussion. A  
58 detailed explanation of the methods have been described elsewhere<sup>8</sup>. All participants provided  
59 informed consent in accordance with their local institutional review board and the US Human Research  
60 Protection Office.

61 Germaine to this investigation, concussions occurring during Division I football practices were  
62 included in the analyses. Data collection began at the start of the 2014 pre-season (i.e., August) and  
63 continued through the end of the 2019 regular season. Performance sites were phased into the  
64 Consortium over three years, with 11 sites contributing data in 2014/15, 14 in 2015/16, and 19 in  
65 2016/17 through the 2019 regular season. Data from the 2018 spring seasons were excluded as a result  
66 of a transition in funding and 2020 because of widespread university closures related to COVID-19.

67 A study-wide definition of concussion was implemented<sup>9</sup> and injury diagnoses were made by  
68 local medical staff. All injury relevant data were entered into a centralized database by local  
69 research/medical staff. Number of practice sessions were estimated by school and year based on NCAA  
70 regulations. For each phase of the season, contact practices were estimated as the maximum allowed  
71 while non-contact sessions were estimated as the total number of allowable practices minus the

72 number of allowable contact practices. Athletes (n=745) from a subset of sites (n=6) were equipped with  
73 the Head Impact Telemetry (HIT) System<sup>10</sup> to capture athlete-level data on head impact exposure.

74 *Statistical Methods:* For the school-level data for number of concussions, a negative binomial  
75 model was fit using the generalized estimating equations method to account for multiple observations  
76 per school. The outcome was the number of concussions during practice per school and school year.  
77 Predictors were Time (spring, Pre-season, regular season), School Year (2014/15 to 2019/20) and the  
78 Time by School Year interaction. The natural log of the number of participants \* the number of sessions  
79 (either all sessions or estimated contact sessions) was used as an offset to account for the differing  
80 practice exposure levels across School, Time, and School Year. Within each model the Time effect was  
81 estimated averaging over any effects of School Year and the Time by School Year interaction.  
82 Comparisons between Time were made with the models using Wald tests. For athlete-level head impact  
83 exposure, median impacts per participant per day for spring, pre-season and regular season practices  
84 (collapsed over school and school year) were compared using Wilcoxon Signed-rank tests to avoid  
85 assuming normality given the small sample.

## 86 **RESULTS**

87 A total of 556 concussions were observed over 9364 total practice sessions (4250 contact  
88 practices) between 2014-2019. As shown in Table 1, using school-level data, the rate of concussions in  
89 spring and pre-season were not different from each other but both were greater than fall. For example,  
90 the rate shown is the number of concussions expected per participant per practice, so if 1000  
91 participants each participated in 10 Spring sessions (10,000 total sessions), one would expect to see 12  
92 concussions. The expected numbers are 11 for pre-season and 3 for fall. Qualitatively similar results  
93 were seen at the athlete-level for median head impacts (Table 2).

## 94 **DISCUSSION**

95 This investigation sought to make use of a diverse, nationally representative sample of collegiate  
96 football programs to evaluate and compare incidence of concussion and HIE during all phases of  
97 football, including preseason, regular season and spring football. The findings suggest that concussion  
98 risk, as examined during all practices and contact practices specifically, is significantly greater during the  
99 spring and fall pre-season relative to the fall regular season. There was no difference between incidence  
100 of concussion in the pre-season and spring season. This finding was supported by examination of head  
101 impact exposure data, showing individual athlete exposure to head impacts was greatest during the  
102 Spring and Pre-seasons.

103 A number of examinations have evaluated concussion risk in the pre-season and regular season.  
104 McCrea et al<sup>5</sup> noted approximately one-half of football related concussions occurring in the fall take  
105 place in the month of August (i.e., preseason), a time interval that approximates one-fifth of the entire  
106 fall season. Similarly, Wasserman<sup>11</sup> reported a three-fold increase in concussion risk during the pre-  
107 season over the regular season. In addition, within a given time of year (e.g., pre-season) concussion  
108 risk increased based on the equipment worn, whereby full pad sessions carried a five-fold risk for  
109 concussion over helmet only sessions. Equivalently, less than 2% of concussions occur during helmet  
110 only sessions, compared to over 2/3rds in full pad sessions<sup>12</sup>. Although there are similar concussion  
111 estimates and risk during the pre- and spring football seasons, the underpinnings for these findings are  
112 not clear. Coaches likely maximize the number of full contact sessions allowed within the practice  
113 guidelines, which carry the greatest concussion risk by practice type. Further, athletes may be putting  
114 forth maximum effort to improve their skill and team standing.

115 Subsequent to these and other investigations, have been calls to change the sport in ways that  
116 improve athlete health and safety. As the risk for concussion nearly doubles during contact sessions  
117 (see Table 1), augmenting practice rules by reducing the number of spring contact sessions appears to  
118 be the most efficacious route to reducing concussion risk without changing game play. Limiting the

119 number of contact sessions at the high school level has been shown to reduce overall head impact  
120 exposure by nearly 50%<sup>13</sup> and there is a known association between head impact exposure and injury  
121 risk<sup>14</sup>. To that end, regular season practices allow for fewer full contact sessions per week and we  
122 hypothesize that coaches may reduce contact practice intensity to reduce injury risk, resulting in a  
123 significantly lower concussion rate (Table 1).

124 Football is a complex athletic game requiring substantial training to optimize performance and  
125 eliminating contact practice sessions should not come at the cost of player education and training.  
126 Consistent with prior recommendations for maintaining athlete instruction<sup>5</sup>, any reduction in the  
127 number of spring contact sessions could be offset with non-contact sessions that allow for skill building  
128 and player development. Indeed, replacing contact sessions with non-contact sessions can be utilized to  
129 train tackling maneuvers in a way that reduces head first contact<sup>15</sup>, thusly reducing concussion risk and  
130 keeping athletes on the field for the largest training benefit. Reducing the number of in-practice injuries  
131 is known to improve game performance<sup>16</sup> and may help facilitate rule change adoption by  
132 administrators.

133 This study is not without limitations. Importantly, athlete exposures were estimated as the  
134 study design precluded the ability to collect exact participation numbers. Further, some teams may not  
135 have used the maximum number of contact or total allowable sessions. In addition, total injuries are  
136 not directly linked to specific session type. In addition, despite broad implementation in head impact  
137 studies, data collected through the HIT System is known to have measurement error. Regardless, the  
138 data presented here are consistent with data presented elsewhere<sup>5</sup>. Lastly, this study only includes  
139 NCAA varsity football athletes and the head impact exposure data are from Division I athletes. As such,  
140 these findings may not be applicable to other levels of play (e.g., lower NCAA Divisions, high school and  
141 youth football).

142



## 143 CONCLUSION

144 This investigation evaluated and compared incidence of concussion and HIE during three distinct  
145 periods in the football calendar: pre-season, regular season, and spring. The findings indicated no  
146 difference in concussion incidence and HIE during the spring and pre-season, both of which were  
147 significantly higher than the regular season. Given the increased attention on athlete health and safety  
148 relative to concussion and all injuries, policy changes to how spring football is conducted are  
149 recommended. Following on recommendations from other investigators, reducing the number of  
150 contact practice sessions while maintaining opportunities for skill development is likely to have a  
151 substantial reduction in exposure and related injury risk.

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213 **Table 1: Rate of Concussion during Practice by Type of Contact and Time for n=19 Division I programs**

Estimated Rate <sup>a</sup> with 95% Confidence Interval				
	Spring	Fall Pre-season	Regular Season	Comparison <sup>b</sup>
All Practice Sessions	.0012 (.0007,.0021)	.0011 (.0009,.0013)	.0003 (.0002,.0003)	Spring > Regular Season, p < 0.001 Pre-season > Regular Season, p < 0.001 Spring > Pre-season, p = 0.80
Contact Practice only	.0022 (.0012,.0039)	.0020 (.0017,.0025)	.0007 (.0005,.0008)	Spring > Regular Season, p < 0.001 Pre-season > Regular Season, p < 0.001 Spring > Pre-season, p = 0.79

214 <sup>a</sup>Rates are estimated from the negative binomial models as the expected number of concussions divided  
 215 by practice exposure (number of participants \* the number of sessions) <sup>b</sup>based on Wald test within a  
 216 negative binomial model

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220 **Table 2: Median Head Impacts Per Player Per Contact Session by School and Time for n=6 programs.**  
 221 **The average number of athletes participating in each season (Spring, Pre-season, Regular Season)**  
 222 **across all years (2015-2019) are presented in parentheses.**

Team	Spring Season	Fall Pre-season	Regular Season	Comparison <sup>a</sup>
1	9 (36)	9 (42)	7 (45)	Spring > Pre-season, p = 0.06 Spring > Regular Season, p = 0.03 Pre-season > Regular Season, p = 0.03
2	8.5 (20)	8 (25)	5 (26)	
3	12 (24)	10 (42)	7 (43)	
4	10 (27)	9 (36)	6 (34)	
5	10 (20)	9 (35)	6 (35)	
6	13 (35)	10 (36)	8 (39)	

223 <sup>a</sup>based on Wilcoxon Signed-Rank tests; data from football athletes instrumented with HIT System