Association Between Previous Concussion Education and Concussion Care-Seeking Outcomes among NCAA Division I Student-Athletes

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ABSTRACT

Context: There are limited data concerning differences in concussion education exposure and how education exposures relates to care-seeking and symptom disclosure, specifically in Division I student-athletes.

Objective: Investigate demographic characteristics associated with concussion education exposure and examine whether overall education exposure (yes vs. no) and education source exposure number (multiple sources vs. single source) affects concussion care-seeking and disclosure factors in Division I student-athletes.

Design: Cross-sectional survey.

Setting: Classroom or online.

Participants: NCAA Division I student-athletes (n=341).

Main Outcome Measure(s): Frequencies and proportions were computed for sex, race, school year, sport, and concussion history across concussion education groups. Prevalence ratios (PR) and 95% confidence intervals (CI) quantified the association between student-athlete characteristics and 1) overall concussion education exposure and 2) source exposure number. Separate multivariable linear regression models estimated adjusted mean differences (MD) and 95%CI to assess differences in concussion knowledge, attitudes, and perceived social norms relative to concussion education exposure and exposure to multiple sources. Separate multivariable binomial regression models estimated adjusted PRs and 95%CI to assess associations of intention, perceived control, and care-seeking/disclosure behaviors and overall
concussion education exposure and exposure to multiple sources. All models controlled for sex, sport, and concussion history.

Results: Overall, n=276 (80.9%) reported previous concussion education, with 179 (64.9%) exposed to multiple sources. Student-athletes that participated in a contact sport (adjusted PR=1.24, 95%CI=1.06,1.44) and those who had a concussion history (adjusted PR=1.19, 95%CI=1.09,1.31) had higher prevalence of previous concussion education exposure. Females had a lower prevalence of reporting multiple sources (adjusted PR=0.82, 95%CI=0.68, 0.99).

Overall concussion education exposure was significantly associated with more favorable perceived social norms surrounding concussion care-seeking (adjusted MD=1.37, 95%CI=0.13,2.61).

Conclusions: Findings highlight potential differences in overall concussion education exposure and provide clinicians with information on groups who may benefit from targeted additional education.

Key Words: mild traumatic brain injury, concussion, concussion prevention
INTRODUCTION

Unreported sport-related concussions (SRCs) remain a critical issue for the safety and well-being of all athletes. Anywhere from 30-50% of SRCs remain unreported, leaving a significant number of athletes without proper care and support after injury. Assessment and immediate care after a suspected concussion is critical and underreporting may lead to decreased or inappropriate care post-injury, posing a threat to the short- and long-term well-being of athletes.

Previous research suggests key factors that lead to high rates of concussion underreporting are pressure to play, lack of medical resources, negative attitudes and stigma surrounding concussion, not believing the injury was serious, fear of letting the team down, and lack of knowledge on the injury. Consistent with these findings, favorable perceived social norms and perceived control over disclosure are also often associated with improved concussion care-seeking outcomes. Furthermore, current research supports utilizing concussion education to improve concussion knowledge, attitudes, and perceived social norms, which, in turn, may improve timely care-seeking post-concussion.

The National Collegiate Athletic Association (NCAA) requires dissemination of concussion education materials to all Division I, II, and III student-athletes each year. However, the mode and type of education remains at the institution’s discretion. This autonomy has the potential to lead to education differences between who receives education and the type of education being utilized, both of which remain largely understudied. Despite the NCAA mandate, only 80% of collegiate student-athletes and two-thirds of coaches reported receiving any type of concussion education. Furthermore, in those who received education, an imbalance of acknowledging education receipt exists. Eighty percent of Athletic Trainers indicated
requiring education acknowledgement forms at the beginning of the season, whereas only 60% of student-athletes reported this requirement. Complete delivery of concussion education is critical to ensuring all student-athletes are provided the education necessary to help improve concussion care-seeking and disclosure behaviors.

Differences also exist in how concussion education is provided. Although the NCAA mandates education, materials used and delivery method vary by institution, as athletes, coaches, and Athletic Trainers reported receiving education from a wide variety of sources including formal meeting/lecture, informal conversation, written materials, online materials, email, video, and posters. Furthermore, the content provided on all platforms differs with 91.6% of collegiate coaches reporting receiving a list of symptoms, 87.3% receiving information about proper concussion management, 68.7% receiving information on the long-term consequences of injury, and 61.3% on the impact on athletic performance of continuing play with an undiagnosed concussion. A wide variety of education types and information may cause message inconsistencies. Conversely, having access to multiple, impactful education sources may be beneficial. However, limited data exists investigating the impact of receiving education from multiple sources and the effect of source exposure number on care-seeking/disclosure behaviors. A recent study in first-year military service academy cadets observed that for cadets with a concussion history, exposure to multiple education sources was clinically associated with disclosing all recalled concussions at the time of injury. Although these findings indicate the potential benefit of multiple source exposures among military service academy cadets, it should be noted that differences exist in who receives concussion education in a variety of settings. Concussion education, in some form, is required in each state for youth athletes. This requirement greatly impacts the level of concussion knowledge and awareness.
student-athletes have before attending an NCAA institution and recent data suggests that youth athletes and coaches in lower income areas and communities with a higher percentage of families with children under 18 living below the poverty line, a lower percentage of parents with a college education, and a lower percentage of white non-Hispanic residents were less likely to have received concussion education. Therefore, some collegiate student-athletes may be at a disadvantage compared to their peers. The overall education exposure and content differences that exist at all levels could greatly impact student-athletes concussion education exposure as well as the potential benefits that may exist from exposure to multiple sources.

Unfortunately, there are limited data on concussion education exposure among collegiate student-athletes. Therefore, this study aimed to investigate: 1) student-athlete demographic characteristics associated with overall concussion education exposure and exposure to multiple sources and 2) how overall concussion education exposure and exposure to multiple sources impacts concussion disclosure factors in NCAA student-athletes. We hypothesized that overall concussion education exposure and exposure to multiple sources would be associated with higher concussion-related knowledge and more favorable concussion-related attitudes, perceived social norms, intention, perceived control, and care-seeking/disclosure behaviors.
METHODS

Study Design and Participants

This was a cross-sectional survey design including student-athletes from a single NCAA Division I institution. The study team received full Institutional Review Board approval prior to beginning study activities. Collegiate student-athletes at a single Division I university were invited to participate during concussion baseline testing or via team emails. All participating student-athletes consented to study participation. A total of 379 student-athletes were approached and 350 (92.3%) agreed to participate in the study. Seven of the participants did not complete the survey beyond the demographic questions and two additional participants were excluded due to not reporting concussion education information. Therefore, the final sample for analysis was 341 (90.0%) participants.

Questionnaire and Procedures

The survey was conducted in a classroom setting via hard copy. An online option was available in the event that participants were unable to complete the survey within a classroom setting. Online surveys were completed by 30/341 (8.8%) student-athletes. The study questionnaire was based on previously validated items of concussion care-seeking. All multi-item scale measures had an internal consistency (Cronbach’s Alpha) of 0.8 or higher. Details about the questionnaire are previously published. Survey items included questions regarding demographics (e.g., sex, race, school year, sport) and concussion history. Additional items regarding concussion education exposure and concussion-related knowledge, attitudes, perceived social norms, intention, perceived control, and care-seeking/disclosure behaviors are further explained below in detail.
Student-athletes were asked to report previous concussion education exposure (yes or no) they have received in their lifetime. Student-athletes exposed to concussion education were then asked to identify what source(s) of education they had been exposed to previously. Options included education via a video, talking to a coach, talking to a medical professional, and/or other. Based on the student-athletes’ responses, they were categorized by source exposure number as being exposed to only a single source (i.e., selected one of the sources) or multiple sources (i.e., selected two or more of the sources).15

Concussion knowledge was assessed using 39 validated yes-or-no items concerning symptom recognition, potential long-term effects of concussion, effects of premature return to play, and consequences of incurring multiple concussions. Correct answers were scored as 1-point. All correct scores were summed resulting in a knowledge composite score ranging from 0-39 (higher scores meant better concussion knowledge).8,15,17

Attitude questions consisted of six validated 7-point scale items with question topics encompassing perceptions of concussion symptom disclosure and concussion. Answers were summed resulting in a composite attitude score ranging from 6-42 (higher scores meant more favorable symptom disclosure attitudes).8,15,17

Perceived social norms questions included seven validated 7-point scale items identifying perceptions of the organization, social referent expectations, and actions concerning concussive injury. Answers were summed resulting in a composite social norm score ranged from 7-49 (higher scores meant more favorable perceived social norms).8,15,17

Intention to disclose concussion symptoms consisted of a single validated 7-point scale question regarding a student-athlete’s intention to disclose concussion-related symptoms after injury. An intention score was categorized with higher scores (6 or 7) reflecting agree/strongly
agree to disclose symptoms after concussion and lower scores (1-5) reflecting somewhat agree to strongly disagree for intention to disclose symptoms after concussion.\textsuperscript{8,15,17}

Perceived control over disclosing concussion symptoms consisted of a single validated 7-point scale question regarding how much control student-athletes believed they had over disclosing concussion symptoms. A perceived control score was categorized with higher scores (6 or 7) reflecting agreement/strong agreement with having symptom disclosure control and lower scores (1-5) reflecting some agreement to strong disagreement of symptom disclosure control.\textsuperscript{8,15,17}

We dichotomized intention and perceived control in this way to remain consistent with previous concussion literature.\textsuperscript{8,15,17} Additionally, this was a theoretical cut in our data, with those reporting 6 or 7 indicating higher vs. those reporting lower agreement towards intention and perceived control.\textsuperscript{8,15,17}

Concussion history and injury care seeking/disclosure evaluation began by giving student-athletes the following concussion definition based on previous studies:\textsuperscript{4,8,15,17}

“A change in brain function following a force to the head, which may be accompanied by temporary loss of consciousness and is identified in awake individuals with measures of neurological and cognitive dysfunction. Common concussion symptoms include: headache, feeling slowed down, difficulty concentrating or focusing, dizziness, balance problems/loss of balance, fatigue/loss of energy, feeling in a fog, irritability, drowsiness, nausea, memory loss, sensitivity to light/noise, and blurred vision. IMPORTANT: A concussion can occur without being “knocked out” or unconscious; getting your “bell rung” or “clearing the cobwebs” is a concussion.”
This definition was followed by the question, “Given the definition above, have you ever had a concussion related to sport or other activities?” Student-athletes who answered yes were then asked to report the number of concussions incurred and how many of these concussions were disclosed to a medical professional/someone in authority at the time of injury. The number of disclosed concussions was divided by the number of total concussions for each student-athlete to quantify disclosure (i.e. proportion of reported concussions that were disclosed). Disclosure was then dichotomized as student-athletes who disclosed all suspected concussions at the time of injury vs. student-athletes who did not disclose all suspected concussions at the time of injury. Additional care-seeking behaviors included assessments of ever removing oneself from play due to concussion symptoms and continuing to play despite symptoms; both items were answered as yes or no.

**Statistical Analysis**

Descriptive statistics were computed for all variables and outcomes of interest. Frequencies and proportions were computed for sex (female vs. male), race (Caucasian vs. non-Caucasian), school year (first year vs. upperclassman), sport (contact vs. non-contact), and concussion history (yes vs. no). Classic tabular methods were used to estimate prevalence ratios (PR) and 95% confidence intervals (CI) quantifying how these student-athlete characteristics were associated with overall concussion education exposure (groups: exposure vs. none) and source exposure number (groups: multiple sources vs. single source).

Separate multivariable linear regression models estimated adjusted mean differences (MD) and 95%CI were used to assess differences in concussion knowledge, attitudes, and perceived social norms by concussion education exposure and exposure to multiple sources of education. Separate multivariable binomial regression models estimated adjusted PRs and
95% CI to quantify associations of intention to disclose symptoms, perceived control over symptom disclosure, self-removal due to concussion symptoms, continued play with concussion symptoms, and disclosure of all recalled concussions at the time of injury with concussion education exposure and exposure to multiple sources of education. All multivariable linear and binomial regression models were adjusted for sex, sport, and concussion history. All models assessed the likelihood of positive outcomes (e.g., higher concussion-related knowledge, prevalence of disclosure of all recalled concussions at time of injury); the one exception was the model assessing the prevalence of continuing to play despite symptoms.

Analyses were conducted with SAS 9.4 (SAS Institute Inc.; Cary, NC). For all analyses, missing data were excluded in the models on an analysis-by-analysis basis. MDs with 95% CI excluding 0.0 and PRs with 95% CI excluding 1.0 were considered statistically significant.
RESULTS

Frequencies and Descriptive Statistics

Overall, 341 student-athletes were included in the analyses. The majority were male (n=175, 51.3%), Caucasian (n=264, 77.4%), upperclassmen (n=234, 68.6%), and from contact sports (n=252, 73.9%). Also, 27.6% (n=94) reported a concussion history. A majority of student-athletes (n=276, 80.9%) reported previous concussion education exposure. Of these 276 student-athletes, 274 noted which education sources they had been previously exposed to, with commonly reported concussion education sources including watching a video (n=200, 73.0%), talking with a medical professional (n=200, 73.0%), and talking with a coach (n=141, 51.5%). Of those 274 student-athletes, 179 (65.3%) reported previous exposure to multiple concussion education sources and 95 (34.7%) reported previous exposure to only a single source. Tables 1-4 provide descriptive statistics across study groups.

Association of Concussion Education Exposure with Student-Athlete Characteristics and Concussion-Related Outcomes

A higher prevalence of previous concussion education exposure was found among student-athletes that participated in a contact vs. a non-contact sport (85.3% vs. 68.9%, PR=1.24, 95%CI=1.06, 1.44), and among student-athletes with vs. without a concussion history (91.5% vs. 76.8%, PR=1.19, 95%CI=1.09, 1.31; Table 1). There was no significant difference in concussion education exposure for sex, race, and school year (Table 1). In multivariable regression models assessing association of concussion education exposure and concussion-related outcomes, the only significant finding was that concussion education exposure was associated with higher (more favorable) perceived social norms surrounding concussion care-seeking (adjusted MD=1.37, 95%CI=0.13, 2.61; Table 2).
Females compared to males had a lower prevalence of reporting receiving concussion education from multiple sources (57.9% vs. 70.2%, PR=0.82, 95%CI=0.68, 0.99; Table 3). There was no significant difference in concussion education source exposure number for race, school year, and sport (Table 3). In multivariable regression models assessing association of multiple concussion education source exposures and concussion-related outcomes, no significant findings were observed (Table 4).
DISCUSSION

Findings from this study highlight potential differences in those who recall concussion education exposure. These data provide clinicians in the collegiate setting with information on groups who may benefit from additional targeted concussion education. Specifically, student-athletes who participated in contact sports and those with a concussion history had a higher prevalence of overall concussion education exposure. Furthermore, females had a lower prevalence of receiving education from multiple sources. An additional key finding is that student-athletes with recalled concussion education exposure reported more favorable perceived social norms surrounding concussion care-seeking. Previous research suggests more favorable social norms are associated with improved concussion care-seeking behaviors.\(^{17,19}\)

Only 80.9% of NCAA student-athletes in this study reported previous concussion education exposure, a number that is consistent with previous literature.\(^{6}\) Many student-athletes in the current study (n=108, 31.6%) were first-year students and completed the survey near the time of pre-season baseline testing. Therefore, they may have not yet received the NCAA mandated education. However, all 50 states and the District of Columbia have enacted laws that address the issue of concussion, in which education is required (in some capacity) by coaches, athletes, and/or parents.\(^{13,20}\) Although no significant difference was found in overall concussion education exposure between first-year and upperclassman student-athletes (PR=0.90, 95%CI=0.79, 1.01), only 75.0% (n=81) of first-year student-athletes reported receiving previous education. This number is inconsistent with the notion that all youth and high school athletes should be receiving concussion education\(^{13,20}\) and highlights differences found in previous studies on who actually receives education at the youth level.\(^{9,16}\) The finding that some student-athletes either do not recall or did not receive concussion education in high school prior to arrival
in the collegiate setting highlights the importance of providing salient and timely concussion education that is effective for student-athletes across all levels of sport. Furthermore, these findings provide collegiate clinicians with insightful information regarding which student-athletes might need immediate concussion education. Similar recommendations for concussion education have been made in previous studies.\textsuperscript{6,13,14,16}

The purpose of concussion education remains to improve concussion knowledge and care-seeking/disclosure behaviors as a way to improve overall outcomes after injury.\textsuperscript{6,9,10} The mean concussion knowledge for all student-athletes included in the analyses was 33.3/39±5.3, a result which was consistent with previous studies.\textsuperscript{8,15} In addition, the mean concussion knowledge for student-athletes with a single exposure to concussion education was 33.4/39±4.7 vs. an average knowledge score of 33.1/39±5.9 for those with multiple source exposures, both of which are also consistent with previous literature.\textsuperscript{15} Unlike the previous mentioned studies,\textsuperscript{21} we did not observe differences in overall education exposure or exposure to multiple sources by race. It should be noted, however, that the current study sample being 77.4\% Caucasian did not represent the racial demographic breakdown of all NCAA Division I institutions (who report a breakdown of 56.0\% Caucasian).\textsuperscript{22} We also did not observe any differences by school class consideration (first-years vs. those considered more senior) for the outcomes of interest. All 30 student-athletes who completed the survey online were upperclassmen, therefore there is a reasonable assumption that mode of survey completion did not affect key study outcomes. However, student-athletes with a concussion history and those who participated in a contact sport were more likely to report previous concussion education exposure. The finding that student-athletes with a concussion history are more likely to have recalled concussion education exposure indicates that the dissemination of education may be happening more after injury
and/or in those with previous concussions, which is clinically expected. While this is important, education solely occurring post-injury may miss the impact to help ensure student-athletes self-disclose and receive appropriate care. This study found that contact sport student-athletes reported a higher prevalence of education exposure and males reported a higher prevalence of exposure to multiple sources. Previous studies show that student-athletes who participate in contact sports and who are males are also more likely to have a concussion history.23-25

Demographic findings from this study were consistent with contact sport participation’s association with concussion history (30.4% of contact sport student-athletes vs. 20.0% of non-contact sport student-athletes reported a concussion history). These findings could demonstrate that contact sport student-athletes are more likely to receive concussion education because they are at a higher risk for being exposed to injury. Furthermore, contact sport athletes could be exposed to a more extensive concussion baseline testing due to the increased exposure to injury, making them more aware of concussion and possibly more likely to receive pre-season education. As student-athletes of all sports are mandated to received concussion education,11 these findings further emphasize ineffective execution of the NCAA policy. Summary statistics show that the study sample represents the overall gender breakdown for all NCAA Division I institutions (53.0%).22 However, descriptive statistics in the current study did not as strongly reflect the difference in concussion history between sex (27.4% of males vs. 26.5% of females had a concussion history). However, the finding that males are more likely (females less likely) to have received exposure from multiple sources could be a reflection of the finding that those who participate in contact sports are more likely to have reported receiving concussion education, as a vast majority of males in the current study participated in contact sports (85.7%). Differences found in these data for receiving concussion education highlight that Athletic
Trainers and other sports medicine clinicians may need to take added measures to ensure that female student-athletes, those who participate in lower or non-contact sports, and those without a concussion history are receiving impactful concussion education.

Student-athletes with recalled concussion education exposure reported more favorable perceived social norms surrounding concussion care-seeking. Perceived social norms are a key factor when looking at concussion care-seeking/disclosure behaviors. Social and sport culture, especially at the collegiate level, has a major impact on decision making and overall behaviors of student-athletes. Therefore, new concussion education strategies are now focused on utilizing theory-based approaches, including the Theory of Planned Behavior and Social Norms Theory, as a way to improve misperceptions surrounding concussion care-seeking/disclosure behaviors. Improving disclosure behaviors is essential to improving overall injury outcomes, therefore it is imperative that concussion education programs utilize a theory-based approach. It should also be noted that social norms could differ between sport, institutions, levels of play, etc.; a notion that should be taken into account when shaping future education programs. Team specific platforms could be a future education tool that could build upon using social norms to further improve care-seeking/disclosure behaviors while tailoring to the specific norms and culture of each team.

The current study found no significant association between overall reported concussion education exposure and concussion knowledge, attitudes, intention, perceived control, and care-seeking/disclosure behaviors. In addition, no significant association was found between concussion education source exposure number and concussion knowledge, attitudes, perceived social norms, intention, perceived control, and care-seeking/disclosure behaviors. Evaluating the impact of current concussion education sources is essential to ensuring that student-athletes are
being exposed to resources that will positively impact their care-seeking/disclosure behaviors. Previous literature suggests that most current prescribed concussion education sources are not significantly impacting concussion care-seeking/disclosure behaviors.\textsuperscript{10,14,29} Student-athletes in the current study were reporting based on previous education exposures, which could provide further evidence regarding the lack of salience that exists surrounding the current education sources. In addition, this could also explain the current findings surrounding the education source exposure number as, even though student-athletes were exposed to more education, they might not have been exposed to impactful sources. A recent randomized control trial\textsuperscript{10} investigated the difference in student-athletes’ concussion reporting intentions and behaviors in those who received a theory-based, multifaceted concussion education module vs. those who received the NCAA concussion fact sheet. Student-athletes in the theory-based group had greater odds of reporting improved concussion knowledge, attitudes, self-efficacy, and reporting intentions.\textsuperscript{10}

These findings indicate that not only does education matter in improving care-seeking/disclosure behaviors, but the type of educational content and delivery is important to truly impact those behaviors; further emphasizing the need for theory-based educational sources.

Limitations and Future Implications

The utilization of a cross-sectional survey brings the limitation of response bias (i.e. student-athlete recall that was correlated among key items could induce spurious associations). Questions pertaining to concussion education did not specify when education was received (i.e. at the youth vs. high school vs. collegiate level or time during the season) and did not specify how many times an athlete might have been exposed to specific types of education sources. Therefore, this study was unable to identify the connection between care-seeking behaviors and time from education exposure or total number of education exposures/being exposure to one
source multiple times. Finally, this study was from a single institution and demographic statistics identified that the study sample being 77.4% Caucasian did not represent all NCAA Division I institutions (who report a demographic breakdown of 56.0% Caucasian),\textsuperscript{22} which may limit generalizability beyond similar institutions. Future research should aim to investigate the longitudinal and observed impact of concussion education on care-seeking/disclosure behaviors and collect more information regarding type, timing, duration, and source of education received.

**Conclusions and Clinical Relevance**

Ensuring that all student-athletes receive impactful concussion education is essential to improving injury outcomes. Differences that exist surrounding who receives education and what materials are used may impact a student-athlete’s ability to prevent injury and improve outcomes. These findings may help Athletic Trainers identify student-athletes at risk for not receiving education or who are in need of improved and/or additional education at their respective institutions. Understanding the impact that perceived social norms has on care-seeking/disclosure behaviors and the connection between concussion education exposure and social norms could greatly impact future educational offerings.

Athletic Trainers are key individuals often in charge of designing and delivering educational programming at their institutions.\textsuperscript{6} These findings may help to inform the structure of future concussion education and impact how Athletic Trainers deliver education to student-athletes at all levels. Future research should aim to further investigate ways to eliminate existing concussion education differences and identify what types of concussion education are most beneficial to improving care-seeking/disclosure behaviors.
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|                              | Concussion Education Exposure | No Concussion Education Exposure | PR (95% CI for Concussion Education Exposure (Yes vs. No)) |
|------------------------------|-------------------------------|----------------------------------|----------------------------------------------------------|
|                              | n (%)                         | n (%)                            |                                                          |
| **Sex**                      |                               |                                  |                                                          |
| Female                       | 122 (79.2)                    | 32 (20.8)                        | 0.98 (0.88, 1.09)                                        |
| Male                         | 142 (81.1)                    | 33 (18.9)                        | 1.0                                                      |
| **Race**                     |                               |                                  |                                                          |
| Caucasian                    | 212 (80.3)                    | 52 (19.7)                        | 1.01 (0.88, 1.16)                                       |
| Non-Caucasian                | 51 (79.7)                     | 13 (20.3)                        | 1.0                                                      |
| **School Year**              |                               |                                  |                                                          |
| First Year                   | 81 (75.0)                     | 27 (25.0)                        | 0.90 (0.79, 1.01)                                       |
| Upperclassman                | 194 (83.6)                    | 38 (16.4)                        | 1.0                                                      |
| **Sport**                    |                               |                                  |                                                          |
| Contact                      | 214 (85.3)                    | 37 (14.7)                        | 1.24 (1.07, 1.44)                                       |
| Non-Contact                  | 62 (68.9)                     | 28 (31.1)                        | 1.0                                                      |
| **Concussion History**       |                               |                                  |                                                          |
| Yes                          | 86 (91.5)                     | 8 (8.5)                          | 1.19 (1.09, 1.31)                                       |
| No                           | 189 (76.8)                    | 57 (23.2)                        | 1.0                                                      |

^aPrevalence ratio was statistically significant (excluded 1.00 in 95%CI).

**Note:** Percentages based off row totals. Total samples for each variable differ due to missing data: sex was missing 12 responses; race, 13 responses; school year, 1 response; sport, 0 responses; and concussion history, 1 response.

**Abbreviations:** n=Number of observations; PR=Prevalence ratio; CI=Confidence interval
Table 2. Adjusted mean differences (MD), prevalence ratios (PR), and 95% confidence intervals (CI) assessing association of overall concussion education exposure with concussion-related outcomes.

| Continuous Outcomes (Linear Regression Models) | n  | Mean (SD) of outcome for each group | Adjusted MD (95% CI) |
|-----------------------------------------------|----|-----------------------------------|---------------------|
| **Concussion knowledge**                      |    |                                   |                     |
| CEE                                          | 247| 33.2 (5.6)                        | 0.04 (-1.46, 1.54)  |
| No CEE                                       | 62 | 33.4 (4.1)                        | 0.0                 |
| **Attitudes**                                 |    |                                   |                     |
| CEE                                          | 258| 33.1 (7.1)                        | 1.28 (-0.69, 3.24)  |
| No CEE                                       | 63 | 32.4 (6.9)                        | 0.0                 |
| **Perceived social norms**                   |    |                                   |                     |
| CEE                                          | 262| 45.1 (4.4)                        | 1.37 (0.13, 2.61)*  |
| No CEE                                       | 65 | 44.1 (5.1)                        | 0.0                 |

| Categorical Outcomes (Binomial Regression Models) | n  | n (%) of Outcome for Each Group | Adjusted PR (95% CI) |
|--------------------------------------------------|----|-------------------------------|---------------------|
| **Disclosure intention**                         |    |                               |                     |
| CEE                                              | 264| 236 (89.4)                    | 0.96 (0.87, 1.06)   |
| No CEE                                          | 64 | 58 (90.6)                      | 1.0                 |
| **Perceived disclosure control**                 |    |                               |                     |
| CEE                                              | 264| 248 (93.9)                    | 1.06 (0.97, 1.16)   |
| No CEE                                          | 64 | 58 (90.6)                      | 1.0                 |
| **Removed oneself from play**                   |    |                               |                     |
| CEE                                              | 264| 68 (25.8)                     | 1.21 (0.67, 2.19)   |
| No CEE                                          | 64 | 7 (10.9)                      | 1.0                 |
| **Continued to play**                           |    |                               |                     |
| CEE                                              | 264| 64 (24.2)                     | 0.80 (0.47, 1.36)   |
| No CEE                                          | 64 | 12 (18.8)                     | 1.0                 |
| **Disclosed all concussions**                   |    |                               |                     |
| CEE                                              | 79 | 63 (79.8)                     | 0.90 (0.58, 1.39)   |
| No CEE                                          | 8  | 7 (87.5)                      | 1.0                 |

*Mean difference was statistically significant (excluded 0.00 in 95% CI).

**Abbreviations:** n=Number of observations used in each model output; SD=Standard deviation; MD=Mean difference; CI=Confidence interval; CEE=Concussion education exposure; PR=Prevalence ratio.
Table 3. Prevalence ratios (PR) and 95% confidence intervals (CI) for associations of student-athlete characteristics with concussion education source number.

|                          | Multiple Sources n (%) | Single Source n (%) | PR (95%CI) for Concussion Education Number (Multiple Sources vs. Single Source) |
|--------------------------|------------------------|---------------------|--------------------------------------------------------------------------------|
| **Sex**                  |                        |                     |                                                                                |
| Female                   | 70 (57.9)              | 51 (42.2)           | 0.82 (0.68, 0.99)\(^a\)                                                      |
| Male                     | 99 (70.2)              | 42 (29.8)           | 1.0                                                                            |
| **Race**                 |                        |                     |                                                                                |
| Caucasian                | 136 (64.5)             | 75 (35.6)           | 0.98 (0.78, 1.22)                                                             |
| Non-Caucasian            | 33 (66.0)              | 17 (34.0)           | 1.0                                                                            |
| **School Year**          |                        |                     |                                                                                |
| First Year               | 55 (68.8)              | 25 (31.3)           | 1.07 (0.89, 1.28)                                                             |
| Upperclassman            | 124 (64.3)             | 69 (35.8)           | 1.0                                                                            |
| **Sport**                |                        |                     |                                                                                |
| Contact                  | 145 (68.1)             | 68 (31.9)           | 1.22 (0.96, 1.56)                                                             |
| Non-Contact              | 34 (55.7)              | 27 (44.3)           | 1.0                                                                            |
| **Concussion History**   |                        |                     |                                                                                |
| Yes                      | 58 (68.2)              | 27 (31.8)           | 1.07 (0.89, 1.28)                                                             |
| No                       | 120 (63.8)             | 68 (36.2)           | 1.0                                                                            |

\(^a\)Prevalence ratio was statistically significant (excluded 1.00 in 95%CI).

Note: Percentages based off row totals. Total samples for each variable differ due to missing data: sex was missing 12 responses; race, 13 responses; school year, 1 response; sport, 0 responses; and concussion history, 1 response.

Abbreviations: n=Number of observations; PR=Prevalence ratio; CI=Confidence interval
Table 4. Adjusted mean differences (MD), prevalence ratios (PR), and 95% confidence intervals (CI) assessing association of concussion education source number with concussion-related outcomes.

| Continuous Outcomes (Linear Regression Models) | n  | Mean (SD) of Outcome for Each Group | Adjusted MD (95% CI) |
|-----------------------------------------------|----|-------------------------------------|---------------------|
| **Concussion knowledge**                      |    |                                     |                     |
| Multiple sources                              | 158| 33.0 (6.0)                          | -0.01 (-1.46, 1.44) |
| Single source                                 | 87 | 33.4 (4.8)                          | 0.0                 |
| **Attitudes**                                 |    |                                     |                     |
| Multiple sources                              | 165| 33.0 (7.0)                          | 0.01 (-1.81, 1.82)  |
| Single source                                 | 91 | 33.2 (7.5)                          | 0.0                 |
| **Perceived social norms**                    |    |                                     |                     |
| Multiple sources                              | 168| 45.1 (4.2)                          | 0.26 (-0.85, 1.37)  |
| Single source                                 | 92 | 45.0 (4.7)                          | 0.0                 |

| Categorical Outcomes (Binomial Regression Models) | n  | n (%) of Outcome for Each Group | Adjusted PR (95% CI) |
|--------------------------------------------------|----|--------------------------------|---------------------|
| **Higher disclosure intention**                  |    |                                 |                     |
| Multiple sources                                | 169| 149 (88.2)                      | 0.97 (0.90, 1.05)   |
| Single source                                   | 93 | 85 (91.4)                       | 1.0                 |
| **Higher perceived disclosure control**         |    |                                 |                     |
| Multiple sources                                | 169| 156 (92.3)                      | 0.95 (0.85, 1.07)   |
| Single source                                   | 93 | 90 (96.8)                       | 1.0                 |
| **Removed oneself from play**                   |    |                                 |                     |
| Multiple sources                                | 169| 47 (27.8)                       | 0.99 (0.70, 1.39)   |
| Single source                                   | 93 | 19 (20.4)                       | 1.0                 |
| **Continued to play**                           |    |                                 |                     |
| Multiple sources                                | 169| 44 (26.0)                       | 1.14 (0.74, 1.75)   |
| Single source                                   | 93 | 19 (20.4)                       | 1.0                 |
| **Disclosed all concussions**                   |    |                                 |                     |
| Multiple sources                                | 52 | 43 (82.7)                       | 1.11 (0.86, 1.43)   |
| Single source                                   | 26 | 19 (73.1)                       | 1.0                 |

**Abbreviations:** n=Number of observations used in each model output; SD=Standard deviation; MD=Mean difference; CI=Confidence interval; PR=Prevalence ratio