



Survey of NCAA Student Athletes' Valuation of Experienced Symptoms: A Missing Link Between Concussion Symptomology and Reporting Behavior

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It is estimated that more than 3.8 million sport-related concussions occur annually in the United States, with potentially up to 43% of these unreported and untreated. The purpose of this study was to determine whether any particular sub-group of NCAA athletes is more at-risk to underreport symptoms, events deemed less-severe than concussions, or suspected concussions. We further aimed to assess reasons for not reporting suspected concussive events following a head impact. Student-athletes from 127 NCAA institutions completed an online survey to assess the influence of race, gender, socioeconomic factors, NCAA division, and sport category on the reporting of "sub-concussive" and concussive events, as well as the concussion symptoms they had experienced in sport. The survey also included questions designed to gauge student-athletes' general knowledge of and attitudes about concussions, and to determine any discrepancies between ideal and actual behavior when faced with hypothetical situations involving concussion-like symptoms. Results indicated that collision sport athletes and those competing at the Division II level were particularly at-risk for not reporting symptoms and potential concussive events. Furthermore, student-athletes who listed higher symptom severity to indicate concussion also reported fewer self-defined "sub-concussive events", highlighting a missing link in understanding reporting behavior.

Keywords: intercollegiate athletics, student-athletes, concussion reporting, concussion symptoms, brain injury

Sport-related concussions are traumatic brain injuries induced by biomechanical forces. These injuries can result in functional disturbance that can involve loss of consciousness (McCrory et al., 2017). Clinically, concussions are characterized by immediate and transient post-traumatic impairment of neural functions, such as disturbance of vision and/or equilibrium (Guskiewicz et al., 2000), cognitive deficit, and increased risk for long-term effects (Belanger et al., 2010; Mez et al., 2019; Studenka & Raikes, 2017). Effects can also include metabolic instability, altered neurotransmission, chronic headache, fatigue, sleep difficulties, irritability, sensitivity to light, dizziness, and deficits in short term memory (Chrisman et al., 2013; McCrea et al., 2003).

Research suggests that approximately 3.8 million sport-related concussions occur annually in the United States, and that females experience a disproportionately greater number than males (Covassin et al., 2003a; Harmon et al., 2013). Given these data, it is not surprising that concussions are now recognized as a major public health concern (*TBI Data and Statistics*, 2019; *WHO | Neurotrauma*, n.d.). Concussions are also acknowledged as an increasingly dangerous and difficult-to-manage condition among National Collegiate Athletics Association (NCAA) student-athletes who participate in contact and collision sports (*NCAA.Org - The Official Site of the NCAA*, n.d.). Of specific concern are undiagnosed concussions, which can develop into more complicated issues including longer recovery time and increased risk for further injury (Guskiewicz et al., 2003, 2005; Meehan III et al., 2012). Therefore, the underreporting of potential concussive events represents a major barrier to the protection of student-athletes from deleterious consequences to short- and long-term health.

Current research suggests that over half the intercollegiate student-athletes who experience symptoms following potential concussion do not report them (Kerr et al., 2016; Register-Mihalik, Guskiewicz, et al., 2013). According to an anonymous survey of 262 college student-athletes, 43% reported knowingly hiding concussion symptoms to stay in a game, and 22% indicated that they were unlikely to report concussion symptoms to a coach or certified athletic trainer (ATC) in the future (Torres et al., 2013). Even more alarming, only 13% of student-athletes reported potential concussive injuries self-classified as “bell ringers” or “dings” (potential concussions; Torres et al., 2013). This highlights the reality that a potentially large number of undiagnosed concussive injuries may go untreated due to student-athletes’ misinterpretation of concussion symptoms, diminishment of concussion symptoms as “sub-concussive events”, or blatant disregard for experienced symptomology (Kerr et al., 2016). Several studies indicate that symptoms are not reported because athletes are not sure that they indicate concussion (Chrisman et al., 2013; Lininger et al., 2017), or believe that symptoms experienced following head impact are not severe enough to indicate concussion (Davies & Bird, 2015; Register-Mihalik, Guskiewicz, et al., 2013). This underreporting due to diagnostic uncertainty persists despite adequate knowledge of concussion (Chrisman et al., 2013). Therefore, one main aim of this study was to examine the link between valuation of symptoms experienced and reporting intent and behavior.

The body of literature on concussion reporting suggests that non- and under-reporting occurs for several reasons including: a lack of student-athlete education, a discounted view on the severity of concussions and/or symptoms, a desire to remain “in the game,” a lack of coach approachability, a desire not to let down teammates, coaches, and fans, and other motivators such as scholarships and personal identity (Chrisman et al., 2013; Kroshus et al., 2017). A recent

systematic review of barriers to concussion reporting indicated major reasons for not reporting suspected concussion included: fear of losing current or future playing time, a misconception that concussive injury is not serious, a fear of letting one's team down, and a lack of knowledge of concussion signs and symptoms (Clark & Stanfill, 2019). Lastly, research has shown that social and psychological factors such as team norms and coach expectations influence whether or not an athlete is willing to, and ultimately will, report concussion (Chrisman et al., 2013; Kneavel et al., 2019; Register-Mihalik et al., 2020). Given the practical need to protect student-athletes from the short- and long-term dangers of concussions, it is important that suspected concussions and symptoms be reported and diagnosed. However, little work has been designed to identify specific characteristics of student-athletes that may predispose them to be at greater risk to misrepresent or not report potential concussive events, or concussive symptomology. Therefore, the second aim of this study was to determine the demographic sub-groups of NCAA student-athletes who are most at-risk to misinterpret, misrepresent or not report concussive symptoms.

In line with our first aim, we hypothesized that student-athletes who report that symptoms must be more severe to indicate concussion would also be more likely to misrepresent or not report suspected concussive events or concussive symptomology. In line with our second aim, we hypothesized that significant and meaningful differences in concussion reporting rates would exist across genders, sport type, and collegiate division. We also explored potential links to racial/ethnic grouping, parental education and parental income.

Methods

Participants

The sample of individuals who completed the survey ($N = 240$) included 92 males and 148 females, ranging in age from 18 to 29 years ($M = 19.76$, $SD = 1.42$). This sample size is in line with past work in this area (Kerr et al., 2015, 2016). Student-athletes were drawn from 127 institutions and were participating in 16 sports across all three NCAA Divisions (I, $n = 60$; 25%; II, $n = 105$; 43%; III, $n = 75$; 31.3%). The sample was comprised of student-athletes who identified as White or Caucasian ($n = 194$; 80.8%), More than one race ($n = 13$; 5.4%), Black or African-American ($n = 11$; 4.6%), Asian ($n = 9$; 3.8%), Unknown ($n = 6$; 2.5%), Other ($n = 4$; 1.7%), and American Indian/Alaskan Native ($n = 3$; 1.3%). Parents of these student-athletes represented a primarily educated cohort of individuals, with 175 mothers (72.9%) and 184 fathers (76.7%) having earned at least a bachelor's degree, as reported by their children. The majority of student-athletes also reported being raised in middle- to upper-middle-class homes, with 25 (13.7%) reporting household incomes less than \$50,000, 78 (32.5%) reporting household incomes from \$50,000 to \$100,000, and 100 (41.7%) reporting household incomes more than \$100,000.

Procedures

Subsequent to approval by an institutional review board for the protection of human subjects, a purposeful sample of Division I ($n = 49$), II ($n = 44$), and III ($n = 34$) institutions was targeted for recruitment. Our aim was to sample one college or university from each division in each U.S. state; however, not every state contains an institution in each division. Contact information for head athletic trainers from these 127 institutions was gleaned from publicly

available information on the internet. An e-mail containing a scripted message for student-athletes was sent to head ATCs who were asked to forward the recruiting emails to student-athletes at their respective institutions. After clicking a survey link embedded in this email, student-athletes were asked to respond to 32 questions pertaining to participant demographics (12 items), concussion knowledge (3 items), attitudes about concussion (3 items), intent to report (2 items), and recalled report behavior (12 items). Survey links remained active for ten weeks post-distribution and the research team sent reminder emails to trainers on three occasions. Student-athletes provided consent electronically and completion of the online survey took approximately 15 minutes. Twenty student-athletes who completed at least 75% of the survey were randomly selected as \$25 Amazon gift card winners at the conclusion of the research.

Measures

Student-Athlete and Family Demographics. Student-athletes' gender, race/ethnicity, sport division, and sport category, and parents' combined household income and level of education, were assessed in the demographic portion of the online survey. Sport category was operationalized based on the NCAA's published hierarchy of sport types (*NCAA.Org - The Official Site of the NCAA*, n.d.). Specifically, *limited-contact* sports included bowling, cross country, fencing, golf, rifle, rowing, swimming, tennis, track and field, and volleyball; *contact* sports included baseball, basketball, cheerleading, diving, equestrian, gymnastics, softball, water polo; and *collision* sports included field hockey, football, ice hockey, lacrosse, rugby, skiing, soccer, and wrestling. A chi squared analysis was conducted to determine whether we had equal numbers of participants across the three sport categories across all three divisions. The chi squared analysis on division and sport category was significant, $X^2(4, N = 214) = 29.41, p < .001$. Post hoc comparison of categories using adjusted residuals and adjusted p-value for nine comparisons (critical z value of -2.78) revealed that there were more contact athletes in Division III than would be expected (adjusted residual = 5.33) and fewer contact athletes in Division II than would be expected (adjusted residual = -3.14). Parents' combined gross household income was divided into high and low categories based on a \$100,000 split criterion. Parental education was divided into three categories: less than a four-year degree, four-year degree, and advanced degree. Due to relative homogeneity across the study sample, race/ethnicity was divided into just two categories: White and non-White.

Concussion Knowledge. Student-athletes' concussion knowledge was measured using study-designed survey questions related to: (a) knowledge about concussion symptomology (20 items), (b) general concussion knowledge (3 items), and (c) knowledge about the impact of multiple concussions (5 items; see Table 1; Register-Mihalik, Guskiewicz, et al., 2013). Individual scores were tabulated by assigning a value of +1 for each correct answer. This value was then divided by the total number of items ($n = 28$) to calculate a correct response percentage.

Table 1

Concussion knowledge questions

Please indicate (by checking the box beside the response) which of the following you would consider to be a sign or symptom of concussion. Select all that apply.	#	%
Abnormal sense of smell (False)	202	84
Abnormal sense of taste (False)	203	85
Amnesia (True)	158	66
Joint stiffness (False)	218	91
Blurred vision (True)	227	95
Black eye (False)	207	86
Bleeding from the ear (False)	181	75
Bleeding from the mouth (False)	215	90
Bleeding from the nose (False)	191	80
Confusion (True)	235	98
Fever (False)	203	85
Dizziness (True)	235	98
Headache (True)	236	98
Insomnia (True)	120	50
Loss of consciousness (True)	211	88
Nausea (True)	200	83
Numbness/tingling of arms (True)	154	64
Skin rash (False)	236	98
Sharp burning pain in neck (False)	159	66
Weakness in neck movements (False)	123	51
Which of the following is true regarding concussions? Select all that apply.		
A concussion only occurs if you lose consciousness (False)	232	97
If you are experiencing any signs or symptoms of concussion after a blow to the head or sudden movement of the body, you should not return to play (True)	225	94
A concussion is an injury to the brain (True)	230	96
Of the following, what are possible complications of having multiple concussions? Select all that apply.		
Increased risk of further injury (True)	220	92
Brain damage (True)	238	99
Joint problems (False)	205	85
Memory problems (True)	227	95
No complications exist (False)	240	100
The correct answer is included in parenthesis. The number and percent represent athletes who chose the correct answer.	average score:	85

Attitudes About Concussion. Three factors were used to measure student-athletes' attitudes about concussion: (1) symptom intensity to be considered a concussion, (2) symptom intensity indicating a concussion should be reported, and (3) likelihood to advise symptom reporting (see appendix A). When considering symptom intensity to be considered a concussion, eight commonly recognized symptoms of concussion were listed (Kroshus et al., 2014; McCrory et al., 2005). These included duration of loss of consciousness, nausea, dizziness, light sensitivity, feeling dazed, amnesia, balance problems, and headaches. The scale assessing the intensity of each symptom to be rated ranged from 1 (*no symptoms at all*) to 7 (*intensely symptomatic*). Mean levels of symptom intensity were calculated such that higher scores indicated a more intense level of a symptom was necessary for a student-athlete to consider that a concussion had occurred. A single, study-designed question was used to assess whether student-athletes believed symptom intensity indicated a concussion *should be* reported. The same eight symptoms were listed and a parallel 1-to-7 Likert scale was used. Mean levels of symptom severity were calculated such that higher scores indicated a more severe level of a symptom was necessary to indicate a concussion *should be* reported. The likelihood for a student-athlete to advise another student-athlete to report symptoms was measured using the question: "How likely would you be to advise another athlete to report his/her symptoms to a coach or athletic trainer if he/she had hit his/her head and was exhibiting any of these symptoms?" Responses utilized the same 1-to-7 Likert scale.

Intent to Report. Two factors were used to measure student-athletes' intent to report: (1) symptom intensity indicating a student-athlete *would report* his/her own symptoms, and (2) the likelihood to report his/her own symptoms. The level of symptom intensity necessary to indicate a concussion *would be* reported by that particular student-athlete was assessed using the previously annotated eight symptoms and 1-to-7 Likert scale. Mean levels of symptom intensity were calculated such that higher scores indicated a more intense level of a symptom was necessary to compel concussion reporting. The likelihood for student-athletes to report their own symptoms was measured using the single, study designed question: "If you collided with another athlete and began to experience any of these symptoms, how likely would you be to report it to a coach or athletic trainer?" Responses were prompted by the same eight symptoms and answered on the same 1-to-7 Likert scale.

Report Behavior. Twelve questions aimed at assessing report behavior. Three factors were used to measure student-athletes' recollection of concussion events: (1) total times symptoms were experienced, (2) total times a "sub-concussive" event was suspected to have occurred, and (3) total times a concussion was diagnosed or suspected. The total times symptoms were experienced was assessed directly following the rating of symptom intensity and using the single question: "How many times have you felt any of these symptoms after an impact (with another player, the ground, or anything else) during practice or a game during your collegiate career?" To calculate *symptom report ratio*, the number of times a student-athlete had reported symptoms to a coach or trainer ("How many times have you told a coach or athletic trainer that you were experiencing these symptoms during your collegiate career?") was divided by the total times symptoms were experienced.

The survey did not ask about "sub-concussive" events directly; rather, following the question referring to symptom intensity, a follow-up, open-ended question was asked: "If any of these symptoms occur, but are not severe enough to be considered a concussion, what would you

typically call the incident?” Following this question, two additional questions referred to “the incident” rather than a “sub-concussive event”: “How many times have you EXPERIENCED such an incident during your collegiate career?” and “How many times in your collegiate career have you REPORTED such an incident to your coach or athletic trainer?” For each of these questions, a subject was asked to select an option from 0 to ‘10+’. “*Sub-concussive event*” *report ratio* was calculated as the number of “sub-concussive” events a student-athlete had reported to a coach or trainer divided by the total times a “sub-concussive” event was suspected.

The total times a concussion was suspected or reported was assessed using two questions: “How many total concussions have you experienced that were DIAGNOSED by a medical professional (athletic trainer or doctor) during your collegiate career?” and “How many total concussions do you SUSPECT you may have experienced that were NOT diagnosed by a medical professional (athletic trainer or doctor) during your collegiate career?” To calculate *concussion report ratio*, the number of concussions a student-athlete recalled as having been diagnosed by a trainer or doctor was divided by the number of diagnosed concussions plus the number of concussions the student-athlete suspected had occurred, but had not reported.

In addition to recalled report behavior, four questions were asked to assess participants’ reasons for symptoms and events either being reported or not reported. Regarding symptoms, participants were asked “Why did you choose to tell the coach or athletic trainer that you were feeling those symptoms during your collegiate career? Check all that apply” and “Why did you choose to NOT report to a coach or athletic trainer that you were feeling any of those symptoms during your collegiate career? Check all that apply.” Regarding the self-termed “sub-concussive” event, participants were asked “If applicable, why DID you tell your coach or athletic trainer about such an incident? Select all that apply.” Participants were also asked, “If applicable, why did you NOT tell your coach or athletic trainer about such an incident? Select all that apply.” These response choices were guided by one qualitative assessments of reasons for not reporting suspected concussions (Chrisman et al., 2013) and two assessments of similar forced response survey questions ((McCrea et al., 2004; Register-Mihalik, Guskiewicz, et al., 2013).

Data Analysis

Descriptive statistics were calculated to summarize the data. Data were then cleaned and screened according to the recommendations of Tabachnick & Fidell (2013). All data conformed to the assumptions of multivariate analysis. All quantitative data were analyzed using the software program SPSS 25. Correlations were run between all survey variables. MANOVAs were run separately for all control variables (gender, race, sport category, division, parental income, father’s education & mother’s education) with all survey measures (concussion knowledge score, symptom intensity to be considered a concussion, symptom intensity indicating a concussion should be reported, likelihood to advise symptom reporting, symptom intensity indicating a concussion would be reported, likelihood to report own symptoms, total times symptoms were experienced, total suspected “sub-concussive” events, total suspected concussions, symptom report ratio, “sub-concussive” event report ratio, concussion report ratio) as dependent variables. Tukey post-hoc tests were run for sport category and division. Only significant models are discussed below.

Results

Descriptive Statistics

Student-athletes were generally knowledgeable about concussions. The mean score for concussion knowledge was 85%. Student-athletes also reported that symptoms needed to be moderately high on a scale from 1 to 7 for symptoms to indicate a concussion had occurred ($M = 4.8$, $SD = 1.4$). Likewise, symptom intensity that would indicate a student-athlete *should report* a concussion was rated moderately high on the same scale ($M = 4.4$, $SD = 1.5$). Interestingly, the likelihood for a student-athlete to advise another teammate to report symptoms was higher than the likelihood to report one's own symptoms ($M = 5.8$, *Median* = 6.0). Data also highlighted the relatively high symptom intensity level that would lead a student-athlete to report a concussion ($M = 4.5$, $SD = 1.5$). Finally, the likelihood for a student-athlete to report his/her own concussion was relatively high ($M = 4.7$, *Median* = 5.0).

Frequency statistics suggest that, on average, student-athletes had experienced symptoms of concussion 1.46 ($SD = 2.46$) times, suspected "sub-concussive" events 2.03 ($SD = 1.77$) times, and suspected concussions 1.18 ($SD = 2.01$) times, respectively. The majority of student-athletes had never experienced symptoms of a concussion (59.2%), a suspected "sub-concussive" event (58.8%), or a suspected concussion (59.4%). Fewer student-athletes reported having experienced one (17.1 %), two (11.3%), or three or more (13%) "sub-concussive" events. Likewise, a small percentage of student-athletes reported having experienced one (14.6%), two (9%) or three or more (17%) concussive events. It is also worth noting that concussion report ratio ($M = .33$, $SD = .37$) and symptom report ratio ($M = .43$, $SD = .41$) were low, given the fact that student-athletes reported suspected "sub-concussive events" at much higher ratios ($M = .90$, $SD = .38$).

Correlations

When examining bivariate correlations, a number of statistically significant and practically meaningful associations emerged (see Table 2). First, student-athletes' concussion knowledge score was negatively correlated with their concussion report ratio ($r = -.22$), indicating greater concussion knowledge was associated with less reporting of symptoms that might indicate concussion. 'Symptom intensity to be considered a concussion' was positively related to 'symptom intensity indicating symptoms should be reported' ($r = .62$), and 'likelihood to advise symptom reporting' ($r = .19$). Surprisingly, 'symptom intensity indicating symptoms should be reported' was not associated with the likelihood to advise symptom reporting ($r = -.01$).

'Symptom intensity to be considered a concussion' was positively associated with both 'symptom intensity signifying the student-athlete would report' his/her concussion ($r = .40$) and his/her 'likelihood to report symptoms' ($r = .19$). Symptom intensity indicating a student-athlete *should report* a concussion was positively associated with symptom intensity signifying that a student-athlete *would report* a concussion ($r = .63$). Likewise, the 'likelihood to advise symptom reporting' was positively associated with the 'likelihood to report one's own symptoms' ($r = .58$). Both of these correlations demonstrate a link between attitudes about concussion reporting and intent to report.

'Symptom intensity to be considered a concussion' was negatively associated with the total suspected sub-concussive events ($r = -.18$), indicating that student-athletes who indicated

that symptoms needed to be more intense to indicate concussion also reported having experienced fewer sub-concussive events. Furthermore, the ‘likelihood to advise symptom reporting’ was negatively associated with the total times symptoms were experienced ($r = -.28$) and the total times a sub-concussive event was experienced ($r = -.28$). These findings highlight a potential link between concussion attitudes and recalled concussion-related events.

The ‘likelihood to advise symptom reporting’ was positively associated with reporting symptoms, suspected “sub-concussive” events, and suspected concussions ($r = .40$, $r = .22$, and $r = .26$, respectively). These findings demonstrate a link between student-athletes’ attitudes and reporting behaviors. Interestingly, the likelihood to report one’s own symptoms was negatively associated with the number of times symptoms were experienced ($r = -.31$) and the number of times sub-concussive events were suspected ($r = -.19$). The ‘likelihood to report symptoms’ was positively associated with symptom report ratio ($r = .59$), sub-concussive event report ratio ($r = .19$), and concussion report ratio ($r = .38$). This finding supports a link between intent to report and actual report behavior.

The total times symptoms were experienced was negatively associated with symptom report ratio ($r = -.38$) and “sub-concussive” event report ratio ($r = -.31$), indicating that the more times symptoms were experienced, the fewer times these symptoms were reported or categorized as “sub-concussive” events. The total experienced “sub-concussive” event measure was also negatively associated with “sub-concussive” event report ratio ($r = -.54$), indicating that a greater number of recalled “sub-concussive” events was associated with smaller ratios of reporting these events. Lastly, the total number of suspected and experienced concussions was negatively associated with “sub-concussive” event reporting ($r = -.25$), indicating that a greater number of experienced concussions may be linked to a lower likelihood of reporting events that result from head impact and are accompanied by symptoms not deemed severe enough to indicate concussion.

Finally, it is worth noting that all three measures of reporting behavior (actual reporting behavior, hypothetical reporting behavior, and hypothetically encourage teammate reporting behavior) were positively associated with each other, indicating that report behavior may not be event-specific. For example, individuals who were more likely to report symptoms were also more likely to report suspected sub-concussive events and suspected concussions ($r = .20$ and $r = .53$, respectively).

Group Difference Tests

Student-Athlete Gender. The full model for gender was significant (female $n = 127$; male $n = 76$), $F(9, 193) = 2.06$, $p = .04$, $\eta_p^2 = .09$. Female student-athletes were significantly more likely to advise another student-athlete to report symptoms indicating concussion ($M = 6.08$, $SD = 1.09$) than males ($M = 5.41$, $SD = 1.6$), $F(1, 201) = 14.55$, $p < .001$, $\eta_p^2 = .07$.

Student-Athlete Sport Category. The full model for student-athlete sport category was also significant (collision $n = 85$, contact $n = 55$, limited-contact $n = 63$), $F(18, 384) = 2.41$, $p < .001$, $\eta_p^2 = .101$. The number of times a student-athlete felt symptoms potentially indicating a concussion was significantly different between groups, $F(2, 200) = 16.90$, $p < .001$, $\eta_p^2 = .145$. Tukey post-hoc contrasts revealed that student-athletes participating in collision sports experienced concussion-related symptoms a significantly greater number of times ($M = 2.69$, $SD = 3.21$) than contact sport student-athletes ($M = 1.15$, $SD = 1.65$), $p < .001$. In addition,

student-athletes participating in collision sports experienced concussion-related symptoms a significantly greater number of times than student-athletes participating in limited-contact sports, ($M = .54$, $SD = 1.11$), $p < .001$. The number of times a student-athlete suspected a “sub-concussive” event also differed significantly among groups, $F(2, 200) = 8.77$, $p < .001$, $\eta^2_p = .081$, as did the number of times a student-athlete suspected or was diagnosed with a concussive event, $F(2, 200) = 7.43$, $p = .001$, $\eta^2_p = .069$. Tukey post-hoc comparisons revealed that student-athletes participating in collision sports ($M = 2.68$, $SD = 2.19$) reported a significantly greater number of suspected sub-concussive events than student-athletes participating in limited-contact sports ($M = 1.46$, $SD = .88$, $p < .001$). Likewise, student-athletes participating in collision sports reported a significantly greater number of suspected and diagnosed concussive events ($M = 1.75$, $SD = 2.43$) than student-athletes participating in limited-contact sports ($M = .51$, $SD = 1.11$; $p = .001$).

Tests on Computed Ratios

Separate ANOVA's and t-tests were performed to determine differences among demographic sub-groups on the measured dependent variables; (1) symptom report ratio, (2) sub-concussive event report ratio, and (3) concussion report ratio.

Symptom Report Ratio. Symptom report ratio was significantly greater for female student-athletes ($n = 60$, $M = .50$, $SD = .38$) than for male student-athletes ($n = 38$, $M = .31$, $SD = .43$), $t(96) = -2.29$, $p = .024$, $d = .468$ (see Figure 1). Symptom report ratio also differed across collegiate divisions, $F(2, 95) = 5.87$, $p = .004$, $\eta^2_p = .110$. Specifically, symptom reporting was significantly greater for student-athletes participating at the Division I level ($n = 21$, $M = .53$, $SD = .38$) than those at the Division II level ($n = 45$, $M = .28$, $SD = .37$), $p = .045$. Symptom reporting was also significantly greater for student-athletes participating at the Division III level ($n = 32$, $M = .56$, $SD = .42$) than those at the Division II level, $p = .006$.

“Sub-Concussive” Event Report Ratio. “Sub-concussive” event report ratio differed across the three divisions, $F(2, 237) = 4.12$, $p = .017$, $\eta^2_p = .034$ (see Figure 2). Specifically, “sub-concussive” event reporting was significantly lower among student-athletes at the Division II level ($n = 105$, $M = .82$, $SD = .32$) than those at the Division III level ($n = 75$, $M = .98$, $SD = .47$), $p = .022$. “Sub-concussive event” report ratio also differed across the three sport categories, $F(2, 237) = 3.32$, $p = .038$, $\eta^2_p = .027$. Specifically, student-athletes participating in collision sports reported significantly fewer “sub-concussive events” ($n = 97$, $M = .83$, $SD = .48$) than those participating in limited-contact sports ($n = 74$, $M = .96$, $SD = .22$), $p = .043$.

Concussion Report Ratio. Concussion report ratio differed across levels of mother's education, $F(2, 84) = 4.215$, $p = .018$, $\eta^2_p = .091$ (see Figure 3). Specifically, student-athletes with mothers who attained a four-year college degree reported a significantly greater number of concussions ($n = 33$, $M = .46$, $SD = .41$) than student-athletes whose mothers had attained an advanced degree ($n = 21$, $M = .20$, $SD = .32$), $p = .024$. Concussion report ratio also differed across the three collegiate divisions, $F(2, 84) = 3.86$, $p = .025$, $\eta^2_p = .084$. Concussion report ratio was significantly greater for student-athletes at the Division III level ($n = 26$, $M = .45$, $SD = .33$) than for those at the Division II level ($n = 43$, $M = .22$, $SD = .34$), $p = .03$.

Table 2
Correlations Among All Measured and Computed Variables

	ATTITUDES			INTENT TO REPORT		RECALLED EVENTS			RECALLED REPORT BEHAVIOR		
	symptom intensity to be considered a concussion	symptom intensity should report	likelihood to advise symptom reporting	symptom intensity would report	likelihood to report own symptoms	total times symptoms were experienced	total suspected sub-concussive events	total suspected concussions	symptom report ratio	sub-concussive event report ratio	concussion report ratio
Concussion knowledge score	Pearson correlation Sig. (2-tailed) N	-0.040 0.539 239	-0.047 0.472 239	0.079 0.221 239	-0.097 0.133 239	0.050 0.439 239	0.029 0.655 239	0.034 0.133 211	-0.219* 0.031 97	-0.079 0.222 239	-0.175 0.108 86
Symptom intensity to be considered a concussion	Pearson correlation Sig. (2-tailed) N	0.624** 0.000 232	.186** 0.005 232	0.397** 0.000 232	0.188** 0.004 232	-0.042 0.527 232	-0.177** 0.007 232	-0.048 0.497 204	0.130 0.206 96	0.080 0.225 232	-0.002 0.985 85
Symptom intensity should report	Pearson correlation Sig. (2-tailed) N	-0.012 0.858 240	-0.012 0.858 240	0.627** 0.000 240	0.107 0.098 240	0.019 0.769 240	-0.077 0.233 240	-0.056 0.421 212	0.040 0.695 98	0.046 0.480 240	0.060 0.579 87
Likelihood to advise symptom reporting	Pearson correlation Sig. (2-tailed) N			0.016 0.801 240	0.581** 0.000 240	-0.283** 0.000 240	-0.280** 0.000 240	-0.087 0.207 212	0.398** 0.000 98	0.217** 0.001 240	0.261* 0.015 87
Symptom intensity would report	Pearson correlation Sig. (2-tailed) N				0.017 0.795 240	0.075 0.248 240	-0.024 0.707 240	0.047 0.498 212	-0.042 0.682 98	0.028 0.664 240	0.034 0.753 87
Likelihood to report own symptoms	Pearson correlation Sig. (2-tailed) N					-0.311** 0.000 240	-0.194** 0.003 240	-0.086 0.213 212	0.585** 0.000 98	0.185** 0.004 240	0.384** 0.000 87
Total times symptoms were experienced	Pearson correlation Sig. (2-tailed) N						0.610** 0.000 240	0.468** 0.000 212	-0.376** 0.000 98	-0.307** 0.000 240	-0.136 0.208 87
Total suspected sub-concussive events	Pearson correlation Sig. (2-tailed) N							0.637** 0.000 212	-0.070 0.492 98	-0.542** 0.000 240	-0.142 0.189 87
Total suspected concussions	Pearson correlation Sig. (2-tailed) N								0.106 0.307 95	-0.245** 0.000 212	-0.092 0.401 86
Symptom report ratio	Pearson correlation Sig. (2-tailed) N									0.199* 0.049 98	0.534** 0.000 67
Sub-concussive event report ratio	Pearson correlation Sig. (2-tailed) N										0.353** 0.001 87

* Correlation is significant at the 0.05 level (2-tailed). ** Correlation is significant at the 0.01 level (2-tailed).

Table 3

Descriptive statistics for symptoms, self-defined sub-concussive events, and concussive events.

	Symptoms	Self-defined Sub-Concussive Events	Concussive Events
# of times experienced	1.46 (2.46)	2.03 (1.77)	1.18 (2.01)
% never experienced	59,2	58,8	59,4
% having experienced 1	—	17,1	14,6
% having experienced 2	—	11,3	9,0
% having experienced 3 or more	—	13,0	17,0
Report ratio	.43 (.41)	.90 (.38)	.33 (.37)

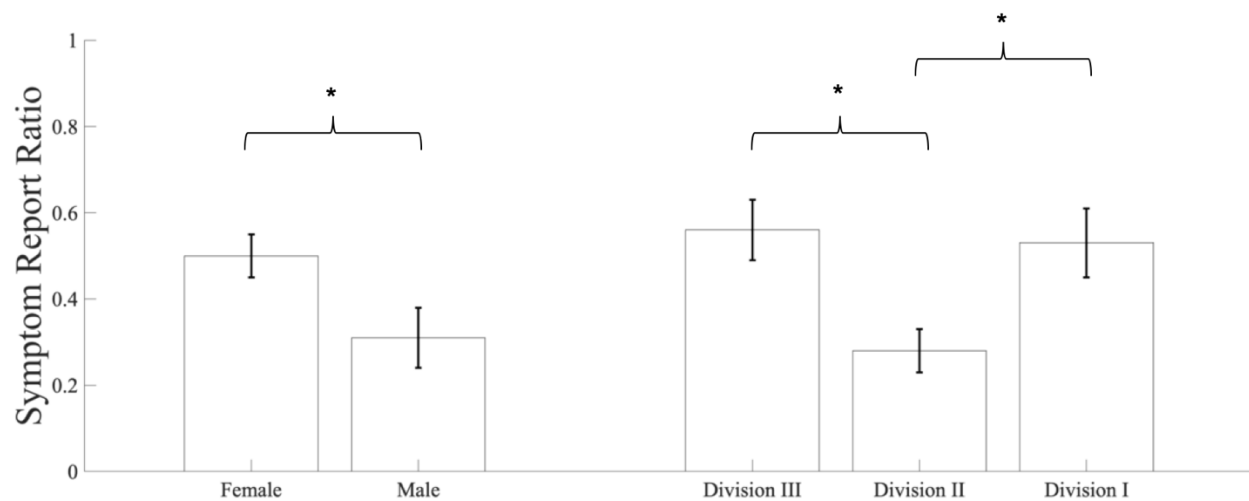


Figure 1.

Symptom report ratio for males and females and division I, II, and III student-athletes.

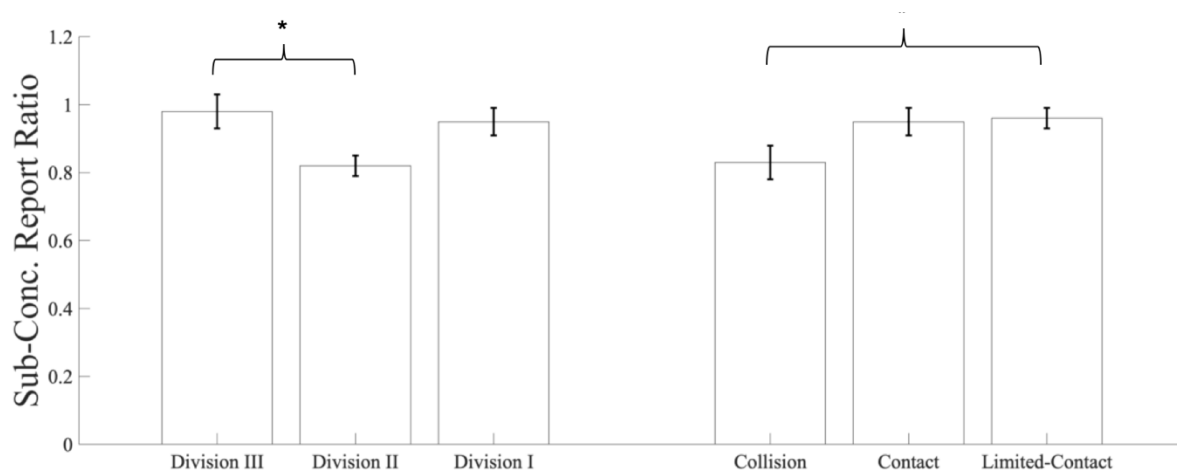


Figure 2.

Self-defined "sub-concussive event" report ratio for division I, II, and III student-athletes, and collision, contact, and limited-contact sport student-athletes.

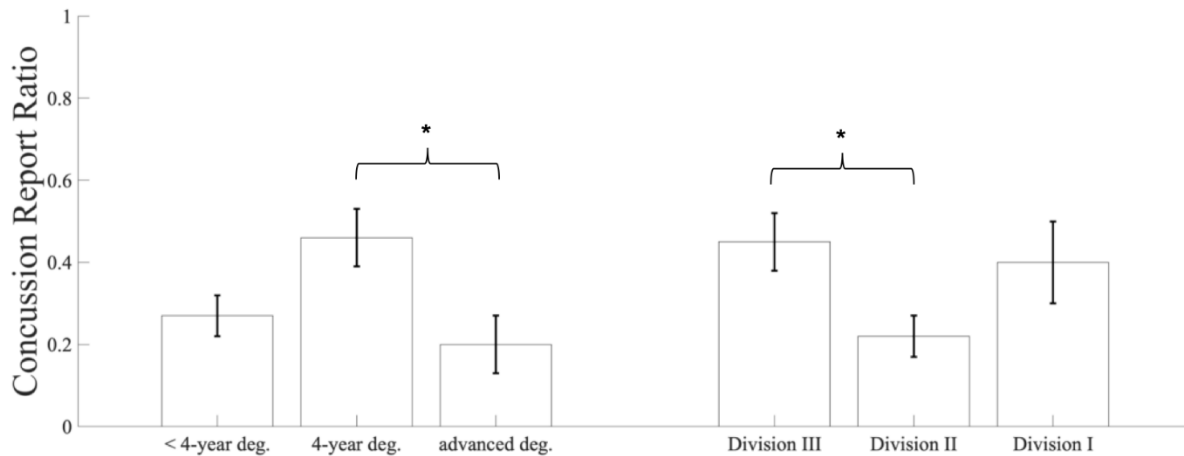


Figure 3.

Concussion report ratio for three levels of mother's education and division I, II, and III student-athletes.

Qualification of "Sub-Concussive" Events

All survey respondents were asked to respond with a term for a head impact resulting in symptoms not severe enough to be considered a concussion. All student-athletes responded to this open-ended item. Fifty student-athletes (20.8% of the sample) categorized the incident as a "head injury," "brain injury," or "trauma." Forty-one student-athletes (17.1% of the sample) categorized the incident as a "headache" or "migraine." Thirty-seven student-athletes (15.4%) labeled the incident as a "blow," "hit," "impact to the head," "collision," or a "bump/knock to the head." Twenty-five student-athletes (10.4%) described the symptoms as being due to a non-concussion-related incident such as "dehydration," "fatigue," "hunger," "soreness," or "generally not feeling well." Seventeen student-athletes (7.1% of the sample) classified the incident as a "mild," "minor," "slight," or "potential" concussion. Ten student-athletes (4.2%) categorized the incident as getting "dazed," "banged-up," "rocked," "blasted," or "shaken up". Nine student-athletes (3.8%) described the incident as a "stinger" or "whiplash." Seven student-athletes (2.9% of the sample) described the incident as a "bell-ringer," and an additional seven called it "nothing." Five student-athletes (2.1%) described the incident as a sub-concussive event and two (0.8%) classified the incident as a concussion. The remaining 30 participants did not know or were unsure how to label the incident.

Reasons Given for Not Reporting Events

Student-athletes were asked to choose from among a list of reasons why they chose to report or not report concussive symptoms or sub-concussive events to a coach, athletic trainer, or doctor. Frequencies of these responses are listed in Table 4. Respondents were also given an "Other" box to write in any reason not included in the option set. Reasons not captured by the forced option-set are listed in Table 5. The primary motivator for student-athletes' reporting of concussive symptoms was a concern for one's own safety. The two primary reasons for not reporting concussive symptoms were: (a) the certainty that their symptoms were not associated with a concussive event, and (b) the desire to keep playing. The same trend followed in reporting behavior regarding suspected "sub-concussive" events.

Table 4

Reasoning Reported by Athletes for Why They Chose to Report or Not Report a Sub-Concussive Event or Symptoms of a Concussion to a Coach or Athletic Trainer by Gender, NCAA Division, and Type of Sport

Symptoms - reported	Overall	Male (%)	Female (%)	Division I (%)	Division II (%)	Division III (%)	Football (%)	Non-Football (%)	Limited contact (%)	Contact (%)	Collision (%)
I'm supposed to report a concussion	45 (19%)	13 (14%)	32 (22%)	9 (15%)	11 (11%)	25 (33%)	1 (4%)	44 (21%)	8 (11%)	13 (19%)	24 (25%)
I was worried about my health/safety	65 (27%)	21 (23%)	44 (30%)	17 (28%)	19 (18%)	29 (39%)	4 (14%)	61 (29%)	16 (22%)	17 (25%)	32 (33%)
My teammates or family told me to do so	26 (11%)	6 (7%)	20 (14%)	6 (10%)	7 (7%)	13 (17%)	1 (4%)	25 (12%)	5 (7%)	10 (15%)	11 (11%)
I was not sure if I had a concussion or not	42 (18%)	18 (20%)	24 (16%)	12 (20%)	13 (12%)	17 (23%)	5 (18%)	37 (18%)	7 (10%)	12 (17%)	23 (24%)
Someone else noticed my symptoms	23 (9.6%)	5 (5%)	18 (12%)	7 (12%)	9 (9%)	7 (9%)	2 (7%)	21 (10%)	5 (7%)	9 (13%)	9 (9%)
The coach or trainer noticed my symptoms	33 (14%)	5 (5%)	28 (19%)	12 (20%)	12 (11%)	9 (12%)	2 (7%)	31 (15%)	6 (8%)	9 (13%)	18 (19%)
Sub-concussive event - reported											
I felt like something was wrong	61 (25%)	23 (25%)	38 (26%)	15 (25%)	18 (17%)	28 (37%)	6 (21%)	55 (26%)	12 (16%)	19 (28%)	30 (31%)
I considered that incident to be a concussion	34 (14%)	9 (10%)	25 (17%)	9 (15%)	7 (7%)	18 (24%)	2 (7%)	32 (15%)	4 (5%)	11 (16%)	19 (20%)
I could not play well after the incident	16 (7%)	6 (7%)	10 (7%)	2 (3%)	5 (5%)	9 (12%)	4 (14%)	12 (6%)	2 (3%)	3 (4%)	11 (11%)
I needed to take some time to recover	37 (15%)	12 (13%)	25 (17%)	10 (17%)	11 (11%)	16 (21%)	5 (18%)	32 (15%)	7 (10%)	11 (16%)	19 (20%)
Symptoms - unreported											
I know that I did not have a concussion	66 (28%)	28 (30%)	38 (26%)	15 (25%)	28 (27%)	23 (31%)	12 (43%)	54 (26%)	17 (23%)	16 (23%)	33 (34%)
I am a tough player	43 (18%)	20 (22%)	23 (16%)	12 (20%)	20 (19%)	11 (15%)	10 (36%)	33 (16%)	9 (12%)	11 (16%)	23 (24%)
I wanted to keep playing	66 (28%)	32 (35%)	34 (23%)	15 (25%)	34 (32%)	17 (23%)	21 (75%)	45 (21%)	9 (12%)	16 (23%)	41 (42%)
I am expected to play injured	10 (4%)	4 (4%)	6 (4%)	3 (5%)	3 (3%)	4 (5%)	3 (11%)	7 (3%)	2 (3%)	3 (4%)	5 (5%)
My coach would react poorly	15 (5%)	6 (7%)	7 (5%)	4 (7%)	7 (7%)	2 (3%)	6 (21%)	7 (3%)	1 (1%)	2 (3%)	10 (10%)
I didn't want to disappoint my coach, team, or fans	30 (13%)	12 (13%)	18 (12%)	5 (8%)	19 (18%)	6 (8%)	10 (36%)	20 (9%)	5 (7%)	7 (10%)	18 (19%)
My team needed me	33 (14%)	17 (19%)	16 (11%)	6 (10%)	18 (17%)	9 (12%)	11 (40%)	22 (10%)	7 (10%)	8 (12%)	18 (19%)
I didn't want to go to the doctor	22 (9%)	9 (10%)	13 (9%)	4 (7%)	13 (12%)	5 (7%)	5 (18%)	17 (8%)	7 (10%)	2 (3%)	13 (13%)
Sub-concussive event - unreported											
Not worth the trouble	39 (16%)	21 (23%)	18 (12%)	7 (12%)	23 (22%)	9 (12%)	11 (39%)	28 (13%)	9 (12%)	8 (12%)	22 (23%)
I did not consider that event to be a concussion	51 (21%)	26 (28%)	25 (17%)	9 (15%)	27 (26%)	15 (20%)	16 (57%)	35 (17%)	8 (11%)	11 (16%)	32 (33%)
I felt fine afterwards	44 (18%)	16 (17%)	28 (19%)	11 (18%)	22 (21%)	11 (15%)	8 (29%)	36 (17%)	8 (11%)	12 (17%)	24 (25%)
It's part of the game	37 (15%)	22 (24%)	15 (10%)	5 (8%)	21 (20%)	11 (15%)	15 (54%)	22 (10%)	5 (7%)	7 (10%)	25 (26%)
I am a tough player	40 (17%)	19 (21%)	21 (14%)	8 (13%)	19 (18%)	13 (17%)	10 (36%)	30 (14%)	6 (8%)	11 (16%)	23 (24%)

Table 5

OTHER Reasoning Reported by Athlete's for Why They Chose to Report or Not Report a Sub-Concussive Event or Symptoms of a Concussion to a Coach or Athletic Trainer

Symptoms - reported	Gender	Division	Football category	Sport category
Had to be helped off the field	Male	III	Football	Collision
I've had more than one concussion and knew the feeling	Female	III	Non-football	Contact
My car accident	Female	III	Non-football	Contact
Sub-concussive event - reported				
I care about my health	Female	III	Non-football	Contact
I couldn't walk off the field straight	Female	I	Non-football	Contact
I had to be helped off the field	Male	III	Football	Collision
I lost consciousness	Male	I	Football	Collision
I was hit in the head during a game and had to be sent off because of it	Female	II	Non-football	Contact
I was in a car accident	Female	III	Non-football	Contact
Mentioned black eye during preseason physicals, they determined I was concussed	Female	III	Non-football	Collision
My AT saw it happening	Female	II	Non-football	Collision
I knew she would get mad at me if I was complaining about a headache and didn't directly tell her about it	Female	III	Non-football	Collision
Teammates told me to	Female	III	Non-football	Contact
Teammates forced be to get checked	Male	I	Non-football	Limited-contact
The trainer came on the field because I went down and did not get back up	Female	II	Non-football	Collision
They noticed I wasn't acting like myself and asked what was wrong	Female	II	Non-football	Limited-contact
They saw it	Female	II	Non-football	Collision
They witnessed it an gave me an immediate evaluation	Female	II	Non-football	Collision
Was witnessed by coach and athletic trainer	Female	II	Non-football	Collision
I always tell if I have a head injury due to so many in the past	Female	II	Non-football	Limited-contact
Symptoms - unreported				
I didn't know I could have a concussion	Female	I	Non-football	Collision
I didn't want to go through the whole protocol again of being symptom free for 24 h, biking, running, etc... and I didn't want to miss class	Female	II	Non-football	Collision
I thought I didn't have one or it was minor	Male	II	Female	Collision
I'm prone to migranes	Female	II	Non-football	Limited-contact
It would quickly go away	Female	III	Non-football	Contact
Symptoms went away quickly	Male	II	Football	Collision
The symptoms were gone within a week and didn't feel like that was severe enough time to go through concussion protocol	Female	III	Non-football	Collision
Wasn't sure if it was just a headache from something else like stress	Female	I	Non-football	Collision
I knew it wasn't a concussion because I have experienced one before	Female	I	Non-football	Collision
Sub-concussive event - unreported				
Did not have to tell coach	Male	III	Non-football	Contact
I didn't want to lose my position in the game	Female	III	Non-football	Contact
Minor headaches are pretty common the first day back in pads	Male	III	Football	Collision
Momma ain't raise no bitch	Male	II	Football	Collision
Nothing too serious	Male	III	Non-football	Limited-contact
Symptoms went away quickly and were extremely below average	Male	II	Football	Collision
With other teammates, there was pressure from the coaches to tell the trainers they felt fine, so they would not have to go through the long process of returning	Female	I	Non-football	Contact

Discussion

The present research was designed to determine the demographic sub-groups of NCAA student-athletes who are most “at-risk” to misrepresent or not report concussive symptoms to a coach or ATC. Furthermore, a main aim was to examine the link between valuation of symptoms following a head impact and the intent to report and actual recalled report behavior of both events and symptoms. Our survey of 240 student-athletes from 127 institutions at the NCAA Division I, II, and III levels highlights a range of statistically significant and meaningful differences. Because this study represents the first attempt to assess student-athletes’ reporting of all three outcomes (suspected concussions, suspected “sub-concussive” events, and symptoms) independently and in relation to knowledge and attitudes about concussion and intent to report, our findings provide unique insight into the disconnect between current return-to-play protocols and student-athletes’ reporting behavior.

In particular, four demographic factors contributed to differences in attitudes about concussion, intent to report, and recalled report behavior: gender, mother’s education, sport category, and collegiate division. While the numbers of experienced symptoms, suspected “sub-concussive” events, and suspected concussion did not differ between men and women, women were more likely to advise another student-athlete to report symptoms than males. Females also reported their own symptoms more often than males. This finding supports other research showing that females are more likely to report concussion symptoms (Wallace et al., 2017) and suspected concussions (McAllister-Deitrick et al., 2020) over males, and exhibit greater intent to report both symptoms and suspected concussions over males (Kroshus et al., 2017).

The only other socio-demographic variable that predicted report behavior was mother’s education level. Student-athletes whose mothers had attained a 4-year degree also reported significantly greater number of concussions than student-athletes whose mothers had attained an advanced degree. To our knowledge, this is the first study to associate mother’s education with recalled concussive events. Previous literature examining college student-athletes has highlighted the potential relationship between parental education and student-athlete well-being outcomes (Dorsch et al., 2016). Furthermore, mother’s education in particular was a significant predictor of overall collegiate academic success for football athletes (Lang et al., 1988). Donnell et al., (2018) reported concussion education disparities related to parental income, which might also be related to parental education. Future studies might look at the link between athlete well-being and academic success or failure with experienced concussions and or the willingness to report those events.

Sport category was a significant predictor of experienced symptoms, “sub-concussive” events, and concussive events with student-athletes participating in collision sports experiencing symptoms, perceived “sub-concussive” events, and suspected concussions more often than student-athletes participating in contact (symptoms only) or limited-contact sports. These findings are in line with research showing that student-athletes participating in collegiate football (a collision sport) sustained a greater number of concussions from practice and games than those participating in other contact or limited-contact sports (Covassin et al., 2003a). In addition, suspected “sub-concussive” events were reported less often for student-athletes participating in collision versus limited-contact sports. These findings are in line with Kerr and colleagues (2016), who cite the rate of not reporting a suspected concussion as highest in collision sports (nondisclosure rate of 68.3%) compared with contact (nondisclosure rate of 28.6%) and limited-contact sports (nondisclosure rate of 20.0%). These findings indicate that individuals

participating in collision sports are particularly at-risk as they sustain a greater number of potential concussions and report suspected events deemed to be “minor” less-frequently than individuals participating in other sports. Reasons for not reporting suspected concussions may be, in part, due to increased pressure to continue competing following a head impact. Kroshus et al., (2015) cite pressure from coaches, teammates, fans, and parents as a key source of underreporting symptoms of suspected concussions. Anderson et al., (2021) cite both pressure from coaches to continue playing and participation in high concussion-risk sport (i.e., basketball, football, field hockey, ice hockey, lacrosse, soccer, softball, volleyball, wrestling) as factors contributing to nondisclosure in collegiate student-athletes. Unique factors related to concussion reporting within different sport categories have not yet been examined; however, future work should aim to understand differences in pressures experienced by athletes in different types of sport. Research also indicates that the sub-cultures of collision, contact, and limited-contact sports may differ, allowing for more acceptable, “aggressive” behavior in collision vs. limited-contact sports (Tucker & Parks, 2001).

The final demographic identified by the current study was NCAA Division. While there was no difference in number of experienced symptoms, “sub-concussive”, or concussive events, all three were reported less frequently for student-athletes competing at the DII level vs. those at the DIII and DI (symptoms only) levels. Our findings indicate that DII student-athletes may be at particular risk for underrepresenting of potential head injury. Several studies have examined concussion reporting behavior for athletes from different NCAA divisions; however, to our knowledge, differences across division have not been reported (Anderson et al., 2021; Covassin et al., 2003a, 2003b; Kroshus, Garnett, Baugh, et al., 2015; Lempke et al., 2020). Interestingly, some research shows that Division II student-athletes are at greater risk than Division I or Division III student-athletes for sustaining multiple injuries (Guskiewicz et al., 2000), but it remains unclear as to why. Further examination of reasons listed for not reporting symptoms or suspected “sub-concussive” events revealed that, among Division II student-athletes, the highest ranked reasons for not reporting symptoms were “I know that I did not have a concussion,” “I wanted to keep playing,” “I didn’t consider the event to be a concussion,” and “I am a tough player.” These responses point to two overarching themes for not reporting: namely, student-athletes’ overestimation of their own ability to properly diagnose the implications of experienced symptoms and the desire to conform to a hypermasculine team or athletic identity (Steinfeldt & Steinfeldt, 2012). Whether or not these particular reasons are more pronounced for Division II student-athletes over Division I and Division III student-athletes is a question that should be addressed in future empirical work.

Perhaps the most interesting finding from this study was that, among the entire cohort of student-athletes, those who reported that symptoms needed to be more intense to indicate a concussion had occurred also reported that symptoms that *should be* and *would be* reported needed to be of greater intensity and also reported having experienced fewer “sub-concussive events”. Interestingly, those who reported that symptoms must be of greater intensity to indicate a concussion also were more likely to report these symptoms and more likely to advise symptom reporting. These finding indicate that symptoms (and potential concussions) may not have been reported when they were not deemed severe enough. These findings also indicate that reasons for not reporting concussion are based on more than lack of knowledge that not reporting can be harmful (e.g., not wanting to let teammates down). Overall, we provide support that NCAA student-athletes do not perceive “sub-concussive events” as threatening to their sport

participation or health, and therefore choose to report these events more often than a suspected concussion or symptoms that might lead to a concussion diagnosis (Llewellyn et al., 2014).

While symptom report ratio (.43) and concussion report ratio (.33) were relatively low, in line with past research showing low rates of reporting both symptoms (Baugh et al., 2014; Delaney et al., 2015; Kaut et al., 2003) and suspected concussions, (Kerr et al., 2016; LaRoche et al., 2016; Register-Mihalik, Guskiewicz, et al., 2013) our data show a high rate of report for “sub-concussive events” (90%). To our knowledge, this is the first study to allow student-athletes to subjectively define what constitutes a “sub-concussive” event. These self-defined events resulted from symptoms judged as not severe enough to indicate concussion. Many student-athletes referred to these events as “minor concussions”, “bell-ringers”, or attributed symptoms to something other than a sport-related head injury, which might explain why they were less reluctant to report.

Providing further support to the finding that symptoms were not directly perceived as potentially harmful, only one in ten student-athletes in the present sample ($n = 24$) referred to head injury using terms indicative of concussion. Broglio and colleagues (2014) argued that the perpetuation of terms such as “ding,” “bell ringer,” and “getting your bell rung” connote an injury that is less-severe than a concussion and could perpetuate decreased symptom reporting. The misclassification of symptoms can be particularly damaging as shown in a group of high-school athletes who received what coaches or ATCs classified as a “mild concussion” or “ding” during practice or a game. These athletes exhibited no symptomology within 15 minutes of the event, but exhibited decline in memory and other symptoms up to 36 hours post-event (Lovell et al., 2004). This finding demonstrates latency in onset, and perhaps a longer-lasting and more severe outcome of a head impact that is initially considered by some athletes to be trivial and unworthy of reporting.

Despite the finding that student-athletes in the present study were generally knowledgeable about concussion, our results showcase a negative relationship between knowledge and symptom reporting. In addition, student-athletes’ knowledge scores were not associated with their reporting of suspected “sub-concussive events”, suspected concussive events, or their likelihood to report or advise reporting of concussion. This finding is in line with past research showing that improved concussion knowledge does not influence reporting behavior at the collegiate level (Kroshus, Baugh, Daneshvar, et al., 2015). Other research has also indicated that greater knowledge of concussion leads to lower reporting of suspected concussion (Anderson et al., 2021; Rawlins et al., 2020). This research suggests that greater concussion knowledge may empower student-athletes to evaluate their own well-being following a head impact and therefore to seek out less help with diagnosing their own concussive symptoms. Interestingly, Sanchez & Dunning, (2018) looked at overconfidence among beginners. Participants in this study learned about a novel disease and were asked to diagnose this disease based on symptoms. Beginners exhibited overconfidence, which leveled off as learning continued. The role of overconfidence in diagnostic error in the field of medicine is well documented (Cassam, 2017). These findings highlight the importance of not only providing and assessing education about concussions, but also examining how individuals rate and assess their own symptoms and experiences. The NCAA currently requires student-athletes to be presented with educational material on the signs and symptoms of concussions and to be made aware of their responsibility to report injury (NCAA, 2014), however, there is currently no standardized protocol to address the evidently difficult task of diagnosing oneself with a concussion based on experienced symptoms.

The disconnect between concussion knowledge and reporting behavior has been attributed to perceived team and peer norms, (Kroshus, Garnett, Baugh, et al., 2015) attitudes about concussion, (Register-Mihalik, Linnan, et al., 2013) intent to report, (Kroshus, Baugh, Daneshvar, et al., 2015; Kroshus et al., 2017) perceived outcomes of reporting, (Kroshus et al., 2014) perceived coach support (Baugh et al., 2014) and pressure felt from coaches, teammates, parents and fans (Kroshus, Garnett, Hawrilenko, et al., 2015). We provide support here for an additional, alternative explanation: specifically, that student-athletes may evaluate their own symptoms differently from one another and differently than ATCs and doctors, therefore putting themselves at risk for under-reporting potential injuries. Indeed, student-athletes who suggested that symptoms needed to be more intense to be considered a concussion also reported fewer “sub-concussive events”, potentially suggesting that less severe symptoms (as experienced by themselves) were not considered worthy of reporting and thus putting them at-risk for misdiagnosis and further injury. In light of these findings, the disconnect between knowledge and reporting behavior may, in part, be a result of a student-athlete’s personal valuation of the level of symptom intensity that warrant reporting.

In light of this interpretation, it remains crucial to delineate student-athletes’ intention to report from their own perception of what they are actually being asked to report (e.g., symptoms or a concussion). In past survey research of this nature, items targeting student-athletes’ intent to report or reporting behavior have assumed that student-athletes were able to properly diagnose themselves with a concussion. For example, Kroshus and colleagues (2015) assessed the intent to report with one statement: “I would continue playing my sport while experiencing a headache that results from a minor concussion”. This statement assumes that student-athletes are able to associate a symptom with the incidence of a minor concussion. If student-athletes cannot, in fact, do this effectively, they might continue to play while experiencing symptoms because they do not consider the symptoms to indicate a dangerous or long-term impairment. Importantly, student-athletes may also recognize the symptoms of a concussion, and the consequences of playing with a concussion, but still be unable or unwilling to properly diagnose themselves as potentially having experienced one. Our data also support past literature suggesting that individuals cite, as a main reason for failing to report symptoms, that “they were not severe enough,” or “I did not consider them to be a concussion” (Kerr et al., 2016; LaRoche et al., 2016). Only 10% of the current sample labeled a head impact as a concussion ($n = 2$), minor concussion ($n = 17$), or sub-concussive event ($n = 5$), which lends insight into the low rates of symptom reporting, particularly when those rates are paired with symptoms that result from a self-identified concussive event.

Although the NCAA mandates concussion education, and the removal of student-athletes who exhibit signs and symptoms of potential concussion, (smeyers@ncaa.org, 2018) there is currently no mandate on symptom reporting or assessment outside of the context of an observed or reported head impact. Our findings support the proposal that education should focus on identification and reporting of symptoms regardless of whether a student-athlete feels those symptoms indicate a potential concussion. Better symptom reporting following head impact could then be followed up with more objective measures of injury.

Limitations

Despite the contributions made by the present research, it is not without limitations. First, our data represent the perspectives of a small percentage of the more than 460,000 NCAA

student-athletes who compete across 24 sports at 1,117 colleges and universities (*NCAA.Org - The Official Site of the NCAA*, n.d.). Although low response can lead to potential self-selection biases, it remains unclear whether this was an issue in the present research. Future empirical efforts should attempt to acquire larger sample sizes, affording a broader representation of student-athletes as well as nested comparisons of reporting behavior within and across different teams, institutions, conferences, and divisions. Research utilizing larger sample sizes could also compare reporting behavior among different races/ethnicities. This could be fruitful in light of research suggesting that Black and Hispanic youth may not have access to proper concussion education (Bloodgood et al., 2013). Despite the ethnic diversity of athletes competing at the high-school and collegiate level, surprisingly little research has examined differences in concussion risk or report behavior across ethnic groups. One final consideration in survey research on reporting behavior is the potential for recall bias, particularly regarding perceived minor injuries (Junge & Dvorak, 2000).

Future Directions

Our survey did not have student-athletes report which specific university they played for. The collection of this information in future studies would help to identify differences across types of schools within divisions and might help explain some of the discrepancies between Division I and Division II institutions. Furthermore, the finding that reporting of concussions depended upon the valuation of symptoms indicates that future work should aim to examine not only reporting behavior of suspected concussions, but also the symptoms associated with concussion, absent of what an athlete might deem them to indicate. Two athletes may have the same severity of symptoms and might differ in report in those symptoms because one feels they are severe enough to indicate concussion, and another feels they are not. Several studies indicate that greater athlete self-efficacy predicts greater reporting (Kroshus et al., 2014; Rawlins et al., 2020). In addition, an athlete's relationship with the coach may be a main indicator of reporting behavior (Chrisman et al., 2013; Lininger et al., 2017; Milroy et al., 2018). Future work should be designed to examine how coaches may influence the reporting of both symptoms and of suspected concussions. In addition, future work could examine an athlete's own ability to evaluate symptoms following head impact and come to meaningful conclusions about when and how to report these.

Conclusion

This study found that, among demographic subgroups of student-athletes, those competing in collision sport and at the Division II level were particularly at risk for not reporting symptoms and potential concussive events. Furthermore, student-athletes' who listed higher symptom severity to indicate concussion also reported fewer self-defined "sub-concussive events", highlighting a missing link in understanding report behavior. Our findings lend empirical support for the inclusion of survey questions in research on concussion reporting regarding experienced symptoms and the respective evaluation of those symptoms separate from suspected concussive events. Furthermore, we provide new evidence regarding why NCAA student-athletes may not seek care for potential injuries (including concussions).

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Appendix

Qualtrics Survey

What is your age? _____

What is your gender?

- Male
- Female
- Other

Please select your ethnicity:

- Hispanic or Latino
- Not Hispanic or Latino

Please select your race:

- American Indian/Alaskan Native
- Asian
- Black or African American
- White
- More than one race
- Unknown
- Other (open ended)

What is your mother's highest level of education?

- Elementary
- Junior High/Middle School
- Some High School
- High School Graduate or GED
- Some College
- Associate's Degree
- Bachelor's Degree
- Master's Degree
- Professional Degree
- Doctorate Degree
- Other (open ended)

What is your father's highest level of education?

- Elementary
- Junior High/Middle School
- Some High School
- High School Graduate or GED
- Some College
- Associate's Degree

- Bachelor's Degree
- Master's Degree
- Professional Degree
- Doctorate Degree
- Other (open ended)

What is your mother's relationship status?

- Married
- Single, never married
- Living with partner, not married
- Widowed
- Divorced
- Separated
- Other (open ended)

What is your father's relationship status?

- Married
- Single, never married
- Living with partner, not married
- Widowed
- Divorced
- Separated
- Other (open ended)

Please indicate the average annual income of the household in which you were raised.

- < 10,000
- \$10,000 - \$24,999
- \$25,000 - \$49,999
- \$50,000 - \$74,999
- \$75,000 - \$99,999
- \$100,000 - \$150,000
- > \$150,000
- Prefer not to answer

Are you a NCAA Division I, II, or III athlete?

- Division I
- Division II
- Division III

What sport do you compete in for your university? (open ended)

Please indicate (by checking the box beside the response) which of the following you would consider to be a sign or symptom of concussion. Select all that apply.

- Abnormal Sense of Smell

- Abnormal Sense of Taste
- Amnesia
- Joint Stiffness
- Blurred Vision
- Black Eye
- Bleeding from the Ear
- Bleeding from the Mouth
- Bleeding from the Nose
- Confusion
- Fever
- Dizziness
- Headache
- Insomnia
- Loss of Consciousness
- Nausea
- Numbness or Tingling of Arms
- Skin Rash
- Sharp Burning Pain in Neck
- Weakness in Neck Movements

Which of the following is true regarding concussions? Select all that apply.

- A concussion only occurs if you lose consciousness
- If you are experiencing any signs and symptoms of concussion after a blow to the head or sudden movement of the body, you should not return to play
- A concussion is an injury to the brain

Multiple concussions: Of the following, what are possible complications of having multiple concussions? Select all that apply.

- Increased risk of further injury
- Brain damage
- Joint problems
- Memory problems
- I don't know
- No complications exist

At what level of symptom intensity would the following symptoms indicate a possible concussion? (1 being no symptoms and 7 being intensely symptomatic)

- Duration of loss of consciousness (1-7)
- Nausea (1-7)
- Dizziness (1-7)
- Light sensitivity (1-7)
- Feeling dazed (1-7)
- Amnesia/Deficit in short term memory (1-7)
- Balance Problems (1-7)

- Headaches (1-7)

If any of these symptoms occur following head impact, but are not severe enough to be considered a concussion, what would you typically call the incident? (open ended)

How many times have you EXPERIENCED such an incident during your collegiate career? (Select 10 for any value equal to or greater than 10)

- 0
- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10+

How many times in your collegiate career have you REPORTED such an event to your coach or athletic trainer? (Select 10 for any value equal to or greater than 10)

- 0
- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10+

If applicable, why DID you tell your coach or athletic trainer about such an incident? Select all that apply.

- I felt like something was wrong
- I considered that incident to be a concussion
- I could not play well after the incident
- I needed to take some time to recover
- Other (open ended)

If applicable, why did you NOT tell your coach or athletic trainer about such an incident? Select all that apply.

- It was not worth the trouble

- I did not consider that event to be a concussion
 - I felt fine afterwards
 - It's part of the game
 - I am a tough player
 - Other (open ended)
- At what level of symptom intensity for the following symptoms do you think an athlete SHOULD report a concussion? (1 being no symptoms and 7 being intensely symptomatic)
 - Duration of loss of Consciousness (1-7)
 - Nausea (1-7)
 - Dizziness (1-7)
 - Light sensitivity (1-7)
 - Feeling dazed (1-7)
 - Amnesia/Deficit in short term memory (1-7)
 - Balance Problems (1-7)
 - Headaches (1-7)
 - If you collided with another athlete and began to experience any of these symptoms, how likely would you be to report it to a coach or trainer? (1 being not likely at all and 7 being completely likely)
 -
 - How many times have you felt any of these symptoms after an impact (with another player, the ground, or anything else) during practice or a game during your collegiate career? Please answer as accurately as possible with a single number. (open ended)
 -
 - How many times have you told a coach or athletic trainer that you were experiencing these symptoms during your collegiate career? Please answer as accurately as possible with only a single number? (open ended)
 -
 - Why did you choose to tell the coach or athletic trainer that you were feeling those symptoms during your collegiate career? Check all that apply.
 - I'm supposed to report a concussion
 - I was worried about my health/safety
 - My teammates or family told me to do so
 - I was not sure if I had a concussion or not
 - Someone else noticed my symptoms
 - The coach or trainer noticed my symptoms
 - Other (open ended)

How many times have you recognized these symptoms in yourself, but NOT report them to a coach or athletic trainer during your collegiate career? Please answer as accurately as possible with only a single number. (open ended)

Why did you choose to NOT report to a coach or athletic trainer that you were feeling any of those symptoms during your collegiate career? Check all that apply.

- I know that I did not have a concussion
- I am a tough player
- I wanted to keep playing
- I am expected to play injured
- My coach would react poorly
- I didn't want to disappoint my coach, team, or fans
- My team needed me
- I didn't want to go to the doctor
- Other (open ended)

How many total concussions have you experienced that were DIAGNOSED by a medical professional (athletic trainer or doctor) during your collegiate career? Please answer as accurately as possible with only a single number. (open ended)

How many total concussions do you SUSPECT you may have experienced that were NOT diagnosed by a medical professional (athletic trainer or doctor) during your collegiate career? Please answer as accurately as possible with only a single number. (open ended)

At what level of intensity of the following would YOU report your symptoms to a coach or athletic trainer? (1 being no symptoms and 7 being intensely symptomatic)

- Duration of loss of consciousness
- Nausea
- Dizziness
- Light sensitivity
- Feeling dazed
- Amnesia/Deficit in short term memory
- Balance Problems
- Headaches

How likely would you be to advise another athlete to report his/her symptoms to a coach or athletic trainer if he/she had hit his/her head and was exhibiting any of these symptoms? (1 being not likely at all, and 7 being completely likely)

Bullet Points

- Collision sport athletes reported fewer symptoms and potential concussions than contact and limited-contact sport athletes
- Division II level athletes reported fewer symptoms and potential concussions than Division I and Division III athletes
- Events deemed not severe enough to indicate concussion were reported with greater frequency than suspected concussions and symptoms by all athletes
- Student-athletes who listed higher symptom severity to indicate concussion also reported fewer self-defined “sub-concussive events”