©Journal of Sports Science and Medicine (2022) **21,** 33-42
http://www.jssm.org DOI: https://doi.org/10.52082/jssm.2022.33

Association between Sensation-Seeking Behaviors and Concussion-Related Knowledge, Attitudes, Perceived Norms, and Care-Seeking Behaviors among Collegiate Student-Athletes

Christine E. Callahan[1,2]✉, Melissa K. Kossman [3], Jason P. Mihalik [1,2,4], Stephen W. Marshall [4,5], Paula Gildner [4], Zachary Y. Kerr [1,2,4], Kenneth L. Cameron [6,7], Megan N. Houston [6], Martin Mrazik [8] and Johna K. Register-Mihalik [1,2,4,9]

[1] Matthew Gfeller Center, Department of Exercise and Sport Science, The University of North Carolina, NC, USA; [2] Human Movement Science Curriculum, Department of Allied Health Sciences, School of Medicine, The University of North Carolina at Chapel Hill, NC, USA; [3] School of Health Professions, University of Southern Mississippi, MS, USA; [4] Injury Prevention Research Center, The University of North Carolina at Chapel Hill NC, USA; [5] Department of Epidemiology, Gillings School of Global Public Health, The University of North Carolina at Chapel Hill, NC, USA; [6] John A. Feagin Jr. Sports Medicine Fellowship, Keller Army Hospital, United States Military Academy, NY, USA; [7] Departments of Physical Medicine and Rehabilitation and Surgery, Uniformed Services University of the Health Sciences, MD, USA; [8] Department of Educational Psychology, University of Alberta, AB, Canada; [9] STAR Heel Performance Laboratory, The University of North Carolina at Chapel Hill, NC, USA

Abstract

There are limited data connecting personality and behavioral tendencies and traits related to concussion care-seeking/disclosure behaviors and minimal research exists surrounding the relationship between risky behaviors, sensation-seeking, and concussion-related outcomes. This study examined the association between sensation-seeking and a student-athlete's concussion-related knowledge, attitudes, perceived social norms, and concussion care-seeking/disclosure behaviors (intention to disclose concussion symptoms, perceived control over symptom disclosure, self-removal from play due to concussion symptoms, continued play with concussion symptoms, and disclosure of all concussions at the time of injury). The current study utilized a retrospective cohort of collegiate student-athletes at a single National Collegiate Athletic Association Division I institution. Separate multivariable linear regression models estimating mean differences (MD) and 95% Confidence Intervals (CI) estimated the association between sensation-seeking and concussion knowledge, concussion attitudes, and perceived social norms. Separate multivariable binomial regression models estimating adjusted prevalence ratios (PR) and 95%CI estimated the association between sensation-seeking and intention to disclose concussion symptoms, perceived control over symptom disclosure, self-removal from play due to concussion symptoms, continued play with concussion symptoms, and disclosure of all concussions at the time of injury. All models were adjusted for sex, sport participation, and concussion history. Higher sensation-seeking was significantly associated with less favorable concussion attitudes (adjusted MD = -1.93; 95%CI = -3.04,-0.83), less favorable perceived social norms surrounding concussion (adjusted MD = -1.39; 95%CI = -2.06,-0.72), and continuing to play while experiencing concussion symptoms (adjusted PR = 1.50; 95%CI = 1.10, 2.06). Student-athletes with increased sensation-seeking could be at risk for failing to disclose a concussion, decreasing athlete safety and resulting in less optimal care post-injury. Results will inform future theory-based concussion education programs which consider behavioral tendencies and traits as well as sport culture to promote concussion care-seeking/disclosure and individualized interventions based on risky behavior engagement.

Key words: Mild traumatic brain injury, risky behaviors, concussion education, concussion, sensation-seeking, college athletes.

Introduction

Concussions account for 6.2% of all injuries reported by National Collegiate Athletic Association (NCAA) student-athletes (Zuckerman et al., 2015). With an injury rate of 4.47 per 10,000 athlete-exposures, concussive injuries greatly impact student-athletes (Zuckerman et al., 2015). Timely care-seeking for individuals experiencing concussion symptoms is a critical issue for athlete well-being. However, an estimated 10-50% of SRCs go unreported or unrecognized (Kerr et al., 2016; Llewellyn et al., 2014; McCrea et al., 2013; Meehan et al., 2013). Delaying concussion symptom reporting or complete lack of reporting undermines timely provision of care and support after injury - leading to a longer clinical recovery (Barnhart et al., 2021), negatively impacting overall athlete health (Kerr et al., 2016; McCrea et al., 2004; Meehan et al., 2013).

Several psychosocial factors are associated with concussion care-seeking including pressure to play, negative attitudes and stigma surrounding concussion, not believing the injury was serious, fear of letting the team down, and lack of concussion knowledge (Broglio et al., 2010; Kerr et al., 2014; Kerr et al., 2016; Meehan et al., 2013; Yeo et al., 2020). Research has identified positive associations among healthier concussion attitudes, perceived social norms surrounding concussion, and improved care-seeking/disclosure behaviors (Register-Mihalik et al., 2019; 2020a; 2020b; Schmidt et al., 2020). Additionally, improving concussion knowledge, concussion attitudes, perceived social norms, and perceived control surrounding concussion disclosure may improve post-concussion care-seeking behaviors (Donnell et al., 2018; Kroshus et al., 2014; Kroshus and Baugh 2016; Register-Mihalik et al., 2013; 2019; Schmidt et al., 2020). To illustrate such findings, a recent concussion education randomized control trial identified that targeting concussion care-seeking/disclosure behaviors through interactive education can improve concussion reporting intentions, concussion knowledge, concussion attitudes, and concussion-related

Received: 31 August 2021 / Accepted: 27 October 2021 / Published (online): 15 February 2022

beliefs (Schmidt et al., 2020). However, the relationships between factors surrounding personality and individual behaviors (such as engaging in risky behaviors) and concussion care-seeking/disclosure outcomes is not fully understood (Gardner et al., 2021; Liebel et al., 2020 Veliz et al., 2021).

Sensation-seeking is defined as, "The tendency to search out and engage in thrilling activities as a method of increasing stimulation and arousal" (APA, 2020). It is associated with participation in highly stimulating activities or risky behaviors such as fighting, drug use, excessive alcohol consumption, or speeding/risky driving (Graupensperger et al., 2018; Sarbescu and Rusu, 2021; Schwebel et al., 2007; Zuckerman 1994). Research has identified sensation-seeking as a behavioral trait as it may change over time (Zuckerman 1994; Zuckerman 2007; Lynne-Landsman et al., 2013). Student-athletes are more likely to participate in risky, sensation-seeking behaviors than non-athletes (Hingson et al., 2002; Zuckerman, 1983). In addition, student-athletes engaging in risky behaviors report higher levels of sensation-seeking compared to those who do not engage in risky behaviors (Roach et al., 2020). These behaviors are seemingly more prevalent among contact sport athletes, who report higher odds of recent alcohol or other drug use during the previous month (Veliz et al., 2015), initiated overall substance use earlier in life (Veliz et al., 2015), and report higher sensation-seeking compared to non-contact sport athletes (Liebel et al., 2020).

Current research has not found personality and behavioral tendencies and traits to be associated with concussion care-seeking/disclosure. Furthermore, minimal research exists surrounding the relationship between risky behaviors, sensation-seeking, and concussion (Gardner et al., 2021; Liebel et al., 2020 Veliz et al., 2021). Risky behaviors for student-athletes expand beyond highly stimulating activities to include making oneself more vulnerable to potential injury and/or withholding concussion symptoms to continue participation (Graupensperger et al., 2018). Specifically, contact sport athletes report a higher concussion rate compared to non-contact sport athletes (Roach et al., 2020) and athletes with a concussion history are more likely to engage in risky behaviors than those without a concussion history (DePadilla et al., 2020; Veliz et al., 2021). Engaging in all types of risky behaviors (athletic-specific or substance associated) negatively impacts athlete safety and performance, making them more vulnerable to long-term injury and impairments that extend beyond athletics. When investigating the connection between sport participation, concussion, and sensation-seeking, Liebel and colleagues (2020) used a large sample of collegiate student-athletes to identify that student-athletes participating in contact sports reported higher sensation-seeking scores than those who participated in non-contact sports. Additional work from Gardner and colleagues (2021) identified that, in young adults with a concussion history, sensation-seeking was positively associated with earlier return to play. These results provide evidence to support investigations to further understand the connection between engaging in risky behaviors/sensation-seeking and concussion care-seeking/disclosure. As such, this study's aim was to determine the association between sensation-seeking and a student-athlete's concussion-related knowledge, attitudes, perceived social norms, and concussion care-seeking/disclosure behaviors. We hypothesized increased sensation-seeking would be associated with: 1) decreased concussion knowledge; 2) less favorable concussion attitudes; 3) less favorable perceived social norms surrounding concussion; and 4) being more likely to engage in negative concussion care-seeking/disclosure behaviors.

Methods

Study design and setting

The current study was a cross-sectional, retrospective analysis. The final de-identified dataset used was created by merging data from two sources using a common student-athlete ID (described below in methods section 2.4). Both data sources utilized the same collegiate student-athlete sample from a single NCAA Division I institution. Institutional Review Board was obtained for both studies by the University of North Carolina at Chapel Hill review board and all participants provided informed consent. Figure 1 outlines the flow of development of the final retrospective dataset utilized for these analyses.

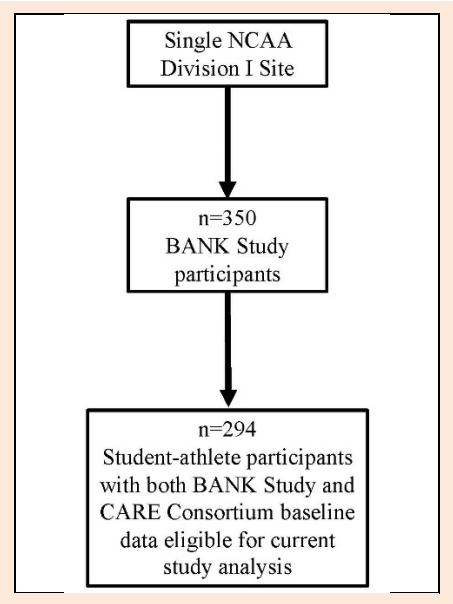

Figure 1. Data linkage process leading to the final sample for the current analyses (*n* = 294).

Design and instrumentation: Data source one

Data source one was the Behaviors, Attitudes, Norms, and Knowledge (BANK) Study, a cross-sectional survey that assessed concussion knowledge, attitudes, perceived social norms, and overall concussion disclosure behaviors. Student-athletes completed the BANK Study survey at preseason baseline. The BANK Study survey was based on previously validated items and has been described in previous studies (Register-Mihalik et al., 2019; Register-Mihalik et al., 2020a; Register-Mihalik et al., 2020b). The current study utilized demographic questions and questions regarding concussion knowledge, concussion attitudes, perceived social norms surrounding concussion, and concus-

sion care-seeking/disclosure behaviors (intention to disclose concussion symptoms, perceived control over symptom disclosure, self-removal from play due to concussion symptoms, continued play with concussion symptoms, and disclosure of all concussions at the time of injury) from the BANK Study.

Concussion knowledge was assessed using 39 yes-or-no items concerning symptom recognition, potential long-term effects of concussion, and effects of premature return to play. Correct answers were scored as one point, resulting in a knowledge composite score ranging from 0-39. Higher scores indicated better concussion knowledge (Register-Mihalik et al., 2019; 2020a; 2020b).

Concussion attitude questions consisted of six, seven-point scale items with question topics encompassing feelings toward symptom disclosure and concussion. A composite attitude score ranged from 6-42. Higher scores indicated more favorable attitudes toward symptom disclosure (Register-Mihalik et al., 2019; 2020a; 2020b).

Perceived social norms questions included seven, seven-point scale items identifying perceptions of organization, social referent expectations, and actions concerning concussive injury. A composite perceived social norms score ranged from 7-49. Higher scores indicated more favorable perceived social norms (Register-Mihalik et al., 2019; 2020a; 2020b).

Intention to disclose concussion symptoms was assessed by asking student-athletes the following question on a seven-point scale, "When I experience possible concussive symptoms, I intend to report them to a medical professional or someone in authority." An intention score was dichotomized with agree/strongly agree grouped as higher intention and somewhat agree to strongly disagree grouped as lower intention (Register-Mihalik et al., 2019; 2020a; 2020b).

Perceived control over concussion symptom disclosure consisted of a single question which asked student-athletes to answer the following on a seven-point scale, "I have control over reporting concussive symptoms to a medical professional or someone in authority." A perceived control score was dichotomized with agree/strongly agree grouped as higher control and somewhat agree to strongly disagree grouped as lower control (Register-Mihalik et al., 2019; 2020a).

Self-removal from play due to concussion symptoms was assessed using the following yes/no question, "Have you ever removed yourself from physical activity or sport because you were experiencing symptoms of a concussion?" Continued play with concussion symptoms was assessed by asking student-athletes to answer yes or no to the following question, "Have you ever continued to participate in physical activity or sport while experiencing symptoms of a concussion?" (Register-Mihalik et al., 2019; 2020a; 2020b).

Disclosure of all concussive injuries at the time of injury began by providing student-athletes with the following concussion definition (McCrea et al., 2004; Register-Mihalik et al., 2019; 2020a; 2020b):

"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."*

Following the definition, student-athletes were asked if they ever incurred a concussion related to sport or other activities. If a student-athlete answered yes, they were then prompted to report the number of concussions incurred and how many of those that they reported to the medical professional/authority personnel who was around at the time of injury. To quantify disclosure (the proportion of reported concussions that a student-athlete had disclosed at the time of injury), the number of disclosed concussions was divided by number of total concussions. Finally, disclosure for each student-athlete was dichotomized as either 1) disclosed all concussions at the time of injury or 2) did not disclose all concussions at the time of injury (Kerr et al., 2018).

Design and instrumentation: Data source two

Data source two was derived from the NCAA-Department of Defense (DOD) Concussion, Assessment, Research and Education (CARE) Consortium. This longitudinal study measured concussion effects in NCAA student-athletes at 30 institutions across the United States. As a part of the study, student-athletes at a single institution (same sample as data source one) completed a comprehensive preseason clinical concussion baseline assessment in the same preseason baseline period as the BANK Study survey.

The current retrospective study utilized the Brief Sensation-Seeking Scale (BSSS) from the NCAA-DOD CARE Consortium baseline data. The BSSS consists of four dimensions (experience seeking, boredom susceptibility, thrill and adventure seeking, and disinhibition), each with two items on a five-point scale from 'strongly disagree' to 'strongly agree.' A final score was calculated by averaging the score for all eight items (final score range = 1-5), higher scores indicating more sensation-seeking (Hoyle et al., 2002). Based on previous research, a one-point increase in BSSS was utilized for all models, representing a 25.0% increase on the averaged five-point scale (Liebel et al., 2020; Willick et al., 2019).

Data linkage

The final de-identified study dataset for the current study analyses was created by merging both study datasets using a common student-athlete ID, beginning with the BANK Study data as the primary source. Student-athletes participating in the clinical baseline testing program, with data from the BANK Study were matched to the NCAA-DOD CARE Consortium datasets and included in the final dataset (Figure 1). Demographic information and dependent variables (concussion knowledge, concussion attitudes, perceived social norms surrounding concussion, intention

to disclose concussion symptoms, perceived control over concussion symptom disclosure, self-removal from play due to concussion symptoms, continued play with concussion symptoms, and disclosure of all concussions at the time of injury) utilized in these analyses originated from the BANK Study data source. The independent variable utilized in this analysis, BSSS score, originated from the NCAA-DOD CARE Consortium data source.

Statistical analyses

Analyses were conducted using SAS 9.4 (SAS Institute Inc., Cary, NC). Missing data were excluded in the models on an analysis-by-analysis basis and reported as such. Frequencies and proportions were computed for sex (female versus male); academic year (first year versus non-first year); race (Caucasian versus non-Caucasian); sport (contact versus non-contact); concussion history (yes versus no); intention to report concussion symptoms (high versus low); perceived control over concussion symptom disclosure (high versus low); self-removing from play due to concussion symptoms (yes versus no); continuing to play despite concussion symptoms (yes versus no); and, in those with a concussion history, disclosing all concussions at the time of injury (yes versus no). Means and standard deviations (SD) were computed for age, concussion knowledge, concussion attitudes, perceived social norms surrounding concussion, and sensation-seeking. Independent t-tests described group differences in reported sensation-seeking for variables of interest including sex (female versus male); sport (contact versus non-contact); concussion history (yes versus no); intention to report concussion symptoms (high versus low); perceived control over concussion symptom disclosure (high versus low); self-removal from play due to concussion symptoms (yes versus no); continuing to play despite concussion symptoms (yes versus no); and, in those with a concussion history, disclosing all concussions at the time of injury (yes versus no).

Separate multivariable linear regression models adjusted estimated mean differences (MDs) and 95% Confidence Intervals (95%CI) were used to quantify the association between sensation-seeking (1-point increase) and concussion knowledge, concussion attitudes, and perceived social norms surrounding concussion while controlling for sex, sport, and concussion history. The MDs with 95%CI excluding 0.0 were considered statistically significant.

Separate multivariable binomial regression models estimated adjusted prevalence ratios (PR) and 95%CI were used to quantify the association between sensation-seeking and intention to disclose concussion symptoms, perceived control over symptom disclosure, self-removal from play due to concussion symptoms, continued play with concussion symptoms, and disclosure of all concussions at the time of injury while controlling for sex, sport, and concussion history. All models assessed the likelihood of responding "yes" to the specific behaviors. The PRs with 95%CI excluding 1.0 were considered statistically significant. Following previous literature and to mitigate the chance of type 2 error, no adjustment for multiple comparisons was made (Rothman, 1990; Streiner and Norman, 2011).

Results

Participants

Overall, 350 student-athletes responded to the BANK Study survey. Of these, 294 student-athletes (mean age 19.4 ± 1.3 years) had both BANK Study data available for merge and available clinical baseline data for the NCAA-DOD CARE Consortium study during the same baseline period. These 294 student-athletes were included in the current study's analyses (Figure 1). Complete demographic information can be found in Table 1.

Table 1. Demographic information for study sample (n = 294).

		n*	%
Sex	Male	152	51.9
	Female	141	48.1
Academic Year	First Year	98	33.5
	Non-First Year	195	66.5
Race	Caucasian	228	79.2
	Non-Caucasian	60	20.8
Sport†	Contact	203	70.0
	Non-Contact	87	30.0
Concussion History	Yes	73	24.8
	No	221	75.2

* Student-athletes who did not self-report data for sex (n = 1), academic year (n = 1), race (n = 6), and sport (n = 4) were not included; percentages add up to 100% of self-reported responses. † Contact sports included baseball, basketball, diving, fencing, field hockey, football, gymnastics, lacrosse, soccer, softball, volleyball, wrestling, and cheer; non-contact sports included cross-country/track, field event, rowing/crew, swimming, and tennis (Rice et al., 2008). Abbreviations. SD = Standard deviation.

Concussion care-seeking/disclosure behaviors

Means, SDs, and 95%CIs for sensation-seeking and concussion knowledge, attitudes, and perceived social norms are reported in Table 2. Majority of student-athletes reported high intention to report concussion symptoms (n = 266, 90.8%) and high perceived control over symptom disclosure (n = 275, 93.9%). Overall, 21.2% (n = 63) of student-athletes reported self-removal from play due to con cussion symptoms and 19.8% (n = 58) continued to play despite concussion symptoms. Of the 73 student-athletes with a concussion history (24.8% of total sample), 78.1% (n = 57) disclosed all symptoms at the time of injury. All frequencies and proportions for concussion care-seeking/disclosure behaviors are reported in Table 3.

Table 2. Measures of concussion knowledge, concussion attitudes, perceived social norms surrounding concussion, and Brief Sensation-Seeking Scale (n = 294).

	Possible Range	Mean	SD	95%CI
Brief Sensation-Seeking Scale	1-5	3.1	0.8	3.0, 3.2
Concussion Knowledge	0-39	33.3	5.3	32.7, 34.0
Concussion Attitudes	6-42	33.2	7.1	32.3, 34.0
Perceived Social Norms	7-49	45.0	4.4	44.5, 45.5

Abbreviations. SD = Standard deviation, CI = Confidence interval.

Sensation-seeking group descriptives

Differences in mean reported sensation-seeking scores by sex, sport, concussion history, and concussion care-seeking/disclosure behaviors are reported in Table 4. Overall

student-athletes who reported male sex, low intention to report concussion symptoms, continuing to play despite experiencing concussion-related symptoms, and not disclosing all concussions at the time of injury (in those with a concussion history) reported significantly higher sensation-seeking behaviors.

Sensation-seeking group descriptives

Differences in mean reported sensation-seeking scores by sex, sport, concussion history, and concussion care-seeking/disclosure behaviors are reported in Table 4. Overall student-athletes who reported male sex, low intention to report concussion symptoms, continuing to play despite experiencing concussion-related symptoms, and not disclosing all concussions at the time of injury (in those with a concussion history) reported significantly higher sensation-seeking behaviors.

Multivariable linear and binomial regression models

Sensation-seeking was not associated with concussion knowledge (*adjusted MD* = 0.08; *95%CI* = -0.76, 0.92; Table 5). Student-athletes reporting more sensation-seeking behaviors reported less favorable concussion attitudes (*adjusted MD* = -1.94; *95%CI* = -3.04,-0.83; Table 5) and less favorable perceived social norms surrounding concussion (*adjusted MD* = -1.40; *95%CI* = -2.06, -0.73; Table 5).

Student-athletes reporting more sensation-seeking behaviors were more likely to report continuing to play despite experiencing concussion symptoms (*adjusted PR* = 1.52; *95%CI* = 1.10, 2.10; Table 5). No other concussion care-seeking/disclosure behaviors were significantly associated with sensation-seeking (Table 5).

Table 3. Frequency and percentages of student-athletes' concussion care-seeking/disclosure behaviors.

	n	High (%)	Low (%)
Intention to Disclose Symptoms*	293	266 (90.8)	27 (9.2)
Perceived Control Over Symptom Disclosure †	293	275 (93.9)	18 (6.1)
		Yes (%)	**No (%)**
Self-Removal from Play	293	62 (21.2)	231 (78.8)
Continued Play	293	58 (19.8)	235 (80.2)
Disclosed All Concussions‡	73	57 (78.1)	16 (21.9)

* An intention score was dichotomized with agree/strongly agree grouped as higher intention and somewhat agree to strongly disagree grouped as lower intention (Register-Mihalik et al., 2019; 2020a; 2020b). † A perceived control score was dichotomized with agree/strongly agree grouped as higher control and somewhat agree to strongly disagree grouped as lower control (Register-Mihalik et al., 2019; 2020a; 2020b). ‡ Disclosing all concussions at the time of injury was only computed for student-athletes with a reported concussion history.

Table 4. Brief Sensation-Seeking Scores by key study variables of interest.

		n	BSSS Score Mean (SD)	*t* statistic	*p*-value
Sex	*Male*	144	3.2 (0.8)	-2.0	0.04
	Female	139	3.0 (0.7)		
Sport	*Contact*	196	3.1 (0.8)	-0.1	0.96
	Non-Contact	83	3.1 (0.8)		
Concussion History	*Yes*	71	3.2 (0.8)	-1.4	0.15
	No	212	3.0 (0.7)		
Intention to Disclose Symptoms	*High*	255	3.0 (0.8)	2.3	0.02
	Low	27	3.4 (0.7)		
Perceived Control Over Symptom Disclosure	*High*	264	3.1 (0.8)	-1.1	0.26
	Low	18	2.9 (0.9)		
Self-Removal from Play	*Yes*	60	3.1 (0.8)	-0.4	0.67
	No	222	3.1 (0.7)		
Continued Play	*Yes*	55	3.3 (0.9)	-2.6	0.01
	No	227	3.0 (0.7)		
Disclosed All Concussions *	*Yes*	57	3.1 (0.8)	2.6	0.01
	No	14	3.7 (0.6)		

* Disclosing all concussions at the time of injury was only computed for student-athletes with a reported concussion history.

Table 5. Multivariable linear and binomial regression results assessing the association of sensation-seeking with concussion disclosure outcomes while controlling for sex, sport played, and concussion history.†

Continuous Outcomes (Linear Regression Models)	**n**	**Adjusted MD‡**	**95%CI**
Concussion Knowledge	261	0.08	-0.76, 0.92
Concussion Attitudes	267	-1.94	-3.04, -0.83*
Perceived Social Norms	272	-1.40	-2.06, -0.73*
Categorical Outcomes (Binomial Regression Models)	**n**	**Adjusted PR‡**	**95%CI**
Intention to Disclose Symptoms	273	0.97	0.93, 1.01
Perceived Control Over Symptom Disclosure	273	1.02	0.97, 1.06
Self-Removal from Play	273	0.95	0.81, 1.11
Continued Play	273	1.52	1.10, 2.10*
Disclosed All Concussions§	69	0.95	0.73, 1.23

*Statistically significant (MDs with 95%CI excluding 0.0, PRs with 95%CI excluding 1.0). † Results utilized a one-point increase in BSSS score (20.0% increase on the five-point scale). ‡Adjusted for all factors in the linear regression or binomial regression models. § Disclosing all concussions at the time of injury was only computed for student-athletes with a reported concussion history. Abbreviations. n = Number of student-athletes used in each model output, MD = Mean difference; CI = Confidence interval; PR = Prevalence ratio.

Discussion

Student-athletes' sensation-seeking behaviors were associated with less favorable concussion attitudes, less favorable perceived social norms surrounding concussion, and continued play despite experiencing concussion symptoms. Findings build upon current research connecting sensation-seeking and concussion (Liebel et al., 2020), suggesting student-athletes with increased sensation-seeking could be at risk for delayed care-seeking or not seeking care at all, resulting in a longer clinical recovery, negatively impacting overall health (Barnhart et al., 2021; Kerr et al., 2016; McCrea et al., 2004; Meehan et al., 2013).

Sensation-seeking descriptives and group differences

Male student-athletes reported significantly higher sensation-seeking levels than females, a finding consistent with previous literature (Kerr et al., 2018), and were more likely to participate in contact sports than non-contact (84.7% vs 15.3%). Athletes participating in contact sports have a higher odds of engaging in risky behaviors than those who participate in non-contact sports (Veliz et al., 2015). Given a large proportion of males in this study participated in contact sports, we anticipated that contact sport athletes would report higher sensation-seeking. However, when analyzing sensation-seeking by sport, there was no significant difference between contact versus non-contact groups. Additionally, previous literature suggests a one-point increase in BSSS resulted in a 21.0% greater risk of concussion history (Liebel et al., 2020) and that those with a concussion history were more likely to engage in risky behaviors than those without a concussion history (Veliz et al., 2021). Therefore, we anticipated student-athletes with a concussion history would report higher sensation-seeking. However, the current study did not find a significant difference in sensation-seeking based on concussion history. Contact sport athletes are more likely to have a concussion history (Cross et al., 2013; Pfister et al., 2016; Tsushima et al., 2019) and, therefore, may have received more exposure to concussion education or have improved concussion knowledge from engaging in the concussion recovery process. As such, exposure to injury and/or education may have impacted sensation-seeking levels. Future research could investigate the impact concussion education has on risky behavior engagement.

Sensation-seeking and concussion knowledge, concussion attitudes, and perceived social norms

The lack of significance between sensation-seeking and concussion knowledge may indicate concussion knowledge does not equate to a lack of engagement in risky concussion-related behaviors (i.e., not disclosing a concussion at the time of injury), a notion suggested in previous research (Register-Mihalik et al., 2013). As such, these findings further emphasize the need for theory-based concussion education to improve care-seeking/disclosure behaviors, suggestions which are provided below.

Student-athletes with higher BSSS scores reported less favorable concussion attitudes and less favorable perceived social norms surrounding concussion. As such, those with less favorable concussion attitudes and perceived social norms toward concussion could be at a higher risk for engaging in negative concussion care-seeking behaviors, negatively impacting and athlete's post-injury care. Sport culture (i.e., pressure to play, negative stigma surrounding concussion, and fear of letting the team down) plays a role in the high rate of unreported concussions (Kerr et al., 2014; 2016; McCrea et al., 2004). Negative sport culture may also affect the connection between engaging in both sensation-seeking and negative concussion care-seeking/disclosure behaviors. Additionally related to sport culture, peer acceptance is extremely important to collegiate-aged adults (Cross et al., 2013; Prien et al., 2018). This acceptance is heightened in student-athletes, who strive to fit in with their teammates and experience different social status compared to their collegiate peers. This acceptance could result in engaging in risky behaviors in order to fit in. As Graupensperger et al. (2019) observed, student-athletes who perceived higher levels of peer acceptance engaged in risky behaviors related to alcohol use, playing with concussion symptoms, and hazing. Additional work in military service academy cadets identified that they perceived their fellow cadets as less likely to report a concussion than themselves, playing into a negative culture related to concussion disclosure (Baugh et al., 2021). These findings suggest sport culture at the team and greater collegiate level could impact student-athletes' behaviors. Promoting an open, positive, and inclusive environment that supports student-athletes to disclose concussion symptoms could positively influence concussion outcomes.

Sensation-seeking and concussion care-seeking/disclosure outcomes

Not disclosing a concussion at the time of injury impacts injury outcomes at all sporting levels (Broglio et al., 2010; Kerr et al., 2016; Llewellyn et al., 2014; McCrea et al., 2004; 2013; Meehan et al., 2013) and was reported by 21.9% of student-athletes in the current study. Results from the current study are consistent with previous literature investigating the association between sensation-seeking and engaging in high physical risk athletic activities (Goma-i-Freixanet et al., 2012; Graupensperger et al., 2019; Martin-Diener et al., 2016; Niedermeier et al., 2019). Specifically, sensation-seeking is associated with increased overall athletic injury risk (Martin-Diener et al., 2016); engaging in high physical risk sports such as mountain climbing, rock climbing, white-water rafting, skiing, and snowboarding (Martin-Diener et al., 2016); and reporting an injury history (Goma-i-Freixanet et al., 2012). Translating these previous findings to the current data, not reporting concussion symptoms at the time of injury may: 1) increase overall risk musculoskeletal injury (a phenomenon which has been seen with athletes returning to play after a concussion McPhearson et al., 2019); and 2) impair overall athletic performance as concussion-related physical impairments (decreased balance and agility) and cognitive symptoms could impact overall decision making and focus.

We observed an association between higher sensation-seeking scores and continuing to play with concussion symptoms. Theory-based concussion education, specifically programs using the Theory of Planned Behavior and

Social Norms Theory, aim to improve concussion care-seeking/disclosure behaviors by changing concussion knowledge, concussion attitudes, and perceived social norms (Kroshus et al., 2014; Kroshus et al., 2015; Register-Mihalik et al., 2013; Schmidt et al., 2020). The current study's findings identifying the association between increased sensation-seeking and concussion attitudes, perceived social norms, and playing with concussive symptoms provide further evidence for theory-based concussion education. Additionally, our findings highlight the need to also address behavioral tendencies and traits, specifically sensation-seeking behaviors, by creating concussion education resources focusing on sensation-seeking as a malleable trait and addressing the risk of playing with concussion symptoms. Furthermore, individualized education programs for student-athletes with higher sensation-seeking may be necessary to improve concussion reporting behavior.

Limitations

The subjects in this study (n = 294) were from a single NCAA Division I institution with a 79.2% Caucasian study sample, which may limit the study's generalizability to all student-athletes as Caucasians represent 56.0% of all NCAA Division I student-athletes (NCAA, 2020a). However, the current study's sample was similar to the NCAA-wide breakdowns for sex (56.0% male versus 51.9% in the current study) and contact sport participation (67.0% versus 70.0% in the current study) (NCAA, 2020a; NCAA, 2020b). Additionally, using a study sample from a single NCAA Division I institution limits the ability to generalize to other NCAA divisions and sport levels (youth, high school, professional). All survey questionnaires utilized for this study required student-athletes to self-report their responses, which may introduce potential limitations related to response bias associated with previous concussive injuries and social desirability bias associated with reporting concussion attitudes, perceived social norms, concussion care-seeking/disclosure behaviors, and sensation-seeking. Finally, due to the cross-sectional survey study design, results are unable to include causal interpretation.

Conclusion

Student-athletes reporting more sensation-seeking behaviors reported less favorable concussion attitudes, less favorable perceived social norms surrounding concussion, and were more likely to report continued play despite experiencing concussion symptoms. Findings indicate student-athletes with increased sensation-seeking could be at risk for concussion non-disclosure and delayed care-seeking. This may result in less optimal care post-injury and, ultimately, negatively impact athlete safety and recovery (Kerr et al., 2016; McCrea et al., 2004; Meehan et al., 2013).

Future research could investigate the relationship between specific risky behaviors and additional behavioral constructs [such as impulsivity as previous research has suggested (Liebel et al., 2020)] and concussion care-seeking/disclosure behaviors. Additionally, future research could investigate the impact that theory-based concussion education promoting positive sport culture and emphasizing behavioral tendencies associated with concussion care-seeking/disclosure behaviors have on injury reporting. Furthermore, individualized interventions could differentiate risky behavior engagement that may benefit sport performance versus risky behavior engagement that may impair performance.

Acknowledgements

The Behaviors, Attitudes, Norms, and Knowledge (BANK) Study (Data Source One) was funded in part by an NCAA-DOD Research Challenge Award. This publication was also made possible, in part, with support from the Grand Alliance Concussion Assessment, Research and Education (CARE) Consortium (Data Source Two), funded, in part by the National Collegiate Athletic Association (NCAA) and the Department of Defense (DOD). The U.S. Army Medical Research Acquisition Activity, 820 Chandler Street, Fort Detrick MD 21702-5014 is the awarding and administering acquisition office. This work was supported by the Office of the Assistant Secretary of Defense for Health Affairs, through the Combat Casualty Care Research Program, endorsed by the Department of Defense, through the Joint Program Committee 6/Combat Casualty Care Research Program – Psychological Health and Traumatic Brain Injury Program under Award No. W81XWH1420151. Opinions, interpretations, conclusions and recommendations are those of the author and are not necessarily endorsed by the Department of Defense. We acknowledge Drs. Thomas McAllister, Steven Broglio, and Michael McCrea who serve as co-Principal Investigators on the NCAA-DOD CARE Consortium.

In addition to the funding for the data source studies as reported in the acknowledgements, Dr. Mihalik reports grants from the National Football League, Department of Defense, National Institutes of Health, and Centers for Disease Control and Prevention outside the submitted work and is Chief Science Officer for Senaptec, Inc. Dr Marshall is partially supported by an Injury Control Research Center award (R49/CE002479) from the National Center for Injury Prevention and Control, Centers for Disease Control and Prevention. Dr. Kerr reports grants from National Football League and Centers for Disease Control and Prevention outside the submitted work**.** Dr. Register-Mihalik reports grants from the National Football League, NOCSAE, Department of Defense, NATA Foundation, and Centers for Disease Control and Prevention outside the submitted work and is a Member of USA Football's Football Development Council.

The experiments comply with the current laws of the country in which they were performed. The datasets generated during and/or analyzed during the current study are not publicly available, but are available from the corresponding author who was an organizer of the study.

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Key points

- Student-athletes' sensation-seeking behaviors were associated with less favorable concussion attitudes, less favorable perceived social norms surrounding concussion, and continued play despite experiencing concussion symptoms.
- Findings suggest student-athletes with increased sensation-seeking could be at risk for delayed concussion care-seeking or not seeking care at all, resulting in a longer clinical recovery, negatively impacting overall health.
- Future research could investigate the impact that theory-based concussion education promoting positive sport culture and emphasizing behavioral tendencies associated with concussion care-seeking/disclosure behaviors have on injury reporting.

AUTHOR BIOGRAPHY

Christine E. CALLAHAN
Employment
A third year doctoral candidate in Human Movement Science at the University of North Carolina at Chapel Hill (UNC-CH). As a part of her doctoral studies at UNC-CH, she serves as a Graduate Researcher at the Matthew Gfeller Center.
Degree
MSc
Research interests
The psychosocial components of concussion prevention and rehabilitation and utilizing psychotherapeutic interventions for concussion rehabilitation.
E-mail: chriscal@live.unc.edu

Melissa K. KOSSMAN
Employment
Assistant Professor in the School of Health Professions at the University of Southern Mississippi.
Degree
PhD
Research interests
General and concussion-specific sport safety and sport culture, the interdisciplinary clinical team, and using mixed-methodological research approaches.
E-mail: m.k.kossman@usm.edu

Jason P. MIHALIK
Employment
Professor in the Department of Exercise and Sport Science at UNC-CH and the Co-Director of the Matthew Gfeller Center. Additionally, Dr. Mihalik serves as an Affiliate Faculty at the UNC-CH Injury Prevention Research Center.
Degree
PhD
Research interests
Head trauma biomechanics with clinical outcomes in civilian athletes and military warfighters.
E-mail: jmihalik@email.unc.edu

Stephen W. MARSHALL
Employment
Director of the Injury Prevention Research Center at UNC-CH, Professor in the UNC-CH Department of Epidemiology, and holds an adjunct appointment in the UNC-CH Department of Exercise and Sport Science Matthew Gfeller Center.
Degree
PhD
Research interests
Injury prevention including musculoskeletal injuries, opioid overdose, occupational injury, homicide and violence prevention, traumatic brain injury, road and other transportation injury, injuries in the military, and surveillance methods.
E-mail: smarshall@unc.edu

Paula GILDNER
Employment
Project Director for the UNC-CH Injury Prevention Research Center and the Matthew Gfeller Center.
Degree
MPH
Research interests
Concussion prevention and education in middle school sports and the role of active rehabilitation for sport and military concussion.
E-mail: pgildner@unc.edu

Zachary Y. KERR
Employment
Assistant Professor in the Department of Exercise and Sport Science at UNC-CH and serves as Core Faculty at the UNC-CH Injury Prevention Research Center, UNC-CH Center for the Study of Retired Athletes, and UNC-CH Matthew Gfeller Center.
Degree
PhD
Research interests
Injury prevention strategies related to concussion and exertional heat stroke, with a focus on injury surveillance and survey research.
E-mail: zkerr@email.unc.edu

Kenneth L. CAMERON
Employment
Director of Orthopedic and Sports Medicine Research at Keller Army Hospital and holds faculty appointments with the John A. Feagin Jr. Orthopedic Sports Medicine Fellowship and the US Army-Baylor University Sports Physical Therapy Doctoral Program.
Degree
MD
Research interests
Injury prevention in military populations.
E-mail: Kenneth.l.cameron.civ@mail.mil

Megan N. HOUSTON
Employment
Project Director and site co-Principal Investigator for the NCAA-DOD Grand Alliance CARE protocol at Keller Army Hospital at the United States Military Academy at West Point.
Degree
PhD
Research interests
Patient-reported outcomes and health-related quality of life following sport-related injury.
E-mail: megan.n.houston.ctr@mail.mil

Martin MRAZIK
Employment
Professor and Associate Chair in the Educational Psychology Department at the University of Alberta.
Degree
PhD
Research interests
The psychoeducational assessment of intelligence, academics, and emotional/behavioral functioning of children, focusing on applied psychological assessment. Additionally, he investigates the neuropsychological assessment of traumatic brain injury and psychological outcomes of sport-related concussion.
E-mail: mrazik@ualberta.ca

Johna K. REGISTER-MIHALIK
Employment
Associate Professor in the Department of Exercise and Sport Science at UNC-CH and serves as Core Faculty at the UNC-CH Injury Prevention Research Center, UNC-CH Center for the Study of Retired Athletes, and UNC-CH Matthew Gfeller Center.
Degree
PhD
Research interests
Innovative prevention and treatment strategies for concussion across the lifespan.
E-mail: johnakay@email.unc.edu

✉ **Christine E. Callahan**
PhD Candidate in Human Movement Science, Matthew Gfeller Center. The University of North Carolina at Chapel Hill, 2207 Stallings Evans Sports Medicine Center, USA