

Factors Associated With Concussion Nondisclosure in Collegiate Student-Athletes

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Context: Mandated concussion education has aimed to improve student-athlete knowledge; however, some collegiate student-athletes continue to not disclose concussion. Concussion knowledge may not be the only factor influencing reporting, as student-athlete sex, sport, and pressure from external stakeholders (eg, coaches, teammates, fans, parents or family) have all been documented as influencing collegiate concussion-reporting behavior.

Objective: To examine factors associated with concussion nondisclosure in collegiate student-athletes.

Design: Cross-sectional study.

Setting: Four National Collegiate Athletic Association Division I and two Division II universities.

Patients or Other Participants: A total of 1125 collegiate student-athletes completed the survey, and 741 provided viable responses and were included for data analysis.

Main Outcome Measure(s): We used a 10- to 15-minute electronic or paper-and-pencil survey that asked about personal and sport demographics, diagnosed concussions and non-disclosed concussion history, concussion knowledge, and level of agreement regarding pressure to play after a head impact experienced during collegiate sport participation. Significant

univariable factors were entered into a multivariable logistic regression analysis.

Results: Sex ($P = .005$), sport-risk type ($P < .001$), diagnosed concussion history ($P < .001$), concussion knowledge ($P = .017$), and pressure from coaches ($P < .001$), teammates ($P < .001$), fans ($P = .024$), and parents or family ($P = .003$) were factors associated with concussion nondisclosure in individual univariable logistic regressions. After we conducted multivariable analyses, male sex ($P = .001$), high concussion-risk sport participation ($P = .048$), diagnosed concussion history ($P < .001$), increased concussion knowledge ($P = .013$), and experiencing pressure from coaches to continue playing after sustaining a hit to the head ($P = .002$) were factors associated with concussion nondisclosure in collegiate student-athletes.

Conclusions: Our results suggest that concussion-education programs should go beyond the identification of signs and symptoms to include the dangers of continuing to play, long-term consequences, and transparency about concussion protocols. Comprehensive concussion-education programs should involve coaches and athletes to improve the reporting culture.

Key Words: coach influence, pressure, reporting behavior

Key Points

- Approximately 16% (116/741) of Division I and Division II collegiate student-athletes reported sustaining a concussion that they did not disclose to their coach, athletic trainer, parent, teammate, or anyone else.
- Nearly 1 of every 5 (18.2%) collegiate student-athletes indicated that they felt pressured by a coach to play after a head impact.
- The odds of nondisclosure increased by 7.3% for each 1-point increase in concussion knowledge, independent of male sex, concussion history, and pressure from coaches.
- Male sex, high-risk sport participation, diagnosed concussion history, concussion knowledge, and experiencing pressure from coaches to continue playing after sustaining a hit to the head were all factors associated with concussion nondisclosure in collegiate student-athletes.

Concussions occur approximately 1.1 million to 1.9 million times annually in US youth 18 years and younger and represent 6% of collegiate injuries.^{1,2} Although common, these injuries can manifest a wide array of clinical symptoms, cognitive impairments, and balance deficits.³ The inconsistent presentation of concussions poses a tremendous challenge for health care professionals tasked with evaluating these injured student-athletes. The evaluation process relies heavily on student-athletes to report suspected injuries along with any subsequent postconcussion symptoms. To appropriately report a concussion, student-athletes must have foundational knowl-

edge of the injury cause, clinical symptoms, and other common impairments associated with the injury. Therefore, in 2010, the National Collegiate Athletic Association (NCAA) mandated that every collegiate student-athlete receive formal concussion education (ie, handouts, lectures, emails) regardless of sport or participation level.⁴ Although this mandate was directly aimed at improving collegiate student-athlete concussion knowledge, researchers^{5–8} have found that some collegiate student-athletes continue to not disclose concussions. This is particularly true in collegiate football: approximately 68% of student-athletes reported that they sustained a possible concussion that they did not

disclose.⁵ Although football has been found to have the highest prevalence of concussion nondisclosure, significant percentages of women's soccer (42%), men's lacrosse (36%), and wrestling (36%) collegiate student-athletes have also reported previous concussion nondisclosure.⁵ This high prevalence of nondisclosure persists among collegiate student-athletes,⁶⁻⁹ suggesting that concussion knowledge may not be the only factor motivating nondisclosure.

Earlier researchers¹⁰ used deductive reasoning to explain concussion-reporting behavior, mainly drawing from the theory of planned behavior (TPB). According to the TPB, the most important element of behavior is the intention to perform that specific behavior, with intention driven by 3 factors: attitudes, subjective norms, and perceived behavioral control.¹¹ Therefore, although concussion knowledge is an important predictor to consider, several other factors may influence a student-athlete's intention to report a head injury.^{5,6,12} Factors such as student-athlete sex,^{5,6,9} sport,^{5,13} concussion history,^{6,9,14} and pressure from external stakeholders (ie, coaches, teammates, fans, parents)⁶ have all been documented as influencing collegiate athlete concussion-reporting behavior. When evaluating former collegiate student-athletes, Kerr et al⁵ observed that males were more likely than females to not disclose a concussion. In addition to these identified sex differences, self-reported concussion history also influenced concussion nondisclosure.^{9,14-16} Evidence of this has been demonstrated in high school¹⁵ and collegiate^{9,14} student-athletes as well as in military cadets.¹⁶ More specifically, when investigating collegiate student-athletes, researchers⁹ found that those with a history of concussion were 2.6 times more likely to not disclose a future concussion. Understanding why student-athletes hesitate to report a concussion is crucial to identifying strategies for improving concussion-reporting behavior.

When asked about the specific reasons for concussion nondisclosure, former collegiate student-athletes cited not wanting to leave the game or practice and not wanting to let their teammates down.⁵ Feeling pressure from teammates to not disclose a concussion was also cited by approximately 46% of collegiate student-athletes.⁹ Similarly, 50%, 22%, and 38% of collegiate student-athletes described feeling significant pressure from coaches, parents, and fans, respectively, when deciding to continue participating in their sport after a hit to the head.⁹ Furthermore, approximately 25% of collegiate student-athletes felt pressure from at least 1 of these sources to not disclose a concussion.⁶ This is concerning as these stakeholders may affect the decisions collegiate student-athletes make on a daily basis regarding their health and wellness. After a concussion, collegiate student-athletes primarily rely on parents, friends, and teammates for support throughout recovery.¹⁷ When student-athletes feel pressure from these support networks to continue playing with a head injury, they may jeopardize their health and recovery.

Student-athletes who fail to report a concussion and continue to play are at an increased risk for sustaining a second head injury.¹⁸ A subsequent head injury has been associated with permanent health implications and even death.¹⁸ In addition to these major health complications, student-athletes who continue to play through a concussion took twice as long to recover as those who were immediately removed from play (44 days versus 22 days).¹⁹ Therefore, by disclosing a concussion immediately after it

occurs, student-athletes may reduce their risk of a second, life-threatening injury and improve their postconcussion recovery outcomes. Critically needed is further evaluation of factors that influence an athlete's intention to disclose a concussion in order to identify where targeted intervention strategies may be most beneficial in improving concussion-reporting behaviors. Therefore, the purpose of our study was to examine factors associated with concussion nondisclosure in collegiate student-athletes.

METHODS

Research Design and Participants

This was a cross-sectional study of NCAA collegiate student-athletes from 4 Division I and 2 Division II universities in Michigan, Ohio, Pennsylvania, and South Carolina. Data were collected from fall 2017 to spring 2018. All collegiate student-athletes included in the study were between 18 and 24 years old and participated in an NCAA-sanctioned sport at their respective institution at the time of study participation. A total of 1125 collegiate student-athletes initiated the study survey. The survey response rate could not be calculated for the current study and is acknowledged as a limitation. Before survey administration, athletes at each participating university were instructed that they must be 18 years or older. To ensure that only athletes 18 or older took the survey, the first question asked, "Are you 18 years or older?" Nine (0.8%) collegiate student-athletes were excluded, as they were younger than 18 years of age at the time of the study and were instructed to stop the survey. To reduce response biases, collegiate student-athletes were excluded if they sustained a concussion within the previous 3 months ($n = 27$; 2.4%), reported impairment from a concussion sustained longer than 3 months before or were receiving treatment for protracted impairment due to concussion at the time of recruitment ($n = 16$; 1.4%), or had missing or incomplete data ($n = 332$; 29.5%). After applying the exclusion criteria, we analyzed data for 741 participants.

Measures

We used a 10- to 15-minute survey that asked about personal and sport demographics, diagnosed concussion and nondisclosed concussion history, concussion knowledge, and level of agreement regarding pressures to play after a head impact experienced during collegiate sport participation. The demographics section addressed age, sex, academic year, level (eg, Division I, II, III), and sport. For the diagnosed concussion history, participants were asked to report the number of concussions they sustained that were diagnosed by a physician or certified athletic trainer. In addition, nondisclosed concussion history was obtained by asking participants to provide the number of possible concussions they had sustained that they did not report to their coach, certified athletic trainer, parent, or teammate. For the purposes of the current study, we transformed diagnosed concussion and nondisclosed concussion history into dichotomous variables (*yes* or *no*). Participant concussion knowledge was assessed using an adapted version of a previously published instrument developed by Register-Mihalik et al.²⁰ Participants were asked to recognize the signs and symptoms of concussion and

answer general concussion-knowledge questions for a total knowledge score (maximum = 49). Higher scores indicated greater knowledge of concussion. An additional 7 concussion signs and symptoms (sensitivity to light and noise, balance problems, fogginess, feeling more emotional, fatigue or low energy, and feeling slowed down) were added to the original instrument to be consistent with current concussion-identification and -management practices. The adapted concussion-knowledge assessment used in the current study had acceptable internal consistency with a Cronbach α of 0.77. Finally, participants were asked to indicate their level of agreement with the following statement: “As a college athlete, I have felt pressure from _____ to return to play after sustaining a hit to the head after playing sports.”⁶ Pressure from external sources (ie, coaches, teammates, fans, parents or family members) was rated on a 7-point Likert scale ranging from 1 (*strongly disagree*) to 7 (*strongly agree*). We transformed the pressure item into a dichotomous variable, with participants who reported *slightly agree*, *agree*, or *strongly agree* categorized as experiencing pressure from external sources and athletes who reported anything else categorized as not experiencing pressure from external sources. The final survey was assessed for face validity by 3 content experts and pilot tested with 10 collegiate undergraduate students who did not participate in sport.

Procedures

Before recruitment and data collection, we obtained university institutional review board exemption approval. We sent head athletic trainers at each participating institution an informative email detailing the study. Certified athletic trainers at each participating institution served as liaisons between the researchers and sports teams to schedule and coordinate data-collection sessions. Data collection occurred in athletic training rooms or designated classrooms, at team practices or meetings, before or after practice, or as participants received treatment for an unrelated musculoskeletal injury. Participants were first provided with an informed consent form to review, and consent was indicated when they voluntarily completed the study survey. The survey was administered to participants via iPad (Apple Inc, Cupertino, CA) or paper and pencil depending upon the resources available at each data-collection site. Survey responses collected via iPad were recorded on the Qualtrics survey platform (Provo, UT). Paper-and-pencil responses were later entered into Qualtrics by a trained researcher. Data were imported into and analyzed using SPSS (version 24; IBM Corp, Armonk, NY).

Data Analysis

Demographic information including age, sex, academic year, division, and sport was described using means, standard deviations (SDs), frequencies, and percentages. Sport was transformed into a binary variable of high (basketball, football, field hockey, ice hockey, lacrosse, soccer, softball, volleyball, wrestling) and low (baseball, bowling, cross-country, golf, rowing, swimming and diving, tennis, track and field, water polo) concussion-risk sports, based on epidemiologic findings from Zuckerman et al.¹ Age, sex (female or male), concussion-risk type (high or low risk), diagnosed concussion history (yes or no),

Table 1. Demographic Information of Current National Collegiate Athletic Association Student-Athletes in Total Sample and Participants with a History of Concussion Nondisclosure

Demographic Variable	No. (%)	
	Total Sample (N = 741)	Concussion-Nondisclosure Group (n = 116)
Sex		
Male	448 (60.5)	84 (72.4)
Female	293 (39.5)	32 (27.6)
Division		
I	287 (38.7)	32 (27.6)
II	370 (49.9)	67 (57.8)
III	84 (11.3)	17 (14.7)
Year in school		
Freshman	133 (17.9)	18 (15.5)
Sophomore	237 (32.0)	34 (29.3)
Junior	171 (23.1)	29 (25.0)
Senior	158 (21.3)	21 (18.1)
Fifth-year senior	25 (3.4)	7 (6.0)
Graduate student	17 (2.3)	7 (6.0)
Sport		
Baseball	43 (5.8)	6 (5.2)
Basketball	62 (8.4)	4 (3.4)
Bowling	7 (0.9)	NA
Cross-country	30 (4.0)	2 (1.7)
Field hockey	22 (3.0)	3 (2.6)
Football	179 (24.2)	52 (44.8)
Golf	7 (0.9)	2 (1.7)
Ice hockey	31 (4.2)	2 (1.7)
Lacrosse	82 (11.1)	9 (7.8)
Rowing	11 (1.5)	1 (0.9)
Soccer	77 (10.4)	14 (12.1)
Softball	28 (3.8)	4 (3.4)
Swimming and diving	20 (2.7)	3 (2.6)
Tennis	31 (4.2)	NA
Track and field	16 (2.2)	2 (1.7)
Volleyball	33 (4.5)	5 (4.3)
Water polo	22 (3.0)	NA
Wrestling	40 (5.4)	7 (6.0)

Abbreviation: NA, not available.

concussion knowledge, and experienced pressure (yes or no) from coaches, teammates, fans, and family or parents were included in analyses as potential factors associated with concussion nondisclosure history (yes or no). Before data analysis, we determined that the assumptions of linearity of the logit and multicollinearity were met. Univariable logistic regression analyses were conducted on each factor to determine the odds of not disclosing a concussion. Significant univariable factors were then used in a multivariable logistic regression analysis. Significance was set a priori at $P \leq .05$.

RESULTS

The final sample consisted of 741 collegiate student-athletes (males = 448 [60.5%], females = 293 [39.5%]) aged 19.89 ± 1.32 years (range = 18–24 years). Participants competed in a variety of sports, including football (n = 179; 24.2%), lacrosse (n = 82; 11.1%), and soccer (n = 77; 10.4%; Table 1). Of the 741 collegiate student-athletes, 218 (29.4%) reported sustaining a concus-

Table 2. Factors Associated With Concussion Nondisclosure According to Univariable Logistic Regression

Variable	<i>B</i>	Standard Error	Wald Value	Odds Ratio (95% CI)	<i>P</i> Value	Nagelkerke <i>R</i> ² Value
Sex	0.63	0.22	8.04	1.88 (1.22, 2.91)	.005 ^a	0.020
Age	0.06	0.08	0.71	1.07 (0.92, 1.24)	.398	0.002
Sport risk type	0.86	0.28	9.10	2.35 (1.35, 4.11)	.000 ^a	0.025
Diagnosed concussion history	0.98	0.21	22.46	2.67 (1.78, 4.00)	.000 ^a	0.050
Concussion knowledge	0.06	0.03	5.75	1.07 (1.01, 1.12)	.017 ^a	0.015
Pressure from teammates	1.20	0.23	26.91	3.32 (2.11, 5.22)	.000 ^a	0.057
Pressure from coaches	1.33	0.22	35.70	3.77 (2.44, 5.82)	.000 ^a	0.076
Pressure from parents or family	0.96	0.32	9.08	2.62 (1.40, 4.90)	.003 ^a	0.019
Pressure from fans	1.03	0.30	11.82	2.79 (1.56, 5.01)	.001 ^a	0.024

^a Indicates difference ($P < .05$).

sion that was diagnosed by a physician or certified athletic trainer. Of these 218, 147 (67.4%) reported 1 diagnosed concussion, 44 (20.2%) reported 2 diagnosed concussions, and 27 (12.4%) reported 3 or more diagnosed concussions. Approximately 16% (116/741) of student-athletes described sustaining a concussion that they did not report to their coach, athletic trainer, parent, teammate, or anyone else. The total concussion-knowledge score was 41.02 ± 4.42 (range = 22–48). Additionally, 18.2% (135/741) recounted experiencing pressure from coaches to return to play after sustaining a hit to the head, 15.9% (118/741) from teammates, 8.1% (60/741) from fans, and 7.0% (52/741) from parents or family members.

Sex, sport-risk type, diagnosed concussion history, concussion knowledge, pressure from coaches, teammates, fans, and parents or family were factors associated with concussion nondisclosure in their individual univariable logistic regressions (Table 2) and were therefore entered into a multivariable logistic regression. Age did not influence concussion nondisclosure and was not included in the multivariable analysis.

After we calculated the multivariable analyses, pressure from teammates, fans, and parents or family was no longer significant. Male sex, high-risk sport participation, diagnosed concussion history, increased concussion knowledge, and experiencing pressure from coaches to continue playing after sustaining a hit to the head were all significant factors associated with concussion nondisclosure in collegiate student-athletes. The final multivariable logistic regression model accounted for 16.8% (Nagelkerke R^2) of the variance in concussion nondisclosure among collegiate-student athletes (Table 3).

DISCUSSION

The aim of our study was to investigate factors that may be associated with concussion nondisclosure among collegiate student-athletes. We found that being a male,

participating in a high concussion-risk sport, and having a history of diagnosed concussion increased the odds of nondisclosure. Also, as concussion knowledge increased, so did the likelihood of concussion nondisclosure. Compared with those who were not pressured, collegiate student-athletes who had felt pressured by a coach to continue participating after an impact to the head were 2.69 times more likely to not disclose a concussion. Although our study of concussion-reporting behaviors was not novel, the findings expand our understanding of factors that may drive injury-disclosure decisions in this population and further highlight the influential nature of the coach-athlete relationship within collegiate athletics.

Sex and Concussion-Risk Sport Type

Male athletes and those in high-risk sports were more likely to not report a concussion than were females and those in low-risk sports. The majority of research supports these findings, with female athletes more likely to report their concussion to an authoritative figure than were male athletes.^{5,21,22} Kerr et al⁵ indicated that male collegiate athletes were 2.88 times more likely to not disclose their concussion than were female collegiate athletes. However, other authors^{9,23} described no sex differences in collegiate athletes regarding disclosing their concussions. Researchers reported that athletes participating in high concussion-risk sports such as cheerleading, football, lacrosse, and soccer were more likely to not disclose their concussion than were athletes participating in low risk sports.²⁴ In a study of retired NCAA athletes, 68% of football athletes were more likely to not disclose their concussions compared with 11% of females in low-risk or noncontact sports.⁵ In addition, almost two-thirds of football athletes were more likely to continue playing with a headache after a hit to the head compared with 35% of female athletes.²⁵ Thus, it is imperative that clinicians continue to educate and monitor male collegiate athletes and those in high concussion-risk

Table 3. Factors Associated With Concussion Nondisclosure According to Multivariable Logistic Regression

Variable	<i>B</i>	Standard Error	Wald Value	Odds Ratio (95% CI)	<i>P</i> Value
Sex	0.822	0.250	10.850	2.275 (1.395, 3.711)	.001 ^a
Sport-risk type	0.591	0.299	3.904	1.806 (1.005, 3.246)	.048 ^a
Diagnosed concussion history	0.836	0.224	13.972	2.308 (1.489, 3.578)	.000 ^a
Concussion knowledge	0.070	0.028	6.178	1.073 (1.015, 1.134)	.013 ^a
Pressure from teammates	0.375	0.331	1.280	1.455 (0.760, 2.785)	.258
Pressure from coaches	0.990	0.317	9.771	2.692 (1.447, 5.008)	.002 ^a
Pressure from parents or family	0.054	0.407	0.018	1.056 (0.475, 2.344)	.894
Pressure from fans	0.117	0.384	0.092	1.124 (0.529, 2.388)	.761

^a Indicates difference ($P < .05$).

sports for possible concussions, as they are more likely to not disclose a concussion to an authority figure. Also, behavior modification should be encouraged to reduce the risk of concussion in this population.

Diagnosed Concussion History

Concussion history was a significant factor associated with concussion nondisclosure. Specifically, collegiate student-athletes who had a history of at least 1 diagnosed concussion were 2.3 times more likely to not report a suspected concussive injury than those who had not sustained a concussion. These findings are similar to those recently reported in the literature on high school athletes,¹⁵ collegiate football players,¹⁴ Irish collegiate student-athletes,⁹ and US military cadets.¹⁶ Collectively, these results strongly suggest that prior personal experience with concussion is a dissuasive factor for injury disclosure. Those who sustained a concussion previously may choose to not report a future injury to avoid what they consider to be negative consequences of the management and recovery process (eg, removal from participation, loss of status on their athletic team, isolation, mental health concerns).¹⁵ Another explanation is that those who successfully recovered from a concussion may feel that they can self-manage their symptoms using strategies that worked for their previous injury. Moving forward, health care providers should take note of the modifying role a diagnosed concussion history has on injury disclosure. We can work to overcome this barrier by being transparent about the postinjury management process and actively seeking opportunities to engage previously concussed athletes in conversations about the importance of disclosure and the potential complications that could result from not reporting.

Concussion Knowledge

The relationship between concussion knowledge and concussion nondisclosure has been continuously investigated among collegiate and high school cohorts. The literature consistently demonstrated that concussion knowledge does not always equate to behavior modification or disclosure of a possible concussion. Among Irish collegiate-athletes, concussion knowledge did not affect nondisclosure.⁹ In our study, the odds of nondisclosure increased by 7.3% for each 1-point increase in concussion knowledge, independent of male sex, concussion history, and pressure from coaches. These results support the ongoing narrative that more knowledge does not, in fact, equate to better reporting of concussions, and they reveal an inverse relationship between concussion knowledge and disclosure. Moreover, our findings affirm those of Piana et al²⁶ that female collegiate ice-hockey athletes with higher concussion-knowledge scores were more likely than their peers to have sustained a concussion and not reported it. These outcomes continue to show that concussion knowledge remains an auxiliary item on the pyramid of influence²⁷ and that behavior modifications will likely continue to not change without changes in the structural foundation of values that shape reporting and nondisclosure.

Pressure from Coaches to Play After a Head Impact

In our sample, nearly 1 out of every 5 collegiate student-athletes indicated that he or she had felt pressured by a coach to play after a head impact. The percentage of participants who felt pressure from coaches to play after a head impact in this study (18.2%) was less than in previous research among Irish collegiate athletes (49.6%).⁹ Our observations were more similar to those of Kroshus et al,⁶ who noted that 13.68% of a US collegiate student-athlete sample experienced pressure from a coach during the previous season to continue playing after a head impact. Although our participants stated they felt pressure from other external stakeholders (ie, teammates, fans, and parents or family), pressure from coaches had the greatest negative influence on concussion nondisclosure. Earlier authors^{20,21,28} determined that athletes were deterred from reporting concussive symptoms by concern about their coaches' reactions and how being removed from play could negatively affect their team. These results highlight the critical role of interpersonal relationships in regard to concussion reporting. The power of coaches to affect team concussion culture has been documented,²⁹ and evidence suggests that positive coach communication regarding concussion identification and reporting significantly increases athletes' intentions to disclose an injury.³⁰ Moving forward, coaches should be educated further about their role in shaping team norms for sport safety⁶ and encouraged to have open conversations about injury reporting with their athletes to normalize concussion disclosure.

Our study had a few limitations that need to be considered when interpreting the results. First, the survey response rate could not be calculated. Before the data-collection sessions, athletes were given the exclusion criteria and did not appear for the session if they were excluded or did not want to participate. We do not know how many student-athletes did this; therefore, the results should be interpreted with caution due to the potential for nonresponse bias. Second, although our dataset was still considered large, female athletes accounted for just over a quarter of the sample. Third, the data were collected from 2 states in the Midwest, 1 state in the mid-Atlantic, and 1 state in the Southeast. Thus, our findings cannot be generalized to all NCAA collegiate student-athletes. Finally, as with all survey research, recall bias may have influenced the results. Our athletes may not have remembered all of their concussions or disclosed a concussion when it was either a subconcussive injury or due to other factors (ie, dehydration). Future investigators should focus on factors that influence disclosure using socioeconomic models, specifically focusing on concussion interventions that target the cultural norms of "winning at all costs." Further work should also address the age at which athletes start to not disclose their concussions, so that interventions can be implemented early in their sport participation. Finally, future authors should concentrate on interpersonal factors and concussion nondisclosure, focusing specifically on the coach-athlete relationship and ways to build trust and relationships between coaches and student-athletes.

CONCLUSIONS

Our results add to the literature on concussion-reporting behaviors as it relates to factors associated with concussion

nondisclosure. We suggest that many factors, and possibly other factors not examined in the current study, may drive concussion-reporting intentions. It may be advantageous to use the TPB to identify other potential factors that may drive concussion-reporting intentions. In addition, our findings highlight the need to continue to educate coaches on the dangers of their athletes participating with a concussion. Moreover, it is imperative to educate coaches on the influence that their behaviors and words have on the coach-athlete relationship. Being male, participating in a high-risk sport, having a history of concussion, possessing increased concussion knowledge, and experiencing pressure from coaches were also factors associated with concussion nondisclosure. Therefore, more comprehensive educational programs are needed for collegiate student-athletes. These results suggest that simply educating athletes about signs and symptoms is not enough to improve their reporting behaviors. Concussion-education programs for collegiate student-athletes should go beyond sign and symptom identification to address the dangers of continuing to play in the presence of a concussion, including the risk of catastrophic injury or increased time loss for delayed reporting, and long-term consequences. Furthermore, it may help if clinicians are transparent about the concussion-management protocol, so that athletes know what to expect when choosing to disclose a concussion. Concussion-education programs should involve coaches in creating a positive reporting culture for athletes. If coaches exhibit positive attitudes toward concussion reporting, athletes may absorb the information and report more often. To avoid misinformation, health care providers should deliver the educational material, yet including coaches and athletes in such programs may improve concussion-reporting behaviors.

REFERENCES

- Zuckerman SL, Kerr ZY, Yengo-Kahn A, Wasserman E, Covassin T, Solomon GS. Epidemiology of sports-related concussion in NCAA athletes from 2009-2010 to 2013-2014: incidence, recurrence, and mechanisms [published correction appears in *Am J Sports Med*. 2016;44(1):NP5]. *Am J Sports Med*. 2015;43(11):2654–2662. doi:10.1177/0363546515599634
- Bryan MA, Rowhani-Rahbar A, Comstock RD, Rivara F; Seattle Sports Concussion Research Collaborative. Sports- and recreation-related concussions in US youth. *Pediatrics*. 2016;138(1):e20154635. doi:10.1542/peds.2015-4635
- McCrory P, Meeuwisse W, Dvořák J, et al. Consensus statement on concussion in sport—the 5th international conference on concussion in sport held in Berlin, October 2016. *Br J Sports Med*. 2017;51(11):838–847. doi:10.1136/bjsports-2017-097699
- 2013–14 NCAA Sports Medicine Handbook. National Collegiate Athletic Association Web site. <http://www.ncaapublications.com/productdownloads/MD14.pdf>. Published 2013. Accessed August 4, 2020.
- Kerr ZY, Register-Mihalik JK, Kroshus E, Baugh CM, Marshall SW. Motivations associated with nondisclosure of self-reported concussions in former collegiate athletes. *Am J Sports Med*. 2016;44(1):220–225. doi:10.1177/0363546515612082
- Kroshus E, Garnett B, Hawrilenko M, Baugh CM, Calzo JP. Concussion under-reporting and pressure from coaches, teammates, fans, and parents. *Soc Sci Med*. 2015;134:66–75. doi:10.1016/j.socscimed.2015.04.011
- McDonald T, Burghart MA, Nazir N. Underreporting of concussions and concussion-like symptoms in female high school athletes. *J Trauma Nurs*. 2016;23(5):241–246. doi:10.1097/JTN.0000000000000227
- Wallace J, Covassin T, Nogle S, Gould D, Kovan J. Knowledge of concussion and reporting behaviors in high school athletes with or without access to an athletic trainer. *J Athl Train*. 2017;52(3):228–235. doi:10.4085/1062-6050-52.1.07
- O'Connor S, Geaney D, Beidler E. Non-disclosure in Irish collegiate student-athletes: do concussion history, knowledge, pressure to play and gender impact concussion reporting? *Phys Sportsmed*. 2020;48(2):186–193. doi:10.1080/00913847.2019.1671141
- Kroshus E, Baugh CM, Daneshvar DH, Viswanath K. Understanding concussion reporting using a model based on the Theory of Planned Behavior. *J Adolesc Health*. 2014;54(3):269–274.e2. doi:10.1016/j.jadohealth.2013.11.011
- Glanz K, Rimer BK, Viswanath K. Theory, research, and practice in health behavior and health education. In: Glanz K, Rimer BK, Viswanath K, eds. *Health Behavior and Health Education: Theory, Research, and Practice*. 4th ed. San Francisco, CA: Jossey-Bass; 2008:23–40.
- Ajzen I, Joyce N, Sheikh S, Cote NG. Knowledge and the prediction of behavior: the role of information accuracy in the theory of planned behavior. *Basic Appl Soc Psych*. 2011;33(2):101–117. doi:10.1080/01973533.2011.568834
- Beidler E, Bretzin AC, Hanock C, Covassin T. Sport-related concussion: knowledge and reporting behaviors among collegiate club-sport athletes. *J Athl Train*. 2018;53(9):866–872. doi:10.4085/1062-6050-266-17
- Baugh CM, Meehan WP 3rd, Kroshus E, McGuire TG, Hatfield LA. College football players less likely to report concussions and other injuries with increased injury accumulation. *J Neurotrauma*. 2019;36(13):2065–2072. doi:10.1089/neu.2018.6161
- Register-Mihalik JK, Valovich McLeod TC, Linnan LA, Guskiewicz KM, Marshall SW. Relationship between concussion history and concussion knowledge, attitudes, and disclosure behavior in high school athletes. *Clin J Sport Med*. 2017;27(3):321–324. doi:10.1097/JSM.0000000000000349
- Register-Mihalik JK, Cameron KL, Kay MC, et al. Determinants of intention to disclose concussion symptoms in a population of U.S. military cadets. *J Sci Med Sport*. 2019;22(5):509–515. doi:10.1016/j.jsams.2018.11.003
- Covassin T, Crutcher B, Bleecker A, Heiden EO, Dailey A, Yang J. Postinjury anxiety and social support among collegiate athletes: a comparison between orthopaedic injuries and concussions. *J Athl Train*. 2014;49(4):462–468. doi:10.4085/1062-6059-49.2.03
- Giza CC, Hovda DA. The new neurometabolic cascade of concussion. *Neurosurgery*. 2014;75 (suppl 4[0 4]):S24–S33. doi:10.1227/NEU.0000000000000505
- Elbin RJ, Sufrinko A, Schatz P, et al. Removal from play after concussion and recovery time. *Pediatrics*. 2016;138(3):e20160910. doi:10.1542/peds.2016-0910
- Register-Mihalik JK, Guskiewicz KM, McLeod TCV, Linnan LA, Mueller FO, Marshall SW. Knowledge, attitude, and concussion-reporting behaviors among high school athletes: a preliminary study. *J Athl Train*. 2013;48(5):645–653. doi:10.4085/1062-6050-48.3.20
- Wallace J, Covassin T, Beidler E. Sex differences in high school athletes' knowledge of sport-related concussion symptoms and reporting behaviors. *J Athl Train*. 2017;52(7):682–688. doi:10.4085/1062-6050-52.3.06
- Kroshus E, Baugh CM, Stein CJ, Austin SB, Calzo JP. Concussion reporting, sex, and conformity to traditional gender norms in young adults. *J Adolesc*. 2017;54:110–119. doi:10.1016/j.adolescence.2016.11.002
- Llewellyn T, Burdette GT, Joyner AB, Buckley TA. Concussion reporting rates at the conclusion of an intercollegiate athletic career.

- Clin J Sport Med.* 2014;24(1):76–79. doi:10.1097/01.jsm.0000432853.77520.3d
24. Register-Mihalik JK, Linnan LA, Marshall SW, Valovich McLeod TC, Mueller FO, Guskiewicz KM. Using theory to understand high school aged athletes' intentions to report sport-related concussion: implications for concussion education initiatives. *Brain Inj.* 2013;27(7–8):878–886. doi:10.3109/02699052.2013.775508
 25. Kaut KP, DePompei R, Kerr J, Congeni J. Reports of head injury and symptom knowledge among college athletes: implications for assessment and educational intervention. *Clin J Sport Med.* 2003;13(4):213–221. doi:10.1097/00042752-200307000-00004
 26. Piana LE, Garvey KD, Kroshus E, Brook EM, Matzkin EG. Implementation and effect of concussion education in collegiate women's ice hockey. *Phys Sportsmed.* 2020;48(1):46–52. doi:10.1080/00913847.2019.1624657
 27. Frieden TR. A framework for public health action: the health impact pyramid. *Am J Public Health.* 2010;100(4):590–595. doi:10.2105/AJPH.2009.185652
 28. Sanderson J, Weathers M, Snedaker K, Gramlich K. "I was able to still do my job on the field and keep playing": an investigation of female and male athletes' experiences with (not) reporting concussions. *Commun Sport.* 2017;5(3):267–287. doi:10.1177/2167479515623455
 29. Baugh CM, Kroshus E, Daneshvar DH, Stern RA. Perceived coach support and concussion symptom-reporting: differences between freshmen and non-freshmen college football players. *J Law Med Ethics.* 2014;42(3):314–322. doi:10.1111/jlme.12148
 30. Milroy JJ, Wyrick DL, Sanders L, Refsteck E, Beamon E. Student-athlete concussion disclosure and coach communication within collegiate athletics. *J Concussion.* 2019;3:2059700219894104. doi:10.1177/2059700219894104

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