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Concussion Symptom Underreporting Among Incoming NCAA Division I College Athletes

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Abstract

Objective—Accurate diagnosis of sport-related concussions relies heavily on truthful self-reporting of symptom severity. Previous studies have emphasized lack of knowledge as a factor in symptom non-disclosure. This study sought to examine concussion knowledge and the relationship of knowledge to reasons for symptom non-disclosure.

Design—Cross-Sectional Study.

Setting—Data were collected during pre-participation athletic evaluations via electronic survey.

Participants—156 incoming NCAA Division I student-athletes.

Main Outcome Measures—Survey items included prior concussion diagnosis, concussion fact and symptom knowledge, reasons and situational contexts for non-disclosure, and stakeholder attitudes.

Results—Participants, on average, had substantial concussion symptom and fact knowledge. Unexpectedly, participants with higher concussion fact knowledge endorsed more reasons that athletes may hide symptoms. Concussion symptom knowledge was unrelated to reasons for non-disclosure. Athletes believed that symptom reporting was less likely in high-stakes versus low-stakes situations and consistently identified their teammates as holding attitudes that support underreporting and athletic trainers as engaging in behaviors that support player safety.

Conclusions—Greater concussion knowledge did not reduce the number of reasons that participants viewed as drivers for concussion non-disclosure. In other words, participants understood why athletes choose to hide symptoms even when they also understood the symptoms, risks, sequelae, and consequences of concussion (and potential harm of non-disclosure).

Situational contexts and important stakeholder attitudes also appeared to importantly influence symptom disclosure decisions. A multifaceted approach that goes beyond current educational strategies to addresses situational, social, and athletic pressures may be needed to initiate a widespread cultural shift away from concussion non-disclosure.

Keywords

sport; brain injury; diagnosis; attitude; reporting; safety

Introduction

Sport-related concussions are mild traumatic brain injuries (MTBI), with symptoms that include, but are not limited to, headaches, sensitivity to light, nausea/vomiting, poor concentration, and lightheadedness.^{1,2} They can be associated with chronic mood disorders, sleep disturbances, and cognitive deficits, and possibly to chronic traumatic encephalopathy (CTE), a progressive neurodegenerative condition.^{3–5} Sport-related concussions are often difficult to diagnose; symptoms are not easily observable, vary widely between individuals, and have different recovery time courses.^{6,7} Accurate diagnosis relies heavily on truthful self-reporting of symptom severity.

Health practitioners, parents, coaches, athletic trainers, sport governing bodies, and athletes have all made appeals for interventions aimed at reducing the risk of sport-related concussions and increasing early detection and treatment.^{8,9} Legislative responses to address the high prevalence rates of sport-related concussions include state laws that require educational materials for parents, athletes, and athletic staff; removal from play of athletes with suspected concussions; and return-to-play protocols that require permission from a health care professional.^{10–12} Other intervention approaches involve training physicians and athletic staff on accurate and state-of-the-science prevention, diagnosis, and treatment protocols.^{13,14} The key to the success of these efforts, however, is truthful reporting of symptoms by athletes. Yet, many athletes do not disclose symptoms when they believe they suffered a concussion.^{15–17} Non-disclosure of symptoms or underreporting the severity of an injury seriously compromises the ability of professionals to protect athletes from the often dangerous consequences of concussion injuries, as well as the ability to enact early interventions.

Despite the importance of accurate symptom reporting, few studies address this issue. A recent review of 30 studies reported that nearly half of the studies focused on “lack of knowledge” as a factor related to non-disclosure of concussion symptoms,¹⁸ with many suggesting that an increase in concussion knowledge among athletes would decrease symptom hiding. The purpose of the present study was to examine the extent to which athlete knowledge about concussions influences beliefs about symptom reporting. We hypothesized that knowledge would be negatively associated with beliefs about reasons for symptom non-disclosure. Sex and sport-type differences in concussion knowledge were examined as was a preliminary investigation of environmental factors (e.g., stakeholder attitudes, situational contexts) that may influence symptom non-disclosure.

Methods

Participants and Procedures

Incoming student athletes completed an electronic questionnaire prior to entry into a large Northeastern university's collegiate athletic program. Athletes were advised about the voluntary nature of the project. A total of 185 student athletes were eligible for participation; 157 (85%) provided written informed consent. One individual was missing all data except sex and race/ethnicity; thus, the present sample was 156 (age 18.4 ± 1.0 years; 49% female; 66% White) and included 128 incoming first-year and 28 transfer student-athletes from 20 National Collegiate Athletic Association (NCAA) Division I teams. The university's Institutional Review Board for the Protection of Human Subjects approved the study.

Measures

Participants completed a 63-item survey about general health, sport and brain health history, and concussion knowledge, attitudes, and beliefs. This survey was collaboratively developed by physicians and researchers based on literature reviews, targeted focus groups, interviews with field experts, and existing protocols in the concussion field. The survey required approximately 30 minutes to complete; only items related to concussion knowledge, attitudes, and beliefs were used in the present study.

Previous concussion experience—Participants responded Yes or No to a single question: "Have you ever been diagnosed with a concussion by a doctor?" A second question asked: "Do you think you have ever sustained a concussion?" and had five response options that were re-coded into two categories: Uncertain ("I don't think so," "maybe/I'm not sure" and "I think so") and certain ("Definitely not" and "Definitely yes"). Percent of participants in each of the previous concussion experience groups was calculated.

Concussion knowledge—Knowledge was measured in two areas: concussion symptom knowledge and concussion fact knowledge. Symptom knowledge was assessed with a list of 13 true symptoms from the Sport Concussion Assessment Tool–3rd Edition¹⁹ (e.g., sensitivity to light, difficulty remembering, and feeling nauseous or vomiting) and eight items not typically associated with concussion (e.g., shortness of breath, nose bleeds, and hives). Participants selected symptoms associated with concussions. Concussion fact knowledge related to causes, diagnosis, sequelae, and recovery/ramifications was assessed with 27 true/false statements (e.g., "Sometimes symptoms of a concussion get worse over time"; "Coaches are as good as doctors at diagnosing concussions"). This scale had good internal consistency ($\alpha = .84$). Percent of correct knowledge symptom and fact responses were calculated.

Concussion Symptom Hiding: Attitudes and Beliefs—Symptom reporting attitudes and beliefs were assessed with two items. In response to the item, "Why do you think that athletes do not report symptoms of a concussion?", participants selected "all that apply" from a list of 13 reasons. One reason was knowledge-based ("They don't know they have a concussion"). Other reasons were related to interpersonal dynamics (e.g., "They don't want to let down their teammates and coaches"), athletic standing (e.g., "They are afraid they will

lose future playing time”), or downplaying (e.g., “They think that getting a concussion is just part of the game”). The sum of endorsed reasons was calculated.

Participants then considered circumstances that influence symptom reporting in response to a second item: “When do you think an athlete is more likely to decide to report concussion symptoms?” Participants chose one option from five pairs of circumstances (choice A vs. choice B) that was more likely to lead to symptom reporting. The pairs of circumstances were: 1) At the beginning of the season vs. At the end of the season; 2) During practice vs. During competition; 3) When he/she is a star player vs. When he/she is an average player; 4) At the beginning of a competition vs. At the end of a competition; and 5) When the team is winning vs. When the team is losing. The percent of participants who picked choice A versus choice B was calculated for each circumstance pair to assess the importance of situational context on symptom reporting.

All concussion symptom disclosure items were framed in the third person (i.e., how *athletes*, not how *you*, may think or behave) to lessen the likelihood of response bias due to social desirability. Prior research has shown that indirect questioning is a viable approach to reducing social desirability bias among survey participants.²⁰

Athletic Stakeholders: Attitudes and Beliefs—Participants provided opinions about whether key stakeholders (teammates, strength trainers, athletic trainers, assistant coaches and head coaches) engaged in behaviors that support player safety (i.e., protecting them from the risks of concussions and/or helpful in their recovery; Cronbach’s $\alpha = 0.90$) or had attitudes that support symptom hiding (i.e., dismissive of the seriousness of concussions; Cronbach’s $\alpha = 0.80$). Participants responded to 12 statements that were either supportive of player safety (e.g., “Demands that athletes tell the truth about concussion symptoms”; “Follows a doctor’s plan for return-to-play.”) or supportive of symptom hiding (e.g., “Thinks that dealing with a concussion is a hassle”; “Thinks an athlete can shake off most symptoms of a concussion.”) by selecting for whom they believed the statements were true (“select all that apply”). Responses related to each stakeholder group were analyzed separately. Percent of participants who endorsed each statement was calculated.

Statistical Analysis

Concussion risk was calculated by separating sports teams into two groups (10 teams each): high-risk and low-risk (Table 1). Risk categories were based on prior epidemiological studies of high school and university athletes that calculated concussion rates by dividing the number of reported concussions by the number of athlete exposures.^{21,22} Sport-specific concussion risk rankings were similar across high school and college. The present study categorized a sport as high-risk based on (a) a high school rate of at least 1 per 10,000 athletic exposure and (b) a college rate of at least 3 per 10,000 athletic exposures. Only women’s volleyball categorization was discrepant using these cutoffs. A low-risk categorization was chosen based on the high school ranking²¹ as this was a study of incoming first-year athletes. Low-risk categorization of golf teams and women’s crew were based on consultations with project physicians and athletic trainers.

The demographic characteristics of the sample, previous concussion experience, and knowledge and symptom reporting scores were assessed with SAS 9.4 (SAS Institute, Cary, NC) univariate analyses. Chi-Square tests assessed prevalence of concussions by sport-risk category (high/low) and sex (male/female) and *t*-tests assessed concussion knowledge and symptom reporting scores by sport-risk category (high/low), sex (male/female), prior concussion diagnosis (yes/no), and certainty of previous concussion experience (certain/uncertain). Correlations were performed between knowledge and symptom hiding items. Results were considered significant at $p < 0.05$ (two-tailed). The percent of options endorsed for situational contexts, symptom hiding, and player safety attitudes and beliefs items was calculated. A post-hoc power analysis (G*Power, v. 3.1.9.2) revealed that the sample size was sufficient to detect a medium effect with the chi-square ($w = 0.25$, $> 80\%$), *t*-tests ($d = 0.50$, $> 80\%$), and bivariate correlations (0.25 , $> 80\%$).

To determine whether the inclusion of transfer students, who had prior exposure to collegiate athletic environments, unduly influenced the results, analyses were performed on the subset of incoming first year students with no prior college experience ($n = 128$). Only two differences were noted and reported in the results below.

Results

Previous Concussion Experience

30 athletes (19.5%) responded affirmatively to “Have you ever been diagnosed with a concussion by a doctor?” (Table 1). More males than females self-reported a concussion diagnosis (60%), but this difference was not significant. A significantly higher percentage of prior concussion diagnoses was reported by athletes who participate in high-risk sports (73%) compared to those who play low-risk sports ($p = 0.0071$). To the question “Do you *think* you have ever sustained a concussion?”, 89 athletes (57%) were certain (i.e., “Definitely yes”, “Definitely not”) and 67 (43%) were uncertain (i.e., “I don’t think so”, “Maybe, I’m not sure”, “I think so”). When the analyses were performed on athletes who were first year students (i.e., transfer students were removed), the relationship between prior concussion diagnoses and sport risk category just missed significance ($p = 0.51$).

Symptom Knowledge and Fact Knowledge

Most participants demonstrated considerable concussion knowledge in both the symptom and general fact knowledge areas. Fifty-seven percent correctly answered $> 80\%$ of the symptom knowledge items (mean $\pm$ SD: 16.6 ± 2.3 , range 0–21; Table 2). Scores did not differ significantly by sex, sport risk status, prior concussion diagnosis, or certainty of prior concussion experience. Similar results were obtained for concussion fact knowledge. Most athletes (79%) answered $> 80\%$ of items correctly (mean $\pm$ SD: 23.1 ± 3.0 , range 0–27; Table 2). Scores did not differ significantly by sex, sport risk status, prior concussion diagnosis status, or certainty of prior concussion experience.

Concussion Symptom Hiding

Over half of participants (59%) endorsed nine or more (out of 13) reasons for hiding symptoms (Table 3). All but two reasons were endorsed by $> 50\%$ of participants. The

number of reasons for non-disclosure differed significantly by sex (10.1/females vs 9.1/males, $p = 0.0044$) and sport risk status (10.2/low-risk vs 9.0/high-risk, $p = 0.0073$). Number of reasons endorsed did not differ significantly by prior concussion diagnosis or certainty of prior concussion experience. When transfer students were removed from the sample, the relationship between sex and reasons for hiding was no longer significant (10.2/females vs 9.4/males, $p = 0.11$).

Concussion symptom knowledge was unrelated to the number of reasons that participants endorsed for non-disclosure. Concussion fact knowledge was significantly positively correlated with the number of reasons ($p < .0001$), with higher fact knowledge being associated with more identified reasons for non-disclosure.

Situational Contexts and Perceptions of Athletic Stakeholders

Descriptive assessment of situational context revealed that athletes were less inclined to report a concussion during high-stake situations (i.e., critical to the outcome of a competition; Figure 1). Characterization of athlete perception of teammate and athletic staff support for symptom hiding (Figure 2) or player safety (Figure 3) showed athletes consistently identified teammates as holding attitudes that support underreporting of concussion symptoms and athletic trainers as engaging in behaviors that support player safety.

Discussion

College athletes had considerable knowledge about concussions at program entry. Yet, this high level of concussion knowledge did not reduce the number of reasons that were viewed as motivations for concussion non-disclosure. In other words, participants understood why athletes choose to hide symptoms even when they also understood the symptoms, risks, sequelae, and consequences of concussion (and potential harm of non-disclosure). The most commonly endorsed reasons for hiding symptoms were related to severity downplaying, loss of athletic standing, and perceived interpersonal pressures. This suggests that athletes may be concerned that reporting symptoms will change team standing or playing time and thus jeopardize professional career prospects. They may perceive that the athletic environment downplays injuries in favor of “toughing it out”, and regards concussions as an accepted risk of the sport.²³ They also may be conditioned by athletic culture to fight through pain as an indication of resolution and strength. Regardless of whether these perceptions are valid, they point to the fact that even when an athlete *knows* he/she is experiencing potential concussion symptoms, contextual and peer influences may outweigh logic. Put another way, athletes sometimes hide concussion symptoms for reasons unrelated to understanding the risk.

Previous researchers have proposed a critical role for environmental factors in symptom reporting^{16,23,24} and substantial anecdotal evidence supports the influence of situational context (e.g., scrimmage vs. playoff game) and community (e.g., teammates, coaches, fans). The present study confirmed the importance of situational context on symptom disclosure as well as athletes' perceptions of key stakeholder attitudes/beliefs regarding concussion. Participants more frequently chose high-stakes versus lower-stakes situations or circumstances as being conducive to hiding concussion symptoms. Thus, context matters.

Although the survey cannot determine factors that explicitly shape reporting attitudes, it suggests that symptom reporting is at least partially dependent on situations and contextual influences.

Perceptions of athletic stakeholders appeared to further complicate concussion symptom reporting decisions. Athletic trainers were viewed as engaging in behaviors that support player safety, whereas teammates were viewed as having attitudes that support symptom hiding. In general, young and emerging adults overvalue social context and network member opinions²⁵ and/or have shorter time horizons over which decisions are made.²⁶ The behavioral economic theory of decision making may be useful for promoting change at the level of the individual athlete as it can alter valuation of social versus personal opinions and immediate versus long-term benefits and consequences. This theory has been successfully applied to other intractable health behaviors. For example, linking calories in alcohol to weight gain may decrease alcohol consumption^{27,28} and levying a tax on soft drinks may decrease soft drink consumption.²⁹ Behavioral economic interventions may offer ways to devalue symptom hiding, reduce peer pressure to hide symptoms, and incentivize rapid reporting.

Taken together, these findings provide objective evidence that a unidimensional approach of athlete-focused, fact-based education does not impact perceived motivations for non-disclosure. There is substantial evidence from multiple disciplines that greater knowledge does not necessarily translate into behavior change.^{30,31} Some of the most historically successful health behavior interventions have required a multi-level and multifaceted approach. The national prevalence rate of adult cigarette use decreased from 42.4% to 16.8% between 1965 and 2014.³² National seatbelt use was ~10% - 15% in the 1950s; 50 years later, it is estimated at 73%.³³ Although it took decades to create epic shifts in these sociocultural attitudes, the magnitude of behavior change was extraordinary. In the case of cigarette use, these changes came about through a broad, multifaceted public health campaign that involved individual smokers, support groups,³⁴ families,³⁵ physicians and other medical professionals,³⁶ workplace environments,³⁷ politicians and advocacy groups, as well as the media and advertising industries.^{38,39} Creating change in concussion symptom non-disclosure may require a similar multifaceted strategy.

A nationwide media campaign depicting the immediate and long-term negative consequences of concussions may be needed to affect change at the sociocultural level. Such a campaign should focus on *why* athletes *should* disclose symptoms. Specifically, it must include concrete strategies and explicit rationales for disclosure. It should also focus on the financial and litigation risks, as well as the health risks, that could impact athletes' families, coaches, and school administrators if concussion symptoms are ignored. High-quality research on the neural, cognitive, and behavioral consequences of sport-related concussion, particularly from independent scientists uninfluenced by the power of the NCAA, NFL or major collegiate conferences, could guide these messages⁵. Validation of key research findings on the short- and long-term effects of sport-related concussion can ensure that public perceptions of concussion risk are based on strong empirical evidence.

The present findings should be considered in light of some limitations. Results are based on responses to a survey developed specifically for this study. Content experts across multiple disciplines collaborated on its development and refinement as there were no existing validated surveys available for addressing the questions of interest. Thus, validity of this survey should be further tested to ensure all domains of knowledge, belief, and attitudes are captured. The data were collected from a sample of incoming collegiate athletes at one state university and thus may not generalize to all collegiate athletes. The sample was not large enough to reliably detect small effect size differences. Participants were asked to provide their opinions about hypothetical situations, rather than actual past behavior or future intentions. Endorsing reasons for hiding symptoms in a hypothetical situation may not necessarily reflect whether a given athlete would actually hide symptoms if he/she were in this situation. Further, as all items were framed in the third person, participants may have responded based on whether “others” would hide symptoms in this situation, and “other” was not specified. It is also possible, for example, that a male football player may have served as the hypothetical “student athlete” for both his teammate as well as a female gymnast participant. Even considering these limitations, this study supports the need for future research focused on disclosure decision-making and the influence of situational, social and athletic pressures. Such studies, combined with novel public health intervention initiatives, are the critical elements needed to initiate a widespread cultural shift away from concussion non-disclosure.

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Conflict of Interest and Source of Funding

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References

1. Junn C, Bell KR, Shenouda C, Hoffman JM. Symptoms of concussion and comorbid disorders. *Curr Pain Headache Rep.* 2015;19(9):1–8.
2. Wasserman EB, Kerr ZY, Zuckerman SL, Covassin T. Epidemiology of sports-related concussions in national collegiate athletic association athletes from 2009–2010 to 2013–2014: symptom prevalence, symptom resolution time, and return-to-play time. *Am J Sports Med.* 2016;44(1):226–233. [PubMed: 26546304]
3. Daneshvar DH, Nowinski CJ, Mckee AC, Cantu RC. The epidemiology of sport-related concussion. *Clin Sports Med.* 2011;30(1):1–17. [PubMed: 21074078]
4. Maruta J, Spielman LA, Yarusi BB, Wang Y, Silver JM, Ghajar J. Chronic post-concussion neurocognitive deficits. II. relationship with persistent symptoms. *Front Hum Neurosci.* 2016;10:1–10. [PubMed: 26858619]
5. Mez J, Daneshvar DH, Kiernan PT, et al. Clinicopathological Evaluation of Chronic Traumatic Encephalopathy in Players of American Football. *JAMA.* 2017;318(4):360–370. [PubMed: 28742910]
6. Lovell MR, Fazio V. Concussion management in the child and adolescent athlete. *Curr Sports Med Rep.* 2008;7(1):12–15. [PubMed: 18296938]
7. Makdissi M, Davis G, McCrory P. Clinical challenges in the diagnosis and assessment of sports-related concussion. *Neurol Clin Pract.* 2015;5(1):2–5. [PubMed: 29443157]

8. Guskiewicz K, Teel E, McCrea M. Concussion: key stakeholders and multidisciplinary participation in making sports safe. *Neurosurgery*. 2014;75(4):S113–S118. [PubMed: 25232875]
9. Logalbo A, Salinas CM, Dougherty M, Field M. Developing an interdisciplinary community-Based sports concussion management program. *Prog Neurol Surg*. 2014;28:184–194. [PubMed: 24923403]
10. Concannon LG. Effects of legislation on sports-related concussion. *Phys Med Rehabil Clin N Am*. 2016;27(2):513–527. [PubMed: 27154860]
11. LaRoche AA, Nelson LD, Connelly PK, Walter KD, McCrea MA. Sport-related concussion reporting and state legislative effects. *Clin J Sport Med*. 2016;26(1):33–39. [PubMed: 25894530]
12. Lowrey KM. State laws addressing youth sports-related traumatic brain injury and the future of concussion law and policy. *J Bus & Tech L*. 2015;10(1):61–72.
13. Kerr HA. Concussion risk factors and strategies for prevention. *Pediatr Ann*. 2014;43(12):e309–e315. [PubMed: 25486039]
14. Schmidt JD, Register-Mihalik JK, Mihalik JP, Kerr ZY, Guskiewicz KM. Identifying impairments after concussion: normative data versus individualized baselines. *Med Sci Sports Exerc*. 2012;44(9):1621–1628. [PubMed: 22525765]
15. Delaney JS, Lamfookon C, Bloom GA, Al-Kashmiri A, Correa JA. Why university athletes choose not to reveal their concussion symptoms during a practice or game. *Clin J Sport Med*. 2015;25:113–125. [PubMed: 24949831]
16. 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(12):220–225. [PubMed: 26582799]
17. 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. [PubMed: 23848520]
18. Kerr ZY, Register-Mihalik JK, Marshall SW, Evenson KR, Mihalik JP, Guskiewicz KM. Disclosure and non-disclosure of concussion and concussion symptoms in athletes: review and application of the socio-ecological framework. *Brain Inj*. 2014;28(8):1009–1021. [PubMed: 24738743]
19. McCrory P, Meeuwisse WH, Aubry M, et al. Consensus statement on concussion in sport—the 4th international conference on concussion in sport held in Zurich, November 2012. *Br J Sports Med*. 2013;5(4):255–279.
20. Fisher RJ. Social desirability indirect questioning. *J Cons Res*. 1993;20(2):303–315.
21. Marar M, McIlvain NM, Fields SK, Comstock RD. Epidemiology of concussions among United States high school athletes in 20 sports. *Am J Sports Med*. 2012;40(4):747–755. [PubMed: 22287642]
22. 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. *Am J Sports Med*. 2015;43(11):2654–2662. [PubMed: 26330572]
23. Chrisman SP, Quitiquit C, Rivara FP. Qualitative study of barriers to concussive symptom reporting in high school athletics. *J Adolesc Health*. 2013;52(3):330–335. [PubMed: 23427783]
24. 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. [PubMed: 25264089]
25. Gardner M, Steinberg L. Peer influence on risk taking, risk preference, and risky decision making in adolescence and adulthood: an experimental study. *Dev Psychol*. 2005;41(4):625–635. [PubMed: 16060809]
26. Whelan R, McHugh LA. Temporal discounting of hypothetical monetary rewards by adolescents, adults, and older adults. *Psychol Rec*. 2009;59(2):247–258.
27. Miller MB, Leffingwell T, Claborn K, Meier E, Walters S, Neighbors C. Personalized feedback interventions for college alcohol misuse: an update of Walters & Neighbors (2005). *Psychol Addict Behav*. 2013;27(4):909–920. [PubMed: 23276309]
28. Peralta RL. Alcohol use and the fear of weight gain in college: reconciling two social norms. *Gender Issues*. 2002;20(4):23–42.

29. Andreyeva T, Long MW, Brownell KD. The impact of food prices on consumption: a systematic review of research on the price elasticity of demand for food. *Am J Public Health*. 2010;100(2):216–222. [PubMed: 20019319]
30. Kelly MP, Barker M. Why is changing health-related behaviour so difficult? *Public Health*. 2016;136:109–116. [PubMed: 27184821]
31. Ryan P Integrated theory of health behavior change: background and intervention development. *Clin Nurse Spec*. 2009;23(3):161–172. [PubMed: 19395894]
32. Center for Disease Control and Prevention. Trends in current cigarette smoking among high school students and adults, United States, 1965–2014. 2016; http://www.cdc.gov/tobacco/data_statistics/tables/trends/cig_smoking/. Accessed January 12, 2017, 2017.
33. National Highway Traffic Safety Administration. Fifth/Sixth report to Congress: Effectiveness of occupant protection systems and their use. Washington DC: US Department of Transportation; 2001.
34. Shahab L, McEwen A. Online support for smoking cessation: a systematic review of the literature. *Addiction*. 2009;104(11):1792–1804. [PubMed: 19832783]
35. Park E-W, Tudiver F, Schultz JK, Campbell T. Enhancing partner support to improve smoking cessation. *Ann Fam Med*. 2004;2(2):170–174. [PubMed: 15083859]
36. Russell MA, Wilson C, Taylor C, Baker CD. Effect of general practitioners' advice against smoking. *BMJ*. 1979;2(6184):231–235. [PubMed: 476401]
37. Fichtenberg CM, Glantz SA. Effect of smoke-free workplaces on smoking behaviour: systematic review. *BMJ*. 2002;325(7357):188–191. [PubMed: 12142305]
38. Wakefield M, Flay B, Nichter M, Giovino G. International perspectives effects of anti-smoking advertising on youth smoking : a review effects of anti-smoking advertising on youth smoking : A Review. *J Health Commun*. 2003;8(3):229–247. [PubMed: 12857653]
39. Wakefield MA, Durkin S, Spittal MJ, et al. Impact of tobacco control policies and mass media campaigns on monthly adult smoking prevalence. *Am J Public Health*. 2008;98(8):1443–1450. [PubMed: 18556601]

Figure 1. Situational Contexts for Symptom Non-Disclosure.

Participants were given five dichotomous choices of situations and asked to choose the situation in which athletes are more likely to report concussion symptoms. Athletes consistently endorsed the choice that was less associated with competitive outcomes (i.e., high-stakes).

Figure 2. Athletic Stakeholders: Symptom Hiding Attitudes.

Participants were given a list of five stakeholders (teammates, strength trainers, athletic trainers, assistant coaches, and head coaches) and asked about their attitudes and beliefs about symptom hiding. Athletes consistently identified their teammates as holding attitudes and beliefs that support symptom non-disclosure.

Figure 3. Athletic Stakeholders: Player Safety Behaviors.

Participants were given a list of five stakeholders (teammates, strength trainers, athletic trainers, assistant coaches, and head coaches) and asked about their player safety behaviors. Athletes consistently identified their athletic trainers as engaging in behaviors that support player safety.

Table 1:
Concussions by Sex and by Sport

This table shows the number of athletes (n) and the percent of athletes with at least one concussion (%) broken down by sex, sport, and sport risk status.

	# Athletes (n)	% with 1 concussion (%)
ATHLETES WITH AT LEAST ONE CONCUSSION	135	19%
Males	63	24%
Females	72	14%
SPORT COMPARISON		
Men's Lacrosse	12	33%
Football	18	17%
Men's Soccer	5	40%
Women's Soccer	3	33%
Women's Lacrosse	6	17%
Men's Wrestling	5	40%
Women's Basketball	3	67%
Women's Field Hockey	7	29%
Men's Basketball	4	25%
Women's Softball	5	20%
Total High-Risk Sports	68	28%
Women's Crew	19	16%
Men's Baseball	7	29%
Men's Track	11	9%
Women's Track	12	0%
Women's Swimming & Diving	6	0%
Women's Volleyball	4	0%
Men's Golf	1	0%
Women's Golf	1	0%
Women's Tennis	1	0%
Women's Gymnastics	5	0%
Total Low-Risk Sports	67	9%

Table 2:
Average Correct Responses for Concussion Knowledge Items and Average Number of
Reasons Endorsed for Hiding Symptoms.

This table shows the means and standard deviations in Symptom Knowledge (range 0–21), General Knowledge (range 0–27) and Reasons for Hiding Concussion Symptoms (range 0–13). * indicates significant differences between the levels of each category at $p < .05$

Category	Symptom Knowledge ^a		General Knowledge ^b		Reasons for Hiding Symptoms ^c	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
All Athletes	16.7	2.5	22.7	4.1	9.4	3.0
Males	16.4	2.8	22.1	5.5	8.62 *	3.4
Females	16.9	2.2	23.2	4.1	10.1	2.4
High-Risk Sport	16.5	2.5	22.8	3.5	8.59 *	3.3
Low-Risk Sport	16.8	2.4	22.6	4.6	10.3	2.3
Prior Concussion Diagnosis	16.7	2.6	22.6	5.0	9.5	2.5
No Prior Concussion Diagnosis	16.8	2.2	23.1	2.4	9.6	2.8
Certain of Concussion History	16.6	2.6	22.5	4.3	9.4	2.6
Not Certain of Concussion History	16.7	2.4	22.9	3.8	9.5	3.4

Note:

^a
range 0–21

^b
range 0–27

^c
range 0–13

* indicates significant differences between the levels of each category at $p < .05$

Table 3:
Reasons for Hiding Symptoms (n=135)

This table shows possible reasons athletes may have for hiding concussion symptoms. The survey listed 13 items and athletes were asked to endorse all items that participants believed athletes consider. The columns show the percent of participants who endorsed each Reason for Hiding Symptoms and are listed in order of most endorsed to least endorsed.

Reason	% of Athletes
They think they CAN just “tough it out.”	93.3%
They don’t want to be pulled out of the game or practice.	90.4%
They are afraid they will lose future playing time.	85.2%
They don’t think it is serious enough.	85.2%
They don’t want to let down their teammates and coaches.	84.4%
They don’t know they have a concussion.	83.7%
They don’t want to appear weak.	79.3%
They think they SHOULD just “tough it out.”	78.5%
They are afraid they will lose their spot on the team.	72.6%
They are afraid the coach will be mad.	64.4%
They are afraid their teammates will be mad.	57.0%
They think getting concussions is just part of the game.	40.7%
They don’t believe that their coaches want them to report it.	27.4%