



Published in final edited form as:

*Soc Sci Med.* 2015 June ; 134: 66–75. doi:10.1016/j.socscimed.2015.04.011.

## Concussion under-reporting and pressure from coaches, teammates, fans, and parents

Emily Kroshus<sup>a,b,c</sup>, Bernice Garnett<sup>d</sup>, Matt Hawrilenko<sup>e</sup>, Christine M. Baugh<sup>c,f,g</sup>, and Jerel P. Calzo<sup>h,i</sup>

Emily Kroshus: emk329@mail.harvard.edu; Bernice Garnett: bgarnett@uvm.edu; Matt Hawrilenko: mhawrilenko@clarku.edu; Christine M. Baugh: cbaugh@g.harvard.edu; Jerel P. Calzo: jerel.calzo@childrens.harvard.edu

<sup>a</sup>Harvard School of Public Health, Department of Social and Behavioral Science

<sup>b</sup>National Collegiate Athletic Association, Sport Science Institute

<sup>c</sup>Harvard University, Edmond J. Safra Center for Ethics

<sup>d</sup>University of Vermont, College of Education and Social Services, Department of Education

<sup>e</sup>Clark University, Department of Clinical Psychology

<sup>f</sup>Harvard University, Interfaculty Initiative in Health Policy

<sup>g</sup>Boston Children's Hospital, Division of Sports Medicine

<sup>h</sup>Boston Children's Hospital, Division of Adolescent & Young Adult Medicine

<sup>i</sup>Harvard Medical School, Department of Pediatrics

### Abstract

Concussions from sport present a substantial public health burden given the number of youth, adolescent and emerging adult athletes that participate in contact or collision sports. Athletes who fail to report symptoms of a suspected concussion and continue play are at risk of worsened symptomatology and potentially catastrophic neurologic consequences if another impact is sustained during this vulnerable period. Understanding why athletes do or do not report their symptoms is critical for developing efficacious strategies for risk reduction. Psychosocial theories and frameworks that explicitly incorporate context, as a source of expectations about the outcomes of reporting and as a source of behavioral reinforcement, are useful in framing this problem. The present study quantifies the pressure that athletes experience to continue playing after a head impact—from coaches, teammates, parents, and fans—and assesses how this pressure, both independently and as a system, is related to future concussion reporting intention. Participants in the study were 328 male and female athletes from 19 teams competing in one of seven sports (soccer, lacrosse, basketball, softball, baseball, volleyball, field hockey) at four colleges in the northeast region of the United States. Results found that more than one-quarter of the sample had

---

Corresponding author: Emily Kroshus, ScD MPH, 221 Columbus Avenue, Boston MA 02116, emk329@mail.harvard.edu, (610)-772-6061.

**Publisher's Disclaimer:** This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final citable form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

experienced pressure from at least one source to continue playing after a head impact during the previous year. Results of a latent profile mixture model indicated that athletes who experienced pressure from all four of the measured sources were significantly more likely to intend to continue playing in the future than were athletes who had not experienced pressure from all sources, or only pressure from coaches and teammates. These findings underscore the importance of designing interventions that address the system in which athletes make decisions about concussion reporting, including athletes' parents, rather than focusing solely on modifying the individual's reporting cognitions.

## Keywords

injury; sport; concussion; symptom reporting

More than eight million adolescent and emerging adults participate in organized competitive sport at the high school or collegiate level in the USA on an annual basis (NCAA, 2013; NFHS, 2014). Concussions, a mild traumatic brain injury that can result from contact with another athlete, equipment, or the playing surface are being increasingly recognized as a frequent injury in many sports (Daneshvar et al., 2011; Marar et al., 2012; Rosenthal et al., 2014;). Although symptoms of most concussions resolve in less than two weeks (Eisenberg et al., 2014), during this period of time the somatic, cognitive and emotional symptoms sustained can interfere substantially with an athlete's activities of daily living and can pose a significant health burden (Kontos et al., 2012; Prichep et al., 2013). In some cases, the neurologic consequences may extend across the life course (Kerr et al., 2012; Kerr et al., 2014; McCrory, Meeuwse, Kutcher et al., 2013; Seichepine et al., 2013). Ongoing efforts to reduce the public health burden of concussions from sport span multiple levels, ranging from attempting to modify individual safety behaviors to changing the rules of sports to reduce exposure to potentially injurious head impacts (Benson et al., 2013; Graham et al., 2014; McCrory, Meeuwse, Aubry et al., 2013).

One critical risk reduction strategy is ensuring that athletes who sustain a potentially concussive impact are immediately removed from play and receive medical evaluation (Benson et al., 2013; Kerr et al., 2014; Meier et al., 2014). Many symptoms of a concussion, such as confusion or dizziness, are not easily observable (Echlin, 2010; Moreau et al., 2014). Consequently, even if there is a trained medical professional on the sidelines of the game or practice, immediate removal from play is often to at least some extent contingent on athlete self-report. The concussed brain is in a metabolically vulnerable state during which additional impacts can have magnified neurologic consequences, including in some cases death or permanent deficits (Borden et al., 2007; Prins et al., 2013). Despite the importance of the safety behavior of timely symptom reporting, many athletes—at all ages and levels of competition—fail to report post head impact symptoms and continue playing their sport with a concussion (Baugh, Kierman, Kroshus et al., 2014; Delaney et al., 2002; Delaney et al., 2015; Kaut et al., 2003; Kroshus, Kubzansky, Goldman & Austin, 2014; Llewellyn et al., 2014; McCrea et al., 2004; Meehan et al., 2013; Register-Mihalik et al., 2012; Torres et al., 2014; Williamson et al., 2005).

Prior research has found that constructs from the Theory of Planned Behavior (TPB; Ajzen, 1991) can help explain between-individual variability in concussion reporting (Chrisman et al., 2013; Kroshus, Baugh, Daneshvar & Viswanath, 2014; Register-Mihalik et al., 2012; Register-Mihalik, et al. 2013). Concussion reporting intention is associated with reporting behavior in prospective analyses (Kroshus, Baugh, Daneshvar, Nowinski & Cantu, 2014), and expectancy value cognitions such as perceived norms and attitudes have been found to be associated with reporting intentions (Kroshus, Baugh, Daneshvar & Viswanath, 2014; Register-Mihalik et al., 2012; Register-Mihalik et al., 2013). However, much of the variability in both intention and reporting behavior is still left unexplained by the TPB model (Kroshus, Baugh, Daneshvar & Viswanath, 2014). A criticism of individually oriented theories such as TPB is that they ignore the important role of context. Chrisman and colleagues (2013) proposed using an expanded TPB model, in which environment interacts with reporting intentions to influence symptom reporting. Building on this model, perhaps a more inclusive framework for elucidating the individual's experience making concussion reporting decisions in consideration of contextual influences, is Bandura's Social Cognitive Theory (SCT; 2004). SCT outlines a triadic reciprocal relationship between individual-level psychological determinants of behavior (such as cognitions, affect, and biological events), environmental factors, and behavior (Bandura, 2004).

The athlete's environment can thus be conceptualized as influencing their reporting behavior directly or by informing their cognitions about the expected outcomes of reporting and the extent to which important referent groups value these behaviors (outcome expectations). These expectations and perceived norms can be learned from the athlete's environment in a variety of ways (observational learning). When an athlete sustains a potentially concussive impact, their interactions with others in their athletic environment—such as teammates, coaches, parents and perhaps even fans—provide critical opportunities for behavioral reinforcement that can inform their future reporting-relevant cognitions and decisions (reciprocal determinism). Chrisman and colleagues found evidence of this feedback model, between coach response to concussion reporting and future concussion reporting behavior, in the experiences of high school athletes with whom they conducted qualitative interviews (2013). However, cognitions about the expected outcomes of reporting a concussion need not necessarily be based on an individual's own experiences with injury. This learning process may also be based on observational learning over the course of an athletic career, with observation not limited to the athlete's teammates. Media representations of how high profile athletes behave or “should” behave when it comes to concussion can also provide information about what behaviors are likely valued in the athlete's sport context (Anderson & Kian, 2011; McGannon et al., 2013). Caron and colleagues (2013) have described how former professional ice hockey players often hid concussive symptoms from teammates and coaches. The authors suggest that the players may have been trying to act in ways that that they perceived to be normative for their masculine sport culture. Thus, reporting behavior may also arise based on a desire to conform to perceived group norms and avoid social sanction for deviating from these norms, as opposed to any explicit communication based on actual deviant behavior.

Guided by SCT, the present study focuses on one particular dimension of environment-athlete interaction as it pertains to concussion reporting: the pressure that athletes experience

from individuals in their sport environment to continue playing with symptoms after a possible concussion. Register-Mihalik and colleagues (2013) have called for the study of how pressure from teammates, coaches and parents is related to concussion reporting behavior. The construct of “pressure”—to not report symptoms of a concussion, to continue playing with symptoms of a concussion, or to return to play with symptoms of a concussion—has been invoked by a number of authors, without explicit definition (e.g., Chrisman et al., 2013; Doolan et al. 2012; Laker, 2011; Llewellyn et al., 2014; Meehan & Bachur, 2009; Register-Mihalik et al., 2013). Pressure to play through injury has been described more extensively for injuries other than concussion (e.g., Niven, 2007; Nixon, 1994; Nixon, 1996; Roderick, 2000; Young et al., 1994; Young & White, 1995). The present study uses Niven’s (2007) conceptualization of the pressure that athletes feel during injury recovery, which is described as a product of social and competitive pressures. A key concept here is that pressure is an internal experience, in response to external demands. Consistent with SCT’s construct of reciprocal determinism and Cialdini and Goldstein’s (2004) description of the individual differences in the impact of overt and covert social influence on behavior, individual appraisals of these environmental demands may vary based on individual characteristics and prior experiences.

The pressure that athletes experience from individuals or groups around them to continue playing while symptomatic after a concussion may be delivered directly or indirectly, and be explicit or implied. In some cases it may be related to the construct of perceived behavioral norms, from the Theory of Planned Behavior. When individuals experience a gap between their behaviors and how they believe a referent group would behave, they can experience an internal pressure to modify their beliefs or behaviors out of a desire for social approval (Cialdini & Goldstein, 2004). However, the extent to which an individual is motivated to make their behavior consonant with norms varies by their extent of identification with the referent group, or the extent to which the referent group represents an aspirational self-concept (Abrams & Hogg, 1990). For athletes, this likely means teammates or other athletes in their sport; prior research has found a significant association between perceived teammate or athlete norms about concussion reporting and concussion reporting intentions and behavior (Kroshus, Kubzanksy, Goldman & Austin, 2014; Register-Mihalik et al., 2013). However, social pressure from groups with whom an athlete does not identify or aspire to emulate can also influence behavior, through a different pathway. Abrams & Hogg (1990) have described how pressure to comply with the explicit or implied demands of a social group are heightened when the source of the pressure controls access to valued commodities, such as rewards or basic necessities, consistent with the construct of incentive motivation from SCT. Parents and coaches control access to valued commodities such as playing time, scholarships, tuition money, and affection. Outside of the athlete’s immediate interpersonal network, spectators or team supporters control the commodity of public approval or adulation, something that is highly valued by some athletes (Brock & Kleiber, 1994). Nixon (1996) found that collegiate athletes who were “lineup regulars” were the most likely to perceive pressure from team fans to continue playing while injured. Bauman (2005) has described how losing valued commodities that are linked to sports participation or competitive outcomes can result in athletes feeling escalating pressure to return to play as soon as possible.

Understanding more about the nature, variability and correlates of the contextual pressures that athletes experience after a head impact is critical for determining whether there are opportunities for targeted intervention. The present study tested the hypotheses that male and female U.S. collegiate athletes who experience greater pressures—from teammates and coaches, and to a lesser extent from parents and fans—to continue playing after a head impact will be less likely to intend to report a suspected future concussion.

## Method

### Sample and procedure

Participants were 328 athletes from four regionally competitive colleges located in the northeast region of the U.S., all engaged in National Collegiate Athletic Association (NCAA) competition. The institutional response rate was 25%, with eight of the twelve schools contacted by email either not responding or declining participation. Schools were eligible for inclusion if they were located in the northeast region of the U.S., and were not a member of a “Power 5” athletic conference, a designation given to the five most athletically competitive U.S. collegiate sports conferences (NCAA, 2014). There were no significant differences between participating and non-participating schools in undergraduate enrollment, number of sports teams sponsored, whether or not the school was public or privately funded, or mean scores of enrolling students on the Standardized Aptitude Test (SAT).

The present research focused on both male and female athletes in contact or collision sports other than football and ice hockey, sports which while perhaps having a lower public profile in the discussion of concussion risk, have nonetheless an elevated risk of concussion (Daneshvar et al., 2011; Marar et al., 2012; Rosenthal et al., 2014). At the four participating schools, 19 of 35 eligible contact and collision team coaches (54%) allowed their team members to have the choice to participate in the research study. The 19 participating sports teams included soccer (6), lacrosse (3), basketball (3), baseball (3), field hockey (2), softball (1) and volleyball (1). On participating teams, the individual participation rate was 74%. The same member of the research team met with each participating team in a private setting near to their respective practice facility and followed a standardized protocol, explaining the purpose of the research, obtaining informed consent, and administering the written survey, which was completed with pen and paper. This process occurred during the spring of 2014. The research was approved by the Harvard School of Public Health Institutional Review Board, with adherence to the institutional approval processes at participating institutions.

### Measures

Measures included in the survey are listed below in the order that they were presented to the participant. They include self-report measures assessing concussion diagnosis and concussion reporting behavior, objective concussion knowledge, subjective experiences of pressure, and intentions related to future concussion reporting. Validated measurement instruments were used where available, and where unavailable items were developed for the purpose of the present study. All items were reviewed by members of the target population for content and clarity before administration to the present sample.

**Concussion knowledge**—Concussion knowledge was assessed using a modified version of Rosenbaum and Arnett’s (2010) Concussion Knowledge Index. This measure includes two parts: a symptom identification component and a causes and consequences of concussions component. Ten items were added to the original measure to make it more challenging and to reflect the evolving research about concussions. Six additional symptom identification items were added based on the symptoms of the revised Sport Concussion Assessment Tool—3<sup>rd</sup> edition (SCAT-3; slower reaction time, mood swings, problems sleeping, sensitivity to noise, depression, and irritability). Four additional statements were added to the causes and consequences of concussion section (It is easy to tell if a person has a concussion by the way the person looks or acts; How quickly an athlete recovers from a concussion depends mainly on how hard they work to recover; Complete recovery from a concussion is not possible; Even if a player is experiencing the effects of a concussion, his performance on the field of play will be the same as it would be had he not suffered a concussion). These items were added based on pilot experiences administering the original Rosenbaum & Arnett (2010) Concussion Knowledge Index, which was originally designed for high school students, to a population of college athletes. Modifications were made to increase the degree of difficulty of the scale and thus increase response variability between participants. Response options for each question were true or false, and the number of correct answers summed to create an index score (range of 0 to 27).

**Concussion history**—History of diagnosed concussions was reported over two time periods: last season and ever. Participants were asked how many times during the respective time period they were diagnosed with a concussion by a medical professional (doctor, athletic trainer, nurse).

**Continued play while symptomatic**—Continued play while symptomatic after a potentially concussive impact was assessed by first asking athletes to review the list of concussion symptoms from the SCAT-3 and indicate how many times during the previous season they sustained an impact after which they experienced at least one of those symptoms. The respondents who indicated that they experienced at least one such impact were then asked to indicate after how many of those impacts they continued playing in a game or practice while experiencing at least one of the listed symptoms. The difference between potentially concussive impacts and number of impacts after which the athlete continued play while symptomatic was calculated.

**Concussion reporting intention**—Intention to report symptoms of a suspected concussion was measured with an item reading: “I intend to report any symptoms I experience after a head impact if I think these symptoms are from a concussion.” The item was scored on a seven-point Likert scale, with response options ranging from 1=strongly disagree to 7=strongly agree.

**Pressure to continue play after a head impact**—Participants were instructed to think about the previous athletic season and indicate their strength of agreement with four statements reading: “I have felt pressure from [source] to return to play after a head impact.” Pressure from four sources was queried: teammates, coaches, parent/guardian, and fans.

Responses to each item were on a seven point Likert scale, ranging from 1=strongly disagree to 7=strongly agree. The wording of “head impact” rather than “concussion” was used to limit variability in responses attributable to differences in the athlete’s ability to recognize which head impacts did or did not result in a concussion. While not every head impact after which an athlete experiences symptoms indicates a concussion has occurred, this determination should be made by a licensed medical professional, such as an athletic trainer or physician.

**Other participant characteristics**—The athlete’s ranking on team was assessed by his or her self-reported roster spot: first team referred to being a regular part of the starting line-up, second team to being a regular substitute, third team to practicing but competing infrequently, and fourth team to practicing or training but not competing. The participant’s age, year in school, institution, sex, and team were also recorded.

## Analysis

One-way analysis of variance (ANOVA) was conducted to assess whether the pressure experienced from each of the four sources differed by the following characteristics: school, team membership, roster spot and year in school. Independent sample t-tests assessed whether there were differences between male and female athletes, and between athletes who had a concussion diagnosed the previous season as compared to those who did not. Linear regression was conducted to separately assess the association between pressures experienced during the previous athletic season from each of the four sources and the athlete’s intention to report symptoms of a suspected future concussion. Bivariate and multivariable analyses were conducted for each source of pressure, with multivariable models also including independent variables of sex, number of diagnosed concussions, and concussion knowledge. Because of the lack of difference in pressure by school or team, standard errors were calculated without adjustment for group level clustering.

In order to explore heterogeneity in the systems of pressure surrounding individuals, we used Mplus 7.3 (Muthen & Muthen, 1998–2012) to build a series of latent profile mixture models adhering to the set of best practices described by Masyn (2013). Mixture models are useful in that they can identify subgroups of individuals with profiles constructed by a number of different variables. To understand the variability in how individuals in this sample experienced pressure, subgroup profiles were characterized by four sources of pressure: pressure from teammates, coaches, parents, and fans. We fit four model structures and examined the number of classes that best explained the data within each structure. In the most basic model structure, we constrained item variances equal across classes (class-invariant variances) and restricted the residual correlations between items to be zero (e.g., diagonal covariance matrices), meaning that the relationship between the items would be completely accounted for by class membership. We then systematically tested the other three combinations of class-varying/class-invariant variances with diagonal/non-diagonal covariance matrices. To choose the final model, we began by identifying the number of classes that best fit the simplest model structure and set this number as the ceiling for all subsequent analyses because the most restrictive structure should require the largest number of classes to explain the data. Subsequently, intention was added to the model in order to

examine whether class membership was systematically related to intention to report symptoms of a suspected concussion. A standard alpha level of 0.05 was adopted for significance for all analyses. Twenty-one participants (6.4% of the full sample) did not provide response to all measures included in the analyses. Missing data was accounted for using full information maximum likelihood estimation, ensuring unbiased estimates under conditions of missingness at random.

## Results

Of the 328 participants, around half were female (53.05%). Across the full sample, fewer than ten percent (8.56%) indicated that they had a concussion diagnosed during the previous athletic season. However, during the previous season almost half continued playing in a game or practice while experiencing post-impact symptoms of a possible concussion. Additional descriptive characteristics of the sample are presented in Table 1.

The mean scores of pressure experienced during the previous season to continue playing after a head impact are reported in Table 2. The percentage of respondents who last season experienced pressure from teammates (as measured by their endorsement of the response option “slightly agree,” “agree,” or “strongly agree”) was 13.26% (mean=2.59/7, SD=1.65), from coaches was 13.68% (mean=2.61/7, SD=1.66), from parents was 9.42% (mean=2.30/7, SD=1.55) and from fans was 8.12% (mean=2.33/7, SD=1.57). Around one-quarter of participants (26.5%) reporting having experienced pressure last season from at least one of the four sources.

One-way ANOVA was conducted to examine differences in mean pressure scores by participant school, team, sex, roster spot, year in school, and whether or not they were diagnosed with a concussion last season. No differences in pressure from any source were found for any variable other than having had a concussion diagnosed last season. Pressure from coaches and from athletes was significantly higher among athletes who had been diagnosed concussion during the previous season as compared to athletes who did not have a diagnosed concussion (coaches  $p = 0.004$ , teammates  $p = 0.004$ ).

Linear regression was conducted to assess whether each of the pressure variables were associated with intention to report symptoms of a future impact that is suspected to be a concussion. Results are presented in Table 3. In both bivariate and multivariable analyses greater levels of pressure from teammates, parents, fans, but not from coaches, was associated with lower intention to report symptoms of a suspected concussion. In all four multivariable analyses, female athletes had significantly higher symptom reporting intention than male athletes; however, the association between pressure and intention persisted independent of athlete sex. Concussion knowledge and history of concussion diagnosis were not significantly associated with reporting intention in any of the multivariable analyses.

In order to explore the heterogeneity in the systems of pressure that athletes experience, a series of mixture models was fit to the data, simultaneously including pressure from each of the four sources. Mixture model fit statistics are presented in the Appendix. In the simple structure, with class-invariant variances and diagonal covariance matrices, the information



criteria conflicted with the Adjusted Lo-Mendell-Rubin Likelihood Ratio Test (LMR) in selecting the best number of classes. To guard against over-extraction, we chose to stop extracting classes at the point the LMR indicated, which was the three-class model. This decision was supported by two factors: an elbow plot of the Bayesian Information Criterion (BIC) indicated strongly decreasing marginal returns as the number of classes increased, and an exploration of the four class structure suggested the additional class was splitting a class represented in the three class structure rather than identifying a qualitatively distinct group of individuals. Upon choosing the best model from each model structure, we compared the final candidate models using the approximate correct model probability ( $cmP_k$ ), a Bayesian statistic derived from the BIC used for selecting the model most likely to be true in a given subset of models. The  $cmP_k$  provided strong support for the three-class model with class-varying variances and a diagonal covariance matrix. This model was also favored by the BIC, the Consistent Akaike's Information Criteria, and was the second most highly favored model by the Approximate Weight of Evidence Criterion. An examination of residuals indicated no extreme values, further validating the model selection. The entropy for the final model was high at 0.94, indicating good precision of classification and differentiation between classes.

The final model characterizes three distinct groups of individuals. Estimates for the final model are presented in Table 4. A "Low Pressure" class describes over half of the sample, whose members report feeling very little pressure from any source. This class is also characterized by extremely low within-class variability. The "Team Pressure" group captures 14% of the sample, which reported feeling moderate pressure from coaches and teammates and lower pressure from parents and fans. The "High Pressure" group, approximately 33% of individuals, reported feeling higher levels of pressure from all sources of pressure measured in the study. Latent profiles are plotted in Figure 1. Sample characteristics by modal class assignment are presented in Table 5. Broadly speaking, there were few notable qualitative differences between classes. Perhaps not surprisingly, participants in the high pressure class were frequently "first team" athletes, meaning they were regularly in the team's starting line-up.

In order to examine whether class membership was predictive of intention to report symptoms of a suspected concussion, we used an automated 3-step procedure to include intention as a distal outcome (Asparouhov & Muthen, 2014; Vermunt, 2010), allowing its variance to vary across classes. Proportions of class membership were very similar to the first model, with the largest shift in class membership appearing to be about 2% of participants being reclassified from the Low Pressure group to the Team Pressure group, indicating the latent class structure in the original model was sound. A Wald test indicated an overall significant difference between classes in intention to report symptoms,  $\chi^2(2) = 9.93$ ,  $p = .007$ . This difference was driven by the difference between the High Pressure group and the other two groups. The High Pressure group (Mean intention to report = 5.78) was significantly less likely to intend to report symptoms than both the Low Pressure group ( $M = 6.28$ ),  $\chi^2(1) = 8.39$ ,  $p = .007$ , and the Team Pressure group ( $M = 6.40$ ),  $\chi^2(1) = 5.42$ ,  $p = .020$ . The practical importance of these differences is notable, with Cohen's  $d$  effect sizes

of 0.40 and 0.50, respectively. There was not a significant difference in intention between the Low Pressure and Team Pressure groups,  $\chi^2(1) = 0.22, p = .64$ .

## Discussion

This study characterized the pressure experienced by U.S. collegiate athletes to continue play after a head impact, and assessed whether this pressure was associated with future concussion reporting intentions. During the previous season around one in four athletes in this sample experienced pressure from a teammate, coach, parent or fan to continue play after a head impact, with no significant differences between male and female athletes. Consistent with recent estimates of under-reporting in other samples of athletes across a range of sports and levels of competition, around half of the athletes in this study indicated that they continued playing with symptoms of a possible concussion (Baugh, Kiernan, Kroshus et al., 2014; Delaney et al., 2015; Kroshus, Kubzansky, Goldman & Austin, 2014; Llewellyn et al., 2014; Meehan et al., 2013; Register-Mihalik et al., 2012; Register-Mihalik et al., 2013; Torres et al., 2014). Athletes who experienced pressure from teammates, parents and fans had lower intention to report symptoms of a future suspected concussion than their peers who experienced pressure from fewer sources.

We can understand this influence of pressure on concussion reporting as being a product of the triadic reciprocal relationship between environment, person, and behavior (Bandura, 2004). The athlete's subjective experience of pressure may be in part informed by their personal characteristics and prior experiences. Athletes who had been diagnosed with a concussion during the previous competitive season (around 10% of the participants) were significantly more likely to have experienced pressure from coaches and teammates than were athletes without a concussion diagnosis during this time frame. These athletes may have had more opportunities for interactions with teammates and coaches during the removal from play and concussion recovery process, and consequently more opportunities for pressure to be communicated. Pressure may also have been internalized through indirect pathways, for example as a result of the loss of valued commodities such as competitive opportunities, or of social sanctions or social isolation from the team, consistent with the construct of incentive motivation from SCT. These previously injured athletes were less likely to intend to report a future concussion, which may be in part attributable to the learning process that occurred as a result of their social interactions and experiences after sustaining their prior concussion.

It is interesting that pressure from coaches was not associated with reporting intention given their seemingly central role in controlling the reinforcements for reporting in the sport environment, such as loss of playing time and inability to regain ones spot in the line-up. There has been a growing focus on the role coaches can play in translating information about concussion safety to athletes and in creating a culture of risk or safety with respect to concussions (Baugh, Kroshus, Daneshvar & Stern, 2014; Chrisman et al., 2014; Covassin et al., 2012; Kroshus et al., 2015; Rivara et al., 2014), with a frequent subtext that there is room for improvement. For example, collegiate football players who perceived less support from their coach for appropriate concussion symptom reporting were more likely to continue play while symptomatic (Baugh, Kroshus, Daneshvar & Stern, 2014); however, there was no

indication of whether this appraisal of what the coach wanted them to do was based on pressure being communicated directly at them. The present results suggest that it is likely that only a relatively small fraction of coaches, at least in the sports included in the present analyses, are part of the problem, and that athletes also experience pressure to continuing playing while symptomatic from others in their sport environment. It is possible that the coach-athlete relationship moderates the association between coach pressure and reporting behavior, or that coaches exert influence on reporting behaviors through their control over valued commodities in the sport environment (such as playing time) and they may influence reporting through those non-verbal pathways rather than through overt pressure. Coaches may also influence reporting behavior indirectly by shaping team norms about concussion safety, for example through their communication with team members about the importance of concussion safety (Kroshus et al., 2015).

The absence of pressure from coaches does not mean the presence of supportive communication that encourages safety behaviors. Nixon's (1994) survey of coaches found that few explicitly supported playing through injury; however, this did not mean that their athletes did not experience an implicit message that playing through injury was a valued behavior. Across a range of sport injuries, the coach-athlete relationship has been found to be an important determinant of injury reporting (e.g., Curry, 1993; Nixon, 1992; Nixon, 1993; Roderick et al., 2000) and of the athlete's psychosocial wellbeing during the injury recovery process (e.g., Abgarov et al., 2012; Bianco, 2001; Malinauskas, 2008; Podlog & Eklund, 2007; Podlog et al., 2014; Yang, 2010). Additional research is needed to explore the nature of coach communication with athletes about concussion safety to understand what dimensions of these interactions are most centrally related to athletes' experiences of pressure to continue playing while symptomatic, adherence to safety protocols, and psychosocial wellbeing during concussion recovery.

The present findings indicate that even at the college level when most athletes are living away from home, some athletes perceive pressure from a parent or guardian to continue play after an impact. Athletes who experience this pressure are less likely to intend to report symptoms of a concussion. The results of the mixture model speak to the systemic forces of pressure surround athletes. Athletes who experience pressure from multiple sources—not just from coaches and teammates but also from parents and fans—have a lower concussion reporting intention than athletes who only experience pressure only from coaches and teammates. Wilder (1978) found that the number of distinct groups aiming to influence behavior is more important than the size of any one group in predicting behavioral outcomes. Perceived pressure from parents and fans may thus be risk factors that function in combination with pressure from others in the sport environment to influence reporting intention.

Concussion education at the collegiate level may thus be ineffectively focusing only the coach-athlete relationship (NCAA, 2013), and not considering broader sport environment that includes pressure, both real and perceived, from others in the athlete's environment. Conceptualizing the broader sport environment, including both parents and fans, is important for developing optimal concussion risk reducing programming. State concussion laws at the high school level increasingly require that parents review concussion education

material prior to their child's sport participation (Baugh, Kroshus, Bourlas & Perry, 2014). While this may not be appropriate at the college level, understanding how to most effectively engage parents of collegiate athletes in supporting a message of concussion safety is a necessary avenue for future work. Additional research is also needed to explore how this pressure—or support for safety—is communicated from parents to athletes. It is possible that the pressure is not direct. For example, if an athlete feels that their parents are highly invested in their athletic success they may perceive that their parents would be supportive of them continuing playing while symptomatic after a concussion, even if the parent does not in fact endorse this attitude. To the extent this is the case, it may be functional to encourage parents to communicate explicitly with their athlete about the importance of concussion safety. It may also be functional for parent-targeted educational strategies to encourage critical reflection about how they communicate with their child about concussion safety and whether they might be inadvertently encouraging a win-at-all-costs mentality (Mezirow, 1981; Merriam, 2001).

The nature of perceived pressure from fans is an area for future study, to understand whether the pressure is communicated explicitly, for example in person or through social media, or whether it is instead of marker of competitive anxiety or of a desire to not let team supporters down. The finding that athletes experiencing lower pressure from parents and fans and higher pressure from teammates and coaches did not have significantly different reporting intention as compared to athletes experiencing low pressure from all sources raises the question of whether experiencing support for safety from one source may help buffer or offset pressure experienced from another source.

Although experiencing pressure was associated with reporting intention, this is not necessarily the only pathway through which pressure could influence reporting behavior. In high emotion and high arousal situations, decisions are often made through more reactive or emotional processes (Figner et al., 2009; Reyna & Farley, 2006). In these situations, the athlete's immediate decisional environment plays a critical role in influencing behavior. Consequently, it is possible that when an athlete who sustains a concussion experiences pressure from important individuals in their immediate sport environment, they may be more likely to continuing playing, independent of their reporting intention and even if they subsequently make a rational, deliberative decision to report their symptoms. Understanding the role of emotion and arousal in decision making related to injury on the field of play, and the way in which pressures in the decisional environment influence these behaviors, is an important area for future research. In the meantime, the potential role of the sport environment in influencing athlete reporting through both deliberative and reactive pathways underscores the importance of making the sport environment, both on and off the field of play, more supportive of safety behaviors for all athletes.

## Limitations

This study has several limitations. Most centrally, the cross-sectional nature of the analysis limits out ability to confidently make causal inferences about the association between pressure and reporting behavior. Longitudinal data, for example with reporting intention assessed at pre-season and recall of in-season pressure and reporting behavior, would allow

for analyses of the extent to which pre-season reporting intention modifies the association between pressure and reporting behavior. It is possible that the retrospective assessments of pressure and reporting behavior are not accurate, for reasons of inaccurate recall, or social desirability bias.

The present study used single item summary-level measures of pressure from each of the four groups—coaches, teammates, parents, and fans. Additionally, the pressure items only measured strength of agreement or disagreement with a statement about the experience of pressure and did not explicitly measure the intensity or duration of pressure. Future research is needed to explore whether a single item summary measure is appropriate or whether a scale measuring different dimensions of pressure would be more psychometrically valid and reliable, and to explore the predictive utility of measuring the intensity and duration of pressure experienced from each source.

Although there were no significant differences between participating and non-participating institutions in publically available characteristics, it is possible that there were differences in terms of institutional support for concussion safety. Consequently, results are not necessarily generalizable to all institutions. Generalizability may also be limited by the sport and level of competition of the teams included in the sample. The inclusion of lower profile collegiate sports teams—those competing in conferences other than the NCAA designated “Power 5” and on male and female contact and collision sports teams other than ice hockey and football—was a decision that was made purposively to explore the experience of collegiate athletes who are at risk of concussion (Daneshvar et al., 2011) but whose injuries receive relatively less public attention. However, it is not clear the extent to which the present findings generalize to the experiences of football and ice hockey players, particularly those at higher levels of competition. It is possible that pressure from individuals in the injured athlete’s environment—teammates, coaches, parents, and fans— may be greater when the potential outcomes of competitive success are greater (e.g., potentially securing a lucrative professional contract). Similarly, whereas the presenting findings indicated that roster spot was not associated with differences in pressure or reporting behavior, roster spot may be a more salient condition when the competitive rewards are greater. Additional research is warranted to explore the experience of pressure to not report symptoms of a concussion in a range of sporting populations.

## Conclusion

Honest and timely symptom reporting by concussed athletes is one important approach to concussion risk reduction. The present study indicates that reducing the pressure that athletes experience from coaches, teammates, parents and fans may help increase symptom reporting behavior. These findings have implications for both research and practice. They suggest the importance of future research about the ways in which an athlete’s sport environment influences his or her concussion safety behaviors, and specifically suggest the importance of approaches that consider that athlete’s network as a whole rather than studying stakeholder groups in isolation. Larger sample multilevel analyses that can establish whether there are higher-order influences on athlete experiences of pressure are warranted. These findings could inform the development of interventions that target the

most impactful level of influence, to most efficiently reduce the pressure that athletes experience after sustaining a concussion, and to increase concussion reporting. In the meantime, the present findings can help expand educational approaches targeted at coaches and parents. There is a need for the development and evaluation of programming for coaches and parents to encourage critical reflection, consistent with Adult Learning Theory (Merriam, 2001; Mezirow, 1981), about how they are communicating with injured athletes, and whether these interactions are having the unintended consequence of encouraging unsafe concussion reporting behaviors. An educational approach of this nature would likely need to be nested in a broader educational program that addressed other cognitions that may be predictive of coach and parent concussion-related communication, such as knowledge and attitudes (Kroshus et al., 2015). Athletic trainers and sports medicine physicians are often the stakeholders in the collegiate sports environment that are responsible for delivering concussion education to athletes and coaches. Initiatives may be warranted to assist them in delivering educational programming, and supporting them in informal communication within the sport environment, that can help establish team cultures that are supportive of concussion safety.

## Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

## Acknowledgements

Christine M. Baugh was supported by the National Institute Of Mental Health of the National Institutes of Health under Award Number T32MH019733. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.

## References

- Abrams D, Hogg MA. Social identification, self-categorization and social influence. *European Review of Social Psychology*. 1990; 1(1):195–228.
- Abgarov A, Jeffery-Tosoni S, Baker J, Fraser-Thomas J. Understanding Social Support Throughout the Injury Process Among Interuniversity Swimmers. *Journal of Intercollegiate Sport*. 2012; 5(2): 213–229.
- 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 and Applied Social Psychology*. 2011; 33(2):101–117.
- Asparouhov T, Muthen B. Auxiliary Variables in Mixture Modeling: 3-Step Approaches Using Mplus. *Mplus Webnotes*. 2014; 15:1–24.
- Bandura A. Health promotion by social cognitive means. *Health Education & Behavior*. 2004; 31(2): 143–164. [PubMed: 15090118]
- Baugh CM, Kroshus E, Bourlas AP, Perry KI. Requiring Athletes to Acknowledge Receipt of Concussion Related Information and Responsibility to Report Symptoms: A Study of the Prevalence, Variation, and Possible Improvements. *The Journal of Law, Medicine & Ethics*. 2014; 42(3):297–313.
- Baugh CM, Kroshus E, Daneshvar DH, Stern RA. Perceived Coach Support and Concussion Symptom Reporting: Differences between Freshmen and Non Freshmen College Football Players. *The Journal of Law, Medicine & Ethics*. 2014; 42(3):314–322.
- Baugh CM, Kiernan PT, Kroshus E, Daneshvar DH, Montenegro PH, McKee AC, Stern RA. Frequency of Head-Impact-Related Outcomes by Position in NCAA Division I Collegiate Football Players. *Journal of Neurotrauma*. 2014; 32(5):314–326. [PubMed: 25155288]

- Bauman J. Returning to play: the mind does matter. *Clinical Journal of Sport Medicine*. 2005; 15(6): 432–435. [PubMed: 16278547]
- Bazarian JJ, Zhu T, Zhong J, Janigro D, Rozen E, Roberts A, Blackman EG. Persistent, long-term cerebral white matter changes after sports-related repetitive head impacts. *PloS One*. 2014; 9(4):e94734. [PubMed: 24740265]
- Benson BW, McIntosh AS, Maddocks D, Herring SA, Raftery M, Dvorak J. What are the most effective risk-reduction strategies in sport concussion? *British Journal of Sports Medicine*. 2013; 47:321–326. [PubMed: 23479492]
- Bianco T. Social support and recovery from sport injury: Elite skiers share their experiences. *Research Quarterly for Exercise and Sport*. 2001; 72(4):376–388. [PubMed: 11770787]
- Borden BP, Tacchetti RL, Cantu RC, Knowles SB, Mueller FO. Catastrophic head injuries in high school and college football players. *The American Journal of Sports Medicine*. 2007; 35(7):1075–1081. [PubMed: 17351124]
- Brock SC, Kleiber DA. Narrative in medicine: The stories of elite college athletes' career-ending injuries. *Qualitative Health Research*. 1994; 4(4):411–430.
- Caron JG, Bloom GA, Johnston KM, Sabiston CM. National Hockey League players' experiences with career-ending concussions. *British Journal of Sports Medicine*. 2013; 47(5):e1–e1.
- Chrisman SP, Quitiquit C, Rivara FP. Qualitative study of barriers to concussive symptom reporting in high school athletics. *Journal of Adolescent Health*. 2013; 52(3):330–335. [PubMed: 23427783]
- Chrisman SP, Schiff MA, Chung SK, Herring SA, Rivara FP. Implementation of concussion legislation and extent of concussion education for athletes, parents, and coaches in Washington State. *The American Journal of Sports Medicine*. 2014; 42(5):1190–1196. [PubMed: 24510067]
- Cialdini RB, Goldstein NJ. Social influence: Compliance and conformity. *Annual Review of Psychology*. 2004; 55:591–621.
- Covassin T, Elbin RJ, Sarmiento K. Educating coaches about concussion in sports: evaluation of the CDC's "Heads Up: Concussion in Youth Sports" initiative. *Journal of School Health*. 2012; 82(5): 233–238. [PubMed: 22494094]
- Curry TJ. A little pain never hurt anyone: Athletic career socialization and the normalization of sports injury. *Symbolic Interaction*. 1993; 16(3):273–290.
- Daneshvar DH, Nowinski CJ, McKee AC, Cantu RC. The epidemiology of sport-related concussion. *Clinics in Sports Medicine*. 2011; 30(1):1–17. [PubMed: 21074078]
- 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. *Clinical Journal of Sports Medicine*. 2015; 25(2):113–125.
- Delaney JS, Lacroix VJ, Leclerc S, Johnston KM. Concussions among university football and soccer players. *Clinical Journal of Sport Medicine*. 2002; 12(6):331–338. [PubMed: 12466687]
- Doolan AW, Day DD, Maerlender AC, Goforth M, Brolinson PG. A review of return to play issues and sports-related concussion. *Annals of Biomedical Engineering*. 2012; 40(1):106–113. [PubMed: 21997390]
- Echlin PS, Tator CH, Cusimano MD, Cantu RC, Taunton DE, Upshur RE, Skopelja EN. Return to play after an initial or recurrent concussion in a prospective study of physician-observed junior ice hockey concussions: implications for return to play after a concussion. *Neurosurgical Focus*. 2010; 29(5):E5. 2010. [PubMed: 21039139]
- Eisenberg MA, Meehan WP, Mannix R. Duration and course of post-concussive symptoms. *Pediatrics*. 2014; 133(6):999–1006. [PubMed: 24819569]
- Figner B, Mackinlay RJ, Wilkening F, Weber EU. Affective and deliberative processes in risky choice: age differences in risk taking in the Columbia Card Task. *Journal of Experimental Psychology: Learning, Memory, and Cognition*. 2009; 35(3):709.
- Graham, R.; Rivara, FP.; Ford, MA.; Spicer, CM., editors. *Sports-Related Concussions in Youth: Improving the Science, Changing the Culture*. National Academies Press; 2014.
- Kaut KP, DePompei R, Kerr J, Congeni J. Reports of head injury and symptom knowledge among college athletes: implications for assessment and educational intervention. *Clinical Journal of Sport Medicine*. 2003; 13(4):213–221. 2003. [PubMed: 12855923]

- Kerr ZY, Marshall SW, Harding HP, Guskiewicz. Nine-year risk of depression diagnosis increases with increasing self-reported concussions in retired professional football players. *American Journal of Sports Medicine*. 2012; 40(10):2206–2212. [PubMed: 22922518]
- Kerr ZY, Evenson KR, Rosamond WD, Mihalik JP, Guskiewicz KM, Marshall SW. Association between concussion and mental health in former collegiate athletes. *Injury Epidemiology*. 2014; 1(1):28–37.
- Kontos AP, Covassin T, Elbin RJ, Parker T. Depression and neurocognitive performance after concussion among male and female high school and collegiate athletes. *Archives of Physical Medicine and Rehabilitation*. 2012; 93(10):1751–1756. [PubMed: 22503738]
- Kroshus E, Baugh CM, Daneshvar DH, Viswanath K. Understanding concussion reporting using a model based on the theory of planned behavior. *Journal of Adolescent Health*. 2014; 54(3):269–274. [PubMed: 24560034]
- Kroshus E, Baugh CM, Daneshvar DH, Nowinski CJ, Cantu RC. Concussion Reporting Intention: A Valuable Metric for Predicting Reporting Behavior and Evaluating Concussion Education. *Clinical Journal of Sport Medicine*. 2014
- Kroshus E, Baugh CM, Hawrilenko MJ, Daneshvar DH. Determinants of coach communication about concussion safety in U.S. collegiate contact and collision sport. *Annals of Behavioral Medicine*. 2015 Online ahead of print.
- Kroshus E, Kubzansky LD, Goldman RE, Austin SB. Norms, athletic identity, and concussion under-reporting among male collegiate ice hockey players: a prospective cohort study. *Annals of Behavioral Medicine*. 2014; 49(1):95–103. [PubMed: 25236670]
- Laker SR. Epidemiology of concussion and mild traumatic brain injury. *PM&R*. 2011; 3(10):S354–S358. [PubMed: 22035677]
- Llewellyn T, Burdette GT, Joyner AB, Buckley TA. Concussion reporting rates at the conclusion of an intercollegiate athletic career. *Clinical Journal of Sport Medicine*. 2014; 24(1):76–79. [PubMed: 24157468]
- Malinauskas R. College athletes' perceptions of social support provided by their coach before injury and after it. *Journal of Sports Medicine and Physical Fitness*. 2008; 48(1):107–112. [PubMed: 18212718]
- Marar M, McIlvain NM, Fields SK, Comstock RD. Epidemiology of concussions among United States high school athletes in 20 sports. *American Journal of Sports Medicine*. 2012; 40(4):747–755. [PubMed: 22287642]
- Marchi N, Bazarian JJ, Puvenna V, Janigro M, Ghosh C, Zhong J, Janigro D. Consequences of repeated blood-brain barrier disruption in football players. *PloS One*. 2013; 8(3):e56805. [PubMed: 23483891]
- McCrea M, Hammeke T, Olsen G, Leo P, Guskiewicz KM. Unreported concussion in high school football players: implications for prevention. *Clinical Journal of Sport Medicine*. 2004; 14(1):13–17. [PubMed: 14712161]
- McCrory P, Meeuwisse WH, Kutcher JS, Jordan BD, Gardner A. What is the evidence for chronic concussion-related changes in retired athletes: behavioural, pathological and clinical outcomes? *British Journal of Sports Medicine*. 2013; 47(5):327–330. [PubMed: 23479493]
- McCrory P, Meeuwisse WH, Aubry M, Cantu B, Dvořák J, Echemendia RJ, Turner M. Consensus statement on concussion in sport: the 4th International Conference on Concussion in Sport held in Zurich, November 2012. *British Journal of Sports Medicine*. 2013; 47(5):250–258. [PubMed: 23479479]
- Meehan WP, Bachur RG. Sport-related concussion. *Pediatrics*. 2009; 123(1):114–123. [PubMed: 19117869]
- Meehan WP III, Mannix RC, O'Brien MJ, Collins MW. The prevalence of undiagnosed concussions in athletes. *Clinical Journal of Sport Medicine*. 2013; 23(5):339–342. [PubMed: 23727697]
- Meier TB, Brummel BJ, Singh R, Nerio CJ, Polanski DW, Bellgowan PSF. The underreporting of self-reported symptoms following sports-related concussion. *Journal of Science and Medicine in Sport*. 2014
- Merriam SB. Andragogy and self directed learning: Pillars of adult learning theory. *New Directions for Adult and Continuing Education*. 2001; 2001(89):3–14.

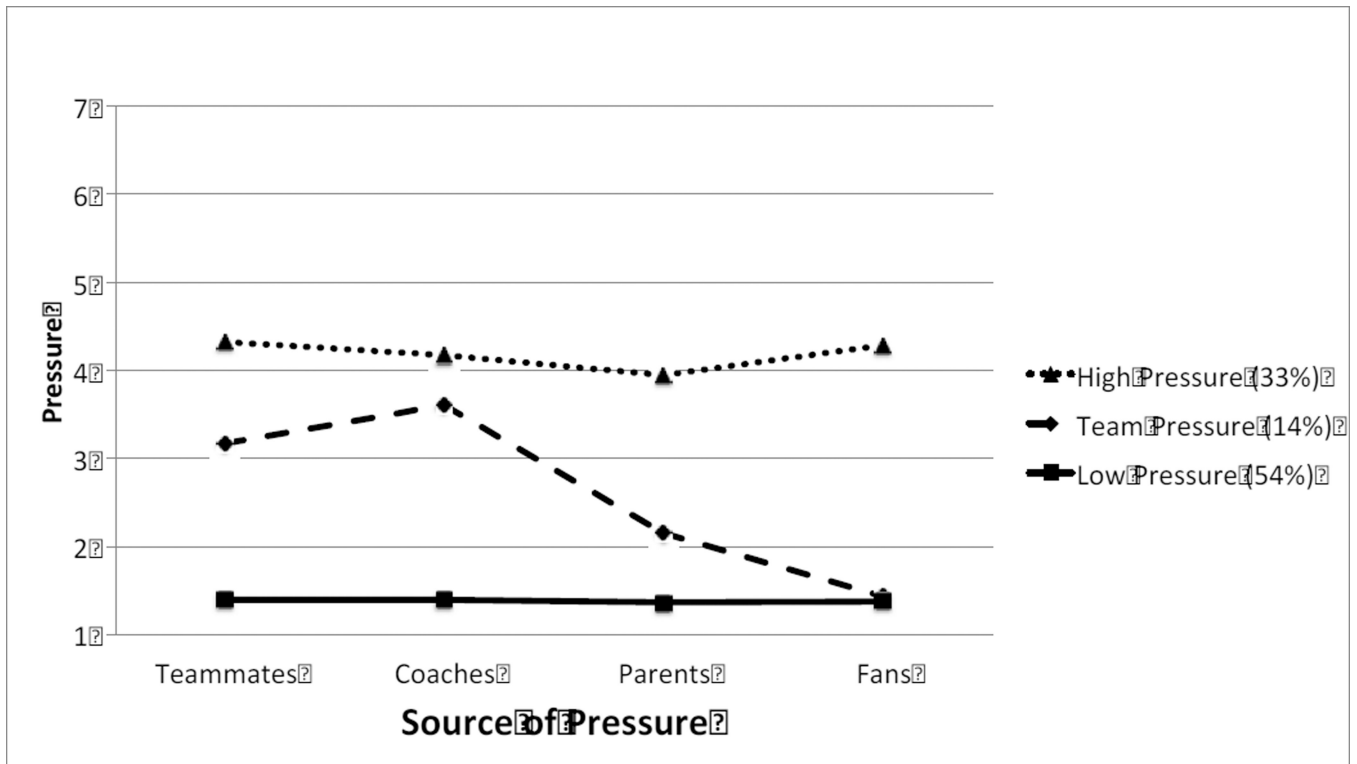


- Mezirow J. A critical theory of adult learning and education. *Adult Education Quarterly*. 1981; 32(1): 3–24.
- Muthen, LK.; Muthen, BO. *Mplus User's Guide*. Seventh Edition. Los Angeles, CA: Muthen & Muthen; 1998–2012.
- National Collegiate Athletic Association. 1981-82- 2012-13 NCAA sports sponsorship and participation rates report. 2013. Available at: <http://www.ncaapublications.com/p-4334-1981-82-2012-13-ncaa-sports-sponsorship-and-participation-rates-report.aspx>
- National Collegiate Athletic Association. Division I steering committee on governance: recommended governance model. 2014. Available at: <http://www.ncaa.org/sites/default/files/DI%20Steering%20Committee%20on%20Gov%20Proposed%20Model%2007%2018%2014%204.pdf>
- National Federation of High School Sports. High school sport participation increases for 25<sup>th</sup> consecutive year. 2014. Available at: <http://www.nfhs.org/articles/high-school-participation-increases-for-25th-consecutive-year/>
- Niven A. Rehabilitation adherence in sport injury: sport physiotherapists' perceptions. *Journal of Sport Rehabilitation*. 2007; 16(2):93–110. [PubMed: 17918697]
- Nixon HL. A social network analysis of influences on athletes to play with pain and injuries. *Journal of Sport & Social Issues*. 1992; 16(2):127–135.
- Nixon HL. Accepting the risks of pain and injury in sport: Mediated cultural influences on playing hurt. *Sociology of Sport Journal*. 1993; 10:183–183.
- Nixon HL. Social pressure, social support, and help seeking for pain and injuries in college sports networks. *Journal of Sport & Social Issues*. 1994; 18(4):340–355.
- Nixon HL. Explaining pain and injury attitudes and experiences in sport in terms of gender, race, and sports status factors. *Journal of Sport & Social Issues*. 1996; 20(1):33–44.
- Prichep LS, McCrea M, Barr W, Powell M, Chabot RJ. Time course of clinical and electrophysiological recovery after sport-related concussion. *The Journal of Head Trauma Rehabilitation*. 2013; 28(4):266–273. [PubMed: 22588360]
- Podlog L, Eklund RC. Professional coaches' perspectives on the return to sport following serious injury. *Journal of Applied Sport Psychology*. 2007; 19(2):207–225.
- Podlog L, Heil J, Schulte S. Psychosocial factors in sports injury rehabilitation and return to play. *Physical Medicine and Rehabilitation Clinics of North America*. 2014; 25(4):915–930. [PubMed: 25442166]
- Prins ML, Alexander D, Giza CC, Hovda DA. Repeated mild traumatic brain injury: Mechanisms of cerebral vulnerability. *Journal of Neurotrauma*. 2013; 30(1):30–38. [PubMed: 23025820]
- Register-Mihalik JK, Guskiewicz KM, McLeod TC, Linnan LA, Mueller FO, Marshall SW. Knowledge, attitude, and concussion-reporting behaviors among high school athletes: a preliminary study. *Journal of Athletic Training*. 2012; 48(5):645–653. [PubMed: 23848520]
- Register-Mihalik JK, Linnan LA, Marshall SW, McLeod TCV, Mueller FO, Guskiewicz KM. Using theory to understand high school aged athletes' intentions to report sport-related concussion: Implications for concussion education initiatives. *Brain Injury*. 2013; 27(7–8):878–886. [PubMed: 23789865]
- Reyna VF, Farley F. Risk and rationality in adolescent decision making implications for theory, practice, and public policy. *Psychological Science in the Public Interest*. 2006; 7(1):1–44. [PubMed: 26158695]
- Rivara FP, Schiff MA, Chrisman SP, Chung SK, Ellenbogen RG, Herring SA. The effect of coach education on reporting of concussions among high school athletes after passage of a concussion law. *The American Journal of Sports Medicine*. 2014; 42(5):1197–1203. [PubMed: 24569704]
- Roderick M, Waddington I, Parker G. Playing Hurt. *Managing Injuries in English Professional Football*. *International Review for the Sociology of Sport*. 2000; 35(2):165–180.
- Rosenbaum AM, Arnett PA. The development of a survey to examine knowledge about and attitudes toward concussion in high-school students. *Journal of Clinical and Experimental Neuropsychology*. 2010; 32(1):44–55. [PubMed: 19381997]
- Rosenthal JA, Foraker RE, Collins CL, et al. National high school athlete concussion rates from 2005–2006 to 2011–2012. *Am J Sports Med*. 2014; 42(7):710–715.

- Seichepine DR, Stamm JM, Daneshvar DH, Riley DO, Baugh CM, Gavett BE, Stern RA. Profile of self-reported problems with executive functioning in college and professional football players. *Journal of Neurotrauma*. 2013; 30(14):1299–1304. [PubMed: 23421745]
- SCAT-3. Sport Concussion Assessment Tool—3<sup>rd</sup> edition. *Br J Sports Med*. 2013; 47:259–262. [PubMed: 23479480]
- Talavage TM, Nauman EA, Breedlove EL, Yoruk U, Dye AE, Morigaki KE, Leverenz LJ. Functionally-detected cognitive impairment in high school football players without clinically-diagnosed concussion. *Journal of Neurotrauma*. 2014; 31(4):327–338. [PubMed: 20883154]
- Vermunt JK. Latent Class Modeling with Covariates: Two Improved Three-Step Approaches. *Political Analysis*. 2010; 18(4):450–469.
- Wilder, DA. Berkowitz, L. *Advances in Experimental Social Psychology*. Vol. 19. New York: Academic Press; 1986. Social categorization: Implications for creation and reduction of intergroup bias; p. 291-355.
- Williamson IJS, Goodman D. Converging evidence for the under-reporting of concussions in youth ice hockey. *British Journal of Sports Medicine*. 2006; 40(2):128–132. [PubMed: 16431999]
- Yang J, Peek-Asa C, Lowe JB, Heiden E, Foster DT. Social support patterns of collegiate athletes before and after injury. *Journal of Athletic Training*. 2010; 45(4):372. [PubMed: 20617912]
- Young K, McTeer W, White P. Body talk: male athletes reflect on sport, injury and pain. *Sociology of Sport Journal*. 1994; 11(2):175–94.
- Young K, White P. Sport, physical danger, and injury: the experiences of elite women athletes. *Journal of Sport and Social Issues*. 1995; 19(1):45–62.

### Highlights

- Quantified pressure from coaches, teammates, parents, and fans to play after a head impact.
- More than one quarter of athletes experienced pressure last year from at least one source.
- A latent profile mixture model explored the systems of pressure experienced.
- Pressure from all sources was associated with the lowest concussion reporting intention.



**Figure 1.**  
Subgroup Profiles for Sources of Pressure.

**Table 1**

Descriptive characteristics of sample of male and female collegiate contact and collision sport athletes (n=328).

Characteristic	% (n) or mean (SD)
School	
School 1	22.56% (74)
School 2	34.76% (114)
School 3	19.82% (65)
School 4	22.87% (75)
Sex	
Male <sup>a</sup>	46.95% (154)
Female <sup>b</sup>	53.05% (174)
Roster spot	
First team	52.48% (169)
Second team	25.47% (82)
Third team	16.77% (54)
Practicing but not competing	5.28% (17)
Year in school <sup>c</sup>	
First year	33.33% (109)
Second year	26.91% (88)
Third year	24.77% (81)
Fourth year	14.68% (48)
Concussion ever diagnosed	41.28% (135)
Concussion diagnosed previous season	8.56% (28)
Continued play while symptomatic with symptoms of a possible concussion last season	47.56% (156)
Concussion Knowledge Index score	22.08 (3.19)
Intention to report symptoms of a suspected concussion <sup>d</sup>	6.13 (1.25)
Number of times last season play was continued after a potentially concussive impact <sup>e</sup>	0.21 (0.93)

<sup>a</sup> Male sports represented in sample were soccer, lacrosse, field hockey, basketball, softball and volleyball

<sup>b</sup> Female sports represented in sample were soccer, lacrosse, basketball, baseball

<sup>c</sup> One participant was in a 5<sup>th</sup> year of school

<sup>d</sup> Intention measured on a seven point scale, with higher scores indicating greater intention to report symptoms of a suspected concussion

<sup>e</sup> This item assessed the difference between the number of impacts sustained last season that resulted in at least one symptom from the SCAT-3 and the number of these impacts the respondent continued playing in a game or practice while symptomatic.

**Table 2**

Pressure experienced by collegiate contact and collision sport athletes to continue playing after a head impact (n=328)

Sample characteristic	Source of pressure to return to play after a head impact			
	Teammates	Coaches	Parents	Fans
All	2.59 (1.65)	2.61 (1.66)	2.30 (1.55)	2.33 (1.57)
<i>Sex</i>				
Female	2.55 (1.66)	2.68 (1.75)	2.41 (1.70)	2.31 (1.56)
Male	2.64 (2.63)	2.54 (1.55)	2.17 (1.37)	2.36 (1.59)
Difference by sex (p)	0.621	0.450	0.181	0.791
<i>Roster spot</i>				
First team	2.71 (1.66)	2.72 (1.69)	2.39 (1.57)	2.41 (1.54)
Second team	2.51 (1.77)	2.48 (1.54)	2.37 (1.69)	2.33 (1.71)
Third team	2.35 (1.47)	2.54 (1.74)	1.92 (1.19)	2.06 (1.43)
Not competing	2.31 (1.54)	2.31 (1.70)	2.13 (1.50)	2.19 (1.47)
Difference by roster spot (p)	0.467	0.625	0.265	0.561
<i>Year in school</i>				
First year	2.61 (1.79)	2.43 (1.61)	2.32 (1.67)	2.31 (1.63)
Second year	2.63 (1.49)	2.89 (1.71)	2.22 (1.37)	2.35 (1.37)
Third year	2.32 (1.57)	2.43 (1.64)	2.20 (1.52)	2.22 (1.58)
Fourth year	2.85 (1.72)	2.77 (1.64)	2.55 (1.64)	2.53 (1.74)
Difference by year in school (p)	0.422	0.235	0.665	0.764
Concussion diagnosed last season				
Yes	2.82 (2.04)	3.44 (2.10)	2.43 (1.93)	2.25 (1.58)
No	2.57 (1.61)	2.53 (1.59)	2.29 (1.51)	2.34 (1.57)
Difference by concussion diagnosis (p)	0.004	0.004	0.683	0.459

*Note:* Pressure measured with item "I have felt pressure from [source] to return to play after a head impact"; responses on a seven point Likert scale, ranging from 1=strongly disagree to 7=strongly agree; ANOVA for differences in pressure from each group by team and by school were not significant for  $p < 0.05$

**Table 3**

Results of multivariable linear regression of association predicting intention to report symptoms of a concussion (n=308).

Variable	Model 1.1 <sup>1</sup> β (SE) p	Model 1.2 <sup>2</sup> β (SE) p	Model 2.1 <sup>3</sup> β (SE) p	Model 2.2 <sup>4</sup> β (SE) p	Model 3.1 <sup>5</sup> β (SE) p	Model 3.2 <sup>6</sup> β (SE) p	Model 4.1 <sup>7</sup> β (SE) p	Model 4.2 <sup>8</sup> β (SE) p
Pressure from teammates	-0.158 (0.06) 0.005	-0.115 (0.06) 0.009	-0.10 (0.06) 0.089	-0.09 (0.06) 0.095	-0.19 (0.06) 0.001	-0.20 (0.06) 0.001	-0.16 (0.06) 0.006	-0.15 (0.06) 0.007
Pressure from coaches								
Pressure from parents								
Pressure from fans								
Sex (ref=female)		-0.18 (0.06) 0.002		-0.20 (0.06) 0.001		-0.20 (0.06) 0.001		-0.18 (0.06) 0.002
Diagnosed ever		-0.05 (0.06) 0.343		-0.05 (0.06) 0.410		-0.07 (0.06) 0.207		-0.07 (0.06) 0.279
Concussion knowledge		0.08 (0.06) 0.174		0.07 (0.06) 0.198		0.07 (0.06) 0.194		0.08 (0.06) 0.147
R <sup>2</sup>	0.025	0.070	0.009	0.058	0.035	0.084	0.024	0.070

<sup>1</sup> Bivariate analysis of teammate pressure

<sup>2</sup> Multivariate analysis of teammate pressure

<sup>3</sup> Bivariate analysis of coach pressure

<sup>4</sup> Multivariate analysis of coach pressure

<sup>5</sup> Bivariate analysis of parent pressure

<sup>6</sup> Multivariate analysis of parent pressure

<sup>7</sup> Bivariate analysis of fan pressure

<sup>8</sup> Multivariate analysis of fan pressure

**Table 4**

Model Estimated Means and Standard Deviations for Indicators of Subgroup Membership (n=309).

Class	Variable	Estimated Mean (SE)	SD
Low Pressure (54%)			
	Pressure from Teammates	1.39 (0.05)	0.11
	Pressure from Coaches	1.40 (0.05)	0.14
	Pressure from Parents	1.36 (0.05)	0.12
	Pressure from Fans	1.37 (0.05)	0.14
Team Pressure (14%)			
	Pressure from Teammates	3.15 (0.28)	0.78
	Pressure from Coaches	3.62 (0.31)	0.72
	Pressure from Parents	2.13 (0.27)	0.75
	Pressure from Fans	1.42 (0.11)	0.17
High Pressure (33%)			
	Pressure from Teammates	4.32 (0.12)	0.49
	Pressure from Coaches	4.17 (0.13)	0.50
	Pressure from Parents	3.94 (0.14)	0.52
	Pressure from Fans	4.27 (0.09)	0.42



**Table 5**

Sample characteristics by modal class assignment.

<b>Variable</b>	<b>Low Pressure % (n=169)</b>	<b>High Pressure % (n=42)</b>	<b>Team Pressure % (n=98)</b>
<i>Sex</i>			
Female	51.5	64.3	52.0
Male	48.5	35.7	48.0
<i>Roster spot</i>			
First team	47.9	59.5	55.8
Second team	26.9	21.4	25.3
Third team	18.6	16.7	14.7
Not competing	6.6	2.4	4.2
<i>Year in school</i>			
First year	35.5	31.0	32.7
Second year	26.6	28.6	27.6
Third year	26.0	14.3	22.4
Fourth year	11.8	26.2	17.3
<i>Concussion diagnosed last season</i>			
No	92.3	85.7	90.8
Yes	7.7	14.3	9.2