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Understanding Concussion Reporting Using a Model Based on the Theory of Planned Behavior

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A B S T R A C T

Purpose: Athlete's report of concussion symptoms to coaching or medical personnel is an important component of concussion risk reduction. This study applies a model based on the Theory of Planned Behavior (TPB) to the prediction of concussive symptom underreporting among late adolescent and young adult male ice hockey players.
Methods: Participants were members of an American Tier III Junior A ice hockey league (ages 18–21 years; male; n = 256). Twelve of 14 league teams and 97% of players within these teams agreed to participate. Written survey items assessed symptom reporting behavior, intention, perceived norms, self-efficacy, perceived outcomes of reporting, and concussion knowledge. Structural equation modeling was used to assess the significance of relationships hypothesized by the TPB-based model and the overall model fit. Data were collected in January 2013.
Results: Results supported the fit of the TPB-based model in explaining reporting behavior; all model pathways were significant in the hypothesized direction. Of the perceived reporting outcomes assessed, those related to athletic performance were identified as most strongly associated with reporting intention.
Conclusions: Results of this study suggest the importance of considering factors such as perceived outcomes of reporting, perceived norms, and self-efficacy, in addition to knowledge, when analyzing concussion underreporting among adolescent athletes. As concussion education for athletes becomes increasingly mandated, testing and applying psychosocial theories such as TPB may help increase program efficacy.

IMPLICATIONS AND CONTRIBUTION

Findings suggest that the Theory of Planned Behavior can help explain concussive symptom reporting behavior among late adolescent male athletes. Programmatic and informal communication with athletes about concussions should address population and context-specific perceived consequences of reporting, subjective norms, and reporting self-efficacy.

Participation in high school and collegiate sport in the United States is at an all-time high, with recent estimates suggesting that on an annual basis more than 7.6 million high school students [1] and 450,000 collegians [2] compete in organized sport. Although the benefits of participation in sport for adolescents are well established [3], there is growing concern about the prevalence and consequences of sport-related concussions. In a nationally representative sample of male and female high school athletes across 20 sports, 2.5 diagnosed concussions were found to occur per 10,000 athlete exposures to a game or practice [4]; the highest rates were observed in boys football, ice hockey, and lacrosse, and girls soccer, lacrosse, and basketball. Accumulating research about the short- and long-term neurologic and

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functional consequences of concussions and sub-concussive repetitive head trauma in sports [5,6] makes it increasingly clear that a public health priority should be to reduce its burden [7]. A multifactorial approach has been suggested as necessary to reduce the risk of concussions from sports [8]. One aspect of this approach to reduce the incidence of continued play after sustaining concussive head trauma and before complete recovery. Concussion underreporting is a problem that has been identified in multiple populations of youth and adolescent athletes [9–12]. Athletes who sustain additional head trauma before the resolution of initial symptoms are at risk of magnified neurologic consequences [13–15].

One commonly proposed strategy to reduce underreporting has been to educate athletes about concussions [16]. At a policy level, states and sports leagues have been increasingly mandating concussion education for players, parents, and coaches [17]. Not all educational materials for athletes have been evaluated, but among those that have, measuring whether symptom-focused knowledge changed post-education has been a commonly used evaluation strategy [18–20]. Implicit in this focus is the assumption that underreporting by athletes is driven by a lack of symptom-focused knowledge. Although evidence suggests an association between an athletes' symptom knowledge and symptom reporting behaviors [21–24], it is unclear to what extent this association is causal. Recent focus groups with high school athletes suggest that factors other than lack of awareness and symptom knowledge—such as not wanting to stop playing, not wanting to look weak, and not wanting to let teammates down—may explain why many athletes do not report symptoms of concussions [25]. It is crucial to understand the motivational aspect of reporting if we are to develop programs and communication strategies to increase concussion symptom reporting effectively.

Precedent in the broader public health literature suggests that we should draw upon existing psychosocial theories of health behavior to understand mechanisms underlying concussion reporting [26]. Using the lens of the Theory of Planned Behavior (TPB) [27], Ajzen and colleagues [28] proposed that knowledge is an important predictor of behavior only to the extent that it "links a behavior of interest to positive or negative outcomes, to the normative expectations of important referent individuals or groups, and to control factors that can facilitate or inhibit performance of the behavior." To date, there has been limited explicit application of behavior change theory to the field of sports injury prevention [29]; however, there have been recent suggestions that TPB may be an appropriate frame for an understanding of concussion reporting behavior [25,30,31].

The Theory of Planned Behavior is a robust expectancy value theory that has been tested in a variety of contexts involving rational decision making [26]. According to the theory, the most important predictor of a behavior is the intention to perform that behavior. Intention is conceptualized as being directly predicted by three factors: attitudes, subjective norms, and perceived behavioral control. As such, intention mediates the association among these factors and the performance of the behavior. Attitude reflects the individual's evaluation of the consequences of performing the behavior. Subjective norms reflect perceived pressure to perform the behavior from people whose opinions and behaviors are considered important to the individual in question. Perceived behavioral control (PBC) reflects an individual's evaluation of the ability to perform the behavior. Ajzen [32] suggested that self-efficacy [33] may be considered a component of an individual's PBC. Similar to PBC, self-efficacy reflects an individual's confidence in the ability to perform a particular behavior under specific relevant conditions. Within TPB, this construct is conceptualized as predicting behavior, both directly and mediated through intention.

Effectively intervening to increase symptom reporting requires first understanding the psychosocial mechanisms through which this reporting is facilitated or constrained. In a population of late adolescent and young adult male ice hockey players, the primary aim of the current study was to empirically assess the fit of a model based on constructs of TPB for explaining concussion reporting behavior. The study also aimed to explore in more detail the prevalence of different perceived consequences of concussion reporting.

Methods

Participants

Study participants were 256 male hockey players (ages 18–21 years) who were competing in an American Tier III Junior A hockey league. Recruitment occurred first at the team level; 12 of 14 league coaches agreed to give team members the opportunity to voluntarily participate in study activities. Research staff visited each of these 12 teams and obtained informed consent from players aged ≥18 years (97% participation). Table 1 reports detailed participant characteristics. All participants completed a written survey as a portion of a multipart study at approximately the halfway point of the 2012–2013 competitive season. Surveys took approximately 20 minutes to complete and items were included in the order listed subsequently. When previously validated or published measures were not available or appropriate for use, new items were developed based on relevant literature reviews and pilot qualitative interviews conducted with late adolescent and young adult male ice hockey players. These pilot qualitative interviews were conducted by a trained interviewer using standard qualitative methods, including key

Table 1
Descriptive statistics for late adolescent male ice hockey players (n = 256)

Demographic factors, n (standard deviation)	
Mean age, years	19.15 (.85)
Mean years playing organized hockey	13.74 (2.05)
Concussion history—career, n (standard deviation)	
Mean number of previously diagnosed concussions	1.02 (1.39)
Mean number of suspected (undiagnosed) concussions	3.47 (8.20)
Measured constructs, n (standard deviation)	
Reporting attitude	27.90 (6.43)
Perceived reporting norms	40.37 (5.54)
Reporting self-efficacy	22.83 (7.05)
Reporting intention	38.84 (10.12)
Concussion knowledge	63.01 (8.01)
Symptoms experienced post-impact and reporting—current season	
Dizziness	52.76%
"Bell rung"	65.22%
Lost consciousness	7.91%
"Saw stars"	42.69%
Vomited or felt nauseous	5.92%
Forgot what to do on the ice	5.14%
Headache at least once during the week	41.10%
Problems studying, concentrating or doing class work	15.48%
Experienced any of these symptoms and did not immediately tell coach or athletic trainer	47.83%
Diagnosed with concussion by medical professional	9.49%

informant and snowballing recruitment until thematic saturation, verbatim transcription of audio-recorded interviews, and analysis using the method of Immersion/Crystallization [34]. The Harvard School of Public Health Institutional Review Board approved all research activities.

Measures

Self-efficacy. Participants reported confidence in their ability to report symptoms of a concussion under various challenging conditions, with a five-item measure (e.g., "I am confident in my ability to report symptoms of a concussion even when I really want to keep playing"). Items were scored on a 7-point scale, with responses ranging from "strongly disagree" to "strongly agree"; the sum of item scores was computed, with a higher score representing greater reporting self-efficacy (mean, 22.83; standard deviation [SD], 7.05). Scale internal consistency was high (Cronbach $\alpha = .91$).

Intention to report concussion symptoms. Participants were provided with a list of eight common symptoms of concussions [22] and were asked whether they intended to immediately report the presence of each symptom to their coach or athletic trainer if the concussion were sustained after an impact. All items were similarly scored on a 7-point scale. The variable was computed as the sum of item scores, with higher scores reflecting a greater intention to report symptoms (mean, 38.84; SD, 10.12). Internal consistency of the measure was high (Cronbach $\alpha = .89$).

Concussion knowledge. Knowledge was assessed using a 13-item modified version of Rosenbaum and Arnett's Concussion Knowledge Index [35]. A full list of items is presented in Table 2. Items were scored on a 7-point scale to allow for interindividual variability in response confidence; they were reverse-coded where appropriate and summed to create a composite score (mean, 63.01; SD, 8.01), with higher scores reflecting more concussion-related knowledge.

Concussion symptoms and reporting behavior. Participants reported (yes/no) whether during the current season they had experienced any of eight listed symptoms after sustaining an impact [22]. Next, they reported (yes/no) to a question assessing whether during the current season they had experienced any of the symptoms mentioned previously after an impact and did not immediately tell a coach or athletic trainer. The item was scored 0 or 1, with 1 indicating non-report.

Attitude about outcomes of concussion reporting. Participants reported how strongly they agreed or disagreed with eight statements about possible positive and negative outcomes of concussion reporting (e.g., "If I report a concussion, I will lose my place in the lineup"). Items were scored on a 7-point scale, with item scores summed and higher scores representing the belief that there are more negative consequences of reporting a concussion (mean, 27.90; SD, 6.43). Internal consistency of the measure was low (Cronbach $\alpha = .62$), which suggests that this set of perceived consequences may not strongly reflect a single latent construct.

Subjective reporting norms. Participants reported how strongly they agreed with seven statements about what a hypothetical athlete or one of their teammates would do in various reporting situations. Items were drawn from Rosenbaum and Arnett's Concussion Attitude Inventory [35], with modifications so that each item separately referred to athlete and teammate norms (e.g., "My teammates would …"; "Most athletes would …"). The 14 items were scored from 1 to 7 and the sum of individual items was computed, with higher scores represented more negative normative beliefs about concussion reporting (mean, 40.37; SD, 5.54). The internal consistency of the scale was adequate (Cronbach $\alpha = .74$). All items in each of the measures described above are included in the Appendix, which can be found in the online edition of this article.

Table 2
Knowledge item scores among late adolescent and young adult male ice hockey players

Knowledge item	Mean (standard deviation)	Correct	β
1. There is a possible risk of death if a second concussion occurs before the first one has healed	4.19 (1.67)	22.9%	1.13**
2. People who have had one concussion are more likely to have another concussion	5.25 (1.45)	50.6%	.27
3. A concussion cannot cause brain damage unless the person has been knocked out (R)	5.57 (1.37)	62.5%	.29
4. The brain never fully heals after a concussion (R)	4.10 (1.57)	20.9%	
5. It is easy to tell if a person has a concussion by the way the person looks or acts (R)	3.81 (1.60)	19.3%	−.35
6. Symptoms of a concussion can last for several weeks	5.87 (1.05)	68.8%	1.78**
7. Resting your brain by avoiding things such as playing video games, texting, and doing schoolwork is important for concussion recovery	5.61 (1.48)	64.2%	−.18
8. After a concussion occurs, brain imaging (e.g., computer-assisted tomography, magnetic resonance imaging, X-ray, etc.) typically shows visible physical damage to the brain (e.g., bruise, blood clot) (R)	3.03 (1.43)	55.1%	−.33
9. A concussion may cause an athlete to feel depressed or sad	5.48 (1.21)	57.3%	.36
10. Once an athlete feels "back to normal," the recovery process is complete (R)	4.92 (1.47)	38.6%	.85
11. Even if a player is experiencing the effects of a concussion, performance on the field of play will be the same as it would be had the player not experienced a concussion (R)	5.06 (1.39)	40.9%	.56
12. Concussions pose a risk to an athlete's long-term health and well-being	5.49 (1.35)	58.7%	.20
13. A concussion can only occur if there is a direct hit to the head (R)	4.90 (1.68)	45.7%	.17

Data represent mean item score (scale scored 1–7), percentage of participants who score 6 (agree) or 7 (strongly agree) with each statement (n = 256), and standardized association with reporting intention. "Correct" indicates an answer of ≥ 6.
R = Item has been reverse coded.
** $p \leq .01$.

Analyses

Bivariate associations were assessed for all model variables. Bivariate associations were also assessed between individual items assessing perceived consequences of reporting that comprised the attitudes measure and reporting intention, and between individual items that comprised the knowledge measure and reporting intention. Structural equation modeling was used to estimate the relationships among variables, where the behavior of interest is failing to report listed symptoms after an impact. Normality assumptions were met and an analysis of variance indicated that there was no significant clustering at the team level for reporting intention, $F(11, 241) = 1.61$, $p = .096$, or behavior, $F(11,241) = 1.25$, $p = .255$, so the model was computed without adjustment for team-level clustering. STATA version 12.1 (StataCorp, College Station, TX) and Mplus 7 (Muthén & Muthén, Los Angeles, CA) were used to conduct analyses.

Results

Table 3 presents individual items assessing perceived outcomes of reporting. Items with the highest mean score and greatest number of participants endorsing agreement or strong agreement were the statements "I will not be allowed to start playing or practicing when I think I'm ready" (27.3%) and "I will lose my spot in the lineup" (29.3%). Few players agreed or strongly agreed that "My teammates will think I made the right decision" (5.1%) or that "I will be better off in the long run" (5.1%). Bivariate associations between individual items and intention to report symptoms found the strongest significant association for a perception that if players report symptoms of a concussion, they will hurt their team's performance ($\beta = -.22$; $p < .001$) and the belief that their teammates will think they made the right decision ($\beta = -.30$; $p < .001$).

Table 4 presents bivariate associations among model variables, plus concussion knowledge. As predicted by TPB, intention to report symptoms was significantly associated with reporting behavior over the current season. Subjective norms and self-efficacy were significantly associated with both intention and behavior, whereas attitude about perceived outcomes of reporting was significantly associated with intention but not behavior ($p = .078$). Concussion knowledge was significantly associated with attitudes about outcomes of reporting, but no other model variable. However, post hoc analyses found that two knowledge items were significantly associated with reporting intention: "There is a possible risk of death if a second concussion occurs before the first one has healed" ($p = .003$) and "Symptoms of a concussion can last for several weeks" ($p = .004$). Table 2 reports individual knowledge item scores, the percentage of participants who answered each item correctly, and the bivariate association between the individual item score and reporting intention.

Table 3
Perceived consequences of reporting among late adolescent male ice hockey players

Perceived outcome item	Mean (standard deviation)	Score ≥6	β
1. I will hurt my team's performance	3.68 (1.64)	13.3%	−.22***
2. I will not be allowed to start playing or practicing when I think I'm ready	4.52 (1.48)	27.3%	−.09
3. I will lose my spot in the lineup	4.30 (1.69)	29.3%	−.10
4. My teammates will think less of me	2.83 (1.62)	8.5%	−.16*
5. I'll be back at full strength sooner than if I waited to report	2.83 (1.62)	7.4%	−.16*
6. I will be held out of upcoming games even if it is *not* a concussion	4.10 (1.69)	20.3%	−.02
7. My teammates will think I made the right decision	3.23 (1.34)	5.1%	−.30***
8. I will be better off in the long run	2.34 (1.32)	5.1%	−.11

Data represent mean item score (scale scored 1–7), percentage of participants who score 6 (agree) or 7 (strongly agree) with each statement (n = 256), and standardized association with reporting intention.
* $p \leq .05$.
*** $p \leq .001$.

Table 4
Standardized bivariate associations between model variables related to concussion-related symptom reporting among late adolescent male ice hockey players (n = 256)

Variable	Behavior	Intention	Attitude	Norm	Self-efficacy
Intention	−.23***				
Attitude	.11	−.27***			
Subjective norm	.15*	−.23***	.05		
Self-efficacy	−.24***	.39***	−.23***	−.19**	
Knowledge	.06	.09	−.16**	−.02	−.04

* $p \leq .05$.
** $p \leq .01$.
*** $p \leq .001$.

A multivariate mean comparison of the individual items comprising the intention index measure found that participants were more likely to intend to report some post-impact symptoms than others ($p < .001$). Symptoms with higher intention to report scores were "vomit or feel nauseous" (mean, 5.56; SD, 1.61), "have a hard time remembering things" (mean, 5.28; SD, 1.61), "experience dizziness or balance problems" (mean, 5.30; SD, 1.47), and "feel sensitive to light or noise" (mean, 5.13; SD, 1.51). Symptoms with lower intention to report scores were "see stars" (mean, 4.17; SD, 2.03), "have problems concentrating on the task at hand" (mean, 4.89; SD, 1.61), "have a headache and/or have head pain" (mean, 3.83; SD, 1.86), and "feel sleepy or in a fog" (mean, 4.68; SD, 1.68). There was no significant between-group difference in intention item scores when comparing a group with higher than median knowledge with a group with lower than median knowledge.

Table 5 presents results of the structural equation modeling analysis. Consistent with TPB, attitudes, reporting self-efficacy, and subjective norms were all significantly associated with behavioral intention in the hypothesized direction. Self-efficacy was also associated with behavior, independent of behavioral intention. Reporting intention was significantly associated with reporting behavior over the current season. The model fit statistics suggest a good fit of the theoretic model to the sample data ($\chi^2 = 1.99$; $p = .37$; Comparative Fit Index [CFI] = 1.00; root mean square error of approximation [RMSEA] = .000). Good model fit is suggested by a CFI value >.9 [36] and an RMSEA value <.08 [37]. Although the model fit the data well, it explained only 22.2% of the variance in intention and 10.5% of the variance in non-reporting behavior.

Table 5
Standardized and unstandardized strength and significance of individual paths in Theory of Planned Behavior–based model predicting concussion underreporting among late adolescent male ice hockey players (n = 256)

	β (standard error)	β
Intention → Behavior	−.02 (.01)*	−.19*
Self-efficacy → Behavior	−.03 (.01)*	−.20*
Self-efficacy → Intention	.47 (.08)***	.32***
Attitude → Intention	−.30 (.09)***	−.19***
Subjective norm → Intention	−.29 (.10)**	.17**

* $p \leq .05$.
** $p \leq .01$.
*** $p \leq .001$.

In post hoc analyses, knowledge was added to the model as an independent predictor of intention. All pathways from the original model retained statistical significance and higher knowledge was significantly associated with lower reporting intention ($\beta = -.14$; $p = .016$). Good model fit was retained in this augmented model ($\chi^2 = 2.13$; $p = .55$; CFI = 1.00; RMSEA = .000), and a similar amount of outcome variance was explained (26.1%). Additional post hoc analyses compared the standard TPB-based model for participants with above- and below-median knowledge scores, testing whether the model fit was equivalent across higher and lower knowledge groups. Wald test indicated that the structural parameters differed significantly between groups (Wald [5] = 11.75; $p = .040$). Follow-up analysis indicated that this difference was driven by between-group differences in the association between self efficacy and intention (Wald [1] = 4.74; $p = .030$); however, this association was statistically significant in both groups ($\beta = .26$, $p = .044$; and $\beta = .63$, $p < .001$ for low and high knowledge, respectively). Otherwise, all other model pathways were not statistically distinguishable between groups. Model fit statistics for both groups were adequate (high knowledge RMSEA = .073, CFI = .973, $\chi^2 = 3.503$, $p = .174$; low knowledge RMSEA= .000, CFI = 1.000, $\chi^2 = .682$, $p = .711$).

Discussion

The results of this study underscore recent suggestions [25,30,31] that constructs from TPB may be important in explaining concussion-reporting behavior. The full-sample TPB-based model was supported, with all pathways significant in the theory-consistent direction and good model fit. This indicates that there is independent predictive value in considering an individual's appraisal of the consequences of concussion reporting, the perception about whether teammates and most athletes would report symptoms of a concussion, and confidence in the ability to report symptoms of a concussion under a variety of challenging situations. However, only about a quarter of the variance in intention and behavior was explained. This suggests that although the model may be a relevant frame through which reporting behavior may partially understood, it may not be sufficient in isolation. This may be a function of the insufficiency of TPB as a theory to fully explain variance in concussion-reporting behavior, or it may be a function of the insufficiency of the constructs included in the present TPB-based analysis. Although TPB may help inform the development of more effective educational programming and knowledge transfer at the individual athlete level, it should be nested within a multilevel approach that considers the influence of factors external to the individual, such as that recently described by Richmond and colleagues [38].

The significant bivariate association of knowledge with perceived consequences of reporting is consistent with the suggestion by Ajzen et al. [28] that knowledge may influence behavior through a path involving perceptions of the personal and affective consequences of performing the behavior. Determining what the biggest concerns are about reporting a concussion for a given population of athletes and then developing interventions to address these specific concerns may be an effective way to change reporting intention and behavior. These interventions might be psychoeducational in nature, addressing specific knowledge needs. For the current population, we found that the perceived outcomes of reporting that were most strongly endorsed were related to short-term athletic performance: being held out of games, hurting the team's performance, and not being allowed to start playing or practicing when players think they are ready. Several of these factors had significant negative associations with reporting intention. If, for example, one wanted to develop an educational strategy that addressed the belief that reporting a concussion means letting the team down, one might provide athletes with specific information about how keeping playing with a concussion can actually hurt the team's performance. Furthermore, in this population there were significant differences in intention to report different post-impact symptoms. Educational strategies targeting knowledge and attitudes about the importance of reporting these specific symptoms may improve overall reporting outcomes. This type of theory-driven, population-specific information provision builds on the recent assertion by Provvidenza and colleagues [39] that concussion-related knowledge transfer strategies should meet a population's unique knowledge needs.

Effective interventions to address a population's beliefs about the consequences of reporting might also include making changes in the reporting environment. Building on TPB, the Integrated Behavioral Model [26] suggests that environmental constraints can influence behavior, independent of intention. Team-specific environmental constraints might include factors such as whether the team has a certified athletic trainer on the sideline, how approachable the coach and/or athletic trainer is perceived to be [25], and whether anyone (e.g., coach, athletic trainer, teammate) asks athletes how they are feeling after an impact. Interventions to mitigate perceived negative consequences of reporting might include addressing these environmental constraints. For example, if athletes think that if they report a concussion they will permanently lose their spot in the lineup, a comprehensive risk reducing intervention might include encouraging the team coach to communicate a protocol for ensuring that all injured athletes get a fair chance to re-earn their spot in the lineup. Although this type of educational intervention that incorporates individual-level psychosocial theory nested within a multilevel ecological approach is not yet standard for concussion education, successful examples in other areas of injury prevention can be used as models (e.g., [40]).

Limitations of the current analysis include its generalizability to populations of athletes in other sports, at different levels of competition, and of the female gender. Attitude, norm, and self-efficacy measures were developed with particular reference to late adolescent and young adult male hockey players based on pilot qualitative interviews with this population, so their utility for analyses in other populations must be evaluated before future use. Additional limitations include the cross-sectional nature of the analysis and the use of self-report retrospective measures for behavior, symptoms, and diagnosed concussions sustained. Although intention has been shown to be a strong predictor of behavior across a range of domains, use of this measure nonetheless constrains our ability to make causal inferences within the specified model. Future longitudinal research is encouraged to test the prospective usefulness of TPB in predicting concussion-reporting behavior, including the strength of the association between behavioral intention and future behavior. Future research is also encouraged to analyze reporting behavior using multilevel models that include possible environmental constraints, such as coach approachability and access to medical resources for concussion management. In addition, the counterintuitive negative association between knowledge and reporting intention in the augmented TPB-based model warrants further exploration. It is possible that this difference is driven by a confounding third factor. For example, athletes with high athletic identity might know more about concussions than peers with lower athletic identity because they follow the sport more closely, but they might also be less likely than their peers to report a concussion because they have more salient sport goals. It is also possible that grouping diverse knowledge items into one index measure is not methodologically appropriate. The individual knowledge item associations with intention reported in Table 2 suggest the utility of item-level analyses for concussion knowledge.

As concussion education becomes increasingly mandated for adolescent athletes through state legislation and sports-league policies, it is becoming even more important that the materials provided are effective in changing or reinforcing target behaviors. It is critical to consider how psychosocial factors relevant to athletes in their environment constrain their willingness and ability to engage in self-protective reporting behaviors if our goal is to reduce the burden attributable to concussion underreporting. The current findings suggest that TPB may be a relevant model through which concussion-reporting behavior may be understood, although it should not be considered sufficient in isolation. The current findings suggest that it may be useful to create educational strategies that address athlete concerns about the consequences of concussion reporting, that shift perceived reporting norms, and that increase reporting confidence in challenging situations. However, it may be important to nest this type of individually focused education into a larger comprehensive intervention that addresses environmental constraints and influences on reporting behavior. We suggest that these models be tested in other sporting populations, and be used to help inform the design and evaluation of concussion education materials and communication strategies targeted at athletes.

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Appendix

Measures

Attitude/Perceived Consequences of Reporting [13,30]

Directions: Please rate how strongly you agree with each statement.

1. If I report what I suspect might be a concussion, I will hurt my team's performance.
2. If I report what I suspect might be a concussion, I will not be allowed to start playing or practicing when I think I'm ready.
3. If I report what I suspect might be a concussion, I will lose my spot in the lineup.
4. If I report what I suspect might be a concussion, my teammates will think less of me.
5. The sooner I report a concussion, the sooner I'll be back at full strength.
6. If I report what I suspect might be a concussion, I will be held out of upcoming games even if it is *not* a concussion.
7. If I report what I suspect might be a concussion, my teammates will think I made the right decision.
8. If I report what I suspect might be a concussion, I will be better off in the long run.

Subjective Norms [36]

Directions: Please read each of the following scenarios and rate how strongly you agree or disagree with the statements that follow.

Scenario 1: *Athlete M experienced a concussion during the first game of the season. Athlete O experienced a concussion of the same severity during the semifinal playoff game. Both athletes had persisting symptoms*.

1. My teammates would feel that Athlete M should have returned to play during the first game of the season.
2. Most athletes would feel that Athlete M should have returned to playing during the first game of the season.
3. My teammates would feel that Athlete O should have returned to play during the semifinal playoff game.
4. Most athletes would feel that Athlete O should have returned to playing during the semifinal playoff game.

Scenario 2: *Player R experiences a concussion during a game. Coach A decides to keep Player R out of the game. Player R's team loses the game*.

5. My teammates would feel that Coach A made the right decision to keep Player R out of the game.
6. Most athletes would feel that Coach A made the right decision to keep Player R out of the game.

Scenario 3: *Athlete R experiences a concussion. Athlete R's team has an athletic trainer on the staff.*

7. My teammates would feel that the athletic trainer, rather than Athlete R, should make the decision about returning Athlete R to play.
8. Most athletes would feel that the athletic trainer, rather than Athlete R, should make the decision about returning Athlete R to play.

Athlete H experienced a concussion and has a game later in the day. He is still experiencing symptoms of concussion. However, Athlete H knows that if he tells his coach about the symptoms, his coach will keep him out of the game.

9. My teammates would feel that Athlete H should tell his coach about the symptoms.
10. Most athletes would feel that Athlete H should tell his coach about the symptoms.

Scenario 4: *Athlete H experienced a concussion and has a game later in the day. He is still experiencing symptoms of concussion. However, Athlete H knows that if he tells his coach about the symptoms, his coach will keep him out of the game.*

11. My teammates would feel that Athlete H should tell his coach about the symptoms.
12. Most athletes would feel that Athlete H should tell his coach about the symptoms.
13. My teammates would continue playing while also having a headache that resulted from a minor concussion.
14. Most athletes would continue playing while also having a headache that resulted from a minor concussion.

Reporting Self-efficacy

Directions: Please rate how strongly you agree with each statement.

1. I am confident in my ability to recognize when I have symptoms of a concussion.
2. I am confident in my ability to report symptoms of a concussion, even when I really want to keep playing.
3. I am confident in my ability to report symptoms of a concussion, even when I think my teammates want me to play.
4. I am confident in my ability to report symptoms of a concussion, even if I do not think they are all that bad.
5. I am confident in my ability to report specific symptoms, even if I am not sure that it is actually a concussion.

Reporting Intention [16,25]

Directions: Please rate how strongly you agree with the following statement: "I would stop playing and report my symptoms if I sustained an impact that caused me to …"

1. See stars
2. Vomit or feel nauseous
3. Have a hard time remembering things
4. Have problems concentrating on the task at hand
5. Feel sensitive to light or noise
6. Have a headache
7. Experience dizziness or balance problems
8. Feel sleepy or in a fog

Symptoms and Behavior [16,25]

Directions: Please read the following statements. Please circle YES if the following has occurred to you THIS SEASON and circle NO if it has not occurred to you THIS SEASON.

1. Dizziness after an impact
2. Had my bell rung
3. Lost consciousness or blacked out after an impact
4. Saw stars after an impact
5. Vomited or felt nauseous after an impact
6. Forgot what to do in the rink after an impact
7. Had a headache at least once during the week after an impact
8. Had problems studying, concentrating or doing class work after an impact
9. Experienced any of these symptoms after an impact but did not immediately tell a coach or athletic trainer (e.g., kept playing in a practice or game)
10. Continued to experience any of these symptoms the day after a hit but did not tell a coach or athletic trainer

Concussion Knowledge [36]

Directions: These questions contain statements about concussions that may or may not be true. Please rate how strongly you agree with each statement.

1. People who have had a concussion are more likely to have another concussion.
2. There is a possible risk of death if a second concussion occurs before the first one has healed.
3. A concussion cannot cause brain damage unless the person has been knocked out.
4. The brain never fully heals after a concussion.
5. It is easy to tell if a person has a concussion by the way the person looks or acts.
6. Symptoms of a concussion can last for several weeks.
7. Resting your brain by avoiding things such as playing video games, texting, and doing schoolwork is important for concussion recovery.
8. After a concussion occurs, brain imaging (e.g., computer-assisted tomography scan, magnetic resonance imaging, X-ray, etc.) typically shows visible physical damage to the brain (e.g., bruise, blood clot).
9. A concussion may cause an athlete to feel depressed or sad.
10. Once an athlete feels “back to normal,” the recovery process is complete.
11. Even if a player is experiencing the effects of a concussion, performance on the field of play will be the same as it would be had the player not experienced a concussion.
12. Concussions pose a risk to an athlete’s long-term health and well-being.
13. A concussion can only occur if there is a direct hit to the head.

All measures were scored on a 7-point scale, with scale points ranging from “strongly disagree” (1) to “strongly agree” (7).