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ORIGINAL ARTICLE

Sports fans, wagering, and concussion knowledge: implications for injury nondisclosure

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Abstract

Objective: Athletes perceive sports fans as a source of concussion nondisclosure pressure. Sports fans are exposed to injury depictions from the media that could lead them to underestimate its seriousness. This study examined the concussion knowledge of non-sports fans, sports fans, and wagering sports fans, as knowledge is a modifiable factor that can influence injury disclosure.
Setting and participants: A convenience sample of 443 Australian adults completed an online survey.
Design: Cross-sectional.
Main measures: Self-rated and actual concussion knowledge (the Rosenbaum Concussion Knowledge and Attitudes Survey; RoCKAS).
Results: There was no significant difference in the concussion knowledge of self-identified sports ($n = 157$) and non-sports ($n = 286$) fans; but sports fans rated their knowledge as significantly higher than non-sports fans ($p < .05$). Wagering sports fans ($n = 24$) had significantly less concussion knowledge than non-wagering sports fans ($\eta^2 = .03$, small effect).
Discussion: Athletes who feel nondisclosure pressure from sports fans may be influenced by people with incomplete concussion knowledge, particularly wagering sports fans. Sports fans over-estimated their knowledge, and this could contribute to the nondisclosure pressure felt by athletes. Programmes to increase injury disclosure by athletes should take these factors into consideration.

Keywords: Traumatic brain injury; sports; athletes; injury prevention; wagering

Each year, an estimated 56 million people will have a mild traumatic brain injury or concussion (Dewan et al., 2019). Sport is a major cause of concussion (Daneshvar et al., 2011) and injury nondisclosure by athletes is common and problematic. Injury nondisclosure occurs because of low concussion knowledge (Kerr et al., 2014; Stephenson et al., 2021), high competitiveness (Doucette, Du Plessis, Webber, Whalen & Garcia-Barrera, 2021) and *play on* pressure from sources such as team mates and fans (Kroshus, Garnett, Hawrilenko, Baugh & Calzo, 2015; Longworth, McDonald, Cunningham, Khan & Fitzpatrick, 2021; Torres et al., 2013). Despite this, the timely disclosure and identification of concussion is vital to minimise risk and provide optimal care.

It is important to identify if the sources affecting athlete nondisclosure are informed about concussion so that this is considered in injury management strategies. Research has investigated the concussion knowledge of known sources of nondisclosure pressure, such as parents, fans,

coaches, and teammates (Kroshus et al., 2015; Lininger, Wayment, Craig, Huffman & Lane, 2019). This has led to efforts to improve concussion knowledge in these groups. These efforts are based on the understanding that, if the parents of an injured junior athlete (for example) were better informed about concussion, they could assist with symptom recognition and therefore support disclosure (Sarmiento, Donnell, Bell, Tennant & Hoffman, 2019). A relatively understudied source of such pressure is from sports fans, and there has been even less attention on the potential pressure from wagering sports fans.

Sport fans are known to influence athletes' perceptions of concussion and reporting intentions (Anderson, Petit, Wallace, Covassin, & Beidler, Anderson, Petit, Wallace, Covassin & Beidler, 2021; Kroshus et al., 2015); but, they are not always considered in nondisclosure studies (Beidler et al., 2018). Sports fans contribute to the broader public acceptance of the injury risk faced by athletes, and shape the culture of sport (Harrison, 2014). Several studies have investigated if the concussion reporting of players is influenced by their perceptions of the fan's views of this injury (Anderson et al., 2021; Kroshus et al., 2015; O'Connor et al., 2020; Williams et al., 2016). In a study of more than 300 US collegiate athletes, 25% of the sample identified sports fans as one of several sources of *play on* pressure, and those players who experienced such pressure, had lower concussion reporting intentions (Kroshus et al., 2015). In a study of 268 Irish collegiate athletes, 38% of the sample felt pressured by fans not to disclose a concussion (O'Connor et al., 2020). Further, among 741 US collegiate athletes, the perceived pressure of sports fans was a significant predictor of concussion nondisclosure in a univariate – but not multivariable – model (Anderson et al., 2021). The views of sports fans can clearly influence the concussion reporting intentions of athletes, and the views of the fans may be influenced by several factors, including the media coverage of sport (McLellan & McKinlay, 2011) and their wagering on sport (Winters & Derevensky, 2019).

Although the concussion knowledge of sports fans has not been widely studied, some insights might be gained from a relevant survey with 146 participants, almost half of whom identified as fans (46%). In this study, concussion knowledge was described as 'modest' (Gardner et al., 2017, p.68). About one quarter of the sample (26%) reported the *media* as their main concussion information source. However, these results were not stratified by group (e.g., fans versus non-fans), and there was no consideration of wagering by fans.

Past studies have documented significant variation in the media portrayal of concussion, including a downplaying of its seriousness (Ahmed & Hall, 2017; Anderson & Kian, 2012; Kennard et al., 2017; McLellan & McKinlay, 2011). Spectators, commentators, coaches and other teammates may share views on a player and their injury, and the team's ability to continue to play with or without the injured player (Hurley, 2016), including via discussions on social media (MacPherson & Kerr, 2019; Sanderson, 2009). There are differences in the neural activation of sport versus non-sports fans when viewing violent sport incidents, with the former showing less activation in brain regions known for empathy and pain (Daniel et al., 2018). Thus, sports fans who rely on media for information about concussion may be exposed to incorrect or incomplete injury descriptions (Ahmed & Hall, 2017; Kennard et al., 2017; McLellan & McKinlay, 2011). Ill- or under-informed sports fans could increase the pressure on athletes to *play on* when concussed. On the other hand, an informed sports fan, perhaps taking their cues from other evidence-based sources, might recognise the injury's seriousness and adopt a more supportive stance over an athlete reporting their concussion.

A significant and increasing number of people – particularly young adult males – wager on sports (Armstrong & Carroll, 2017; Gainsbury & Russell, 2015; Jenkinson et al., 2019; Moore et al., 2013; Winters & Derevensky, 2019), and are exposed to gambling advertisements (Killick & Griffiths, 2020). The addition of a financial consequence for a sports fan from a match with a concussion could amplify the pressure that the fans apply on athletes. The extent of fan pressure could be relative to the fan's personal financial stakes in the outcome from wagering. Indirect evidence in support of these potential links can be drawn from at least one media report

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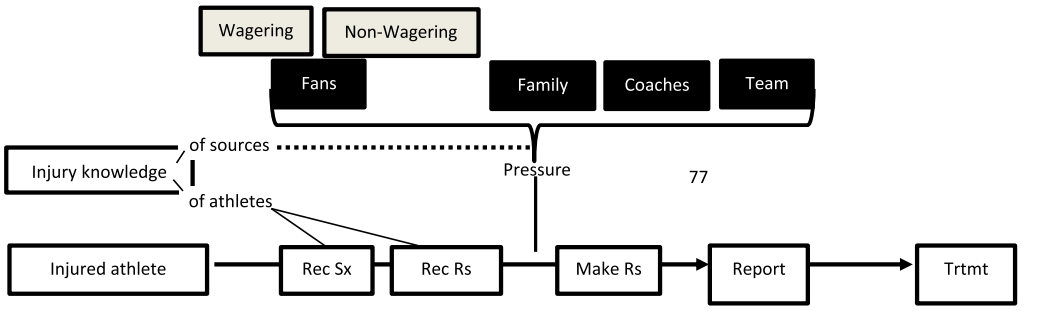

Figure 1. Schematic diagram showing how injury knowledge could impact concussion reporting by athletes. A direct pathway is shown (solid black line), whereby the athlete's knowledge of concussion allows them to recognise (Rec) the symptoms (Sx), and the necessary response (Rs), so that treatment (Trtmt) can occur. There are four sources of nondisclosure pressure shown (back boxes). These sources are drawn from Kroshus et al.(Kroshus et al., 2015) except that the term 'family' instead of 'parents'. In this model, it is proposed that sports fans should be divided into wagering and non-wagering sports fans (grey boxes). This is because athletes may experience different concussion reporting pressures from wagering and non-wagering sports fans. It is further proposed that injury knowledge is a relevant factor in the pressure applied by sources, including both types of fans.

in which a player received an abusive message from a fan linking the management of the player's concussion to the fan's wagering loss (Wang, 2021). To the best of our knowledge, these potential relationships have not been empirically investigated.

The purpose of this study was to investigate the level of concussion knowledge held by self-identified adult sport and non-sports fans in Australia. Sports fans are one of several known sources of pressure on athletes' reporting intentions, as depicted in a proposed model (Fig 1). Unlike the other sources or reporting pressure, sports fans' level of concussion knowledge has not previously been documented. Because concussion has been minimised in the media coverage of sport, it was expected that sports fans might be less knowledgeable about concussion than non-sports fans, after controlling for general education. Given the prevalence of gambling on sports and the potential pressure exerted by fans with financial stakes, a secondary question compared the concussion knowledge of wagering versus non-wagering sports fans.

Method

Prior to commencement, this project was approved by the Queensland University of Technology Human Research Ethics Committee (HREC approval number: 1900000328). A health and safety risk management plan was also approved by the host institution (approval number: 1302).

Sample

Eligible participants had to be $\geq$18 years of age, reside in Australia, and submit a valid response. Since an unsupervised online survey was used for data collection, we followed recommendations for validating responses (Oppenheimer et al., 2009). This process utilised the built-in validity scale (VS) from the Rosenbaum Concussion Knowledge and Attitudes Survey (RoCKAS; Rosenbaum & Arnett, 2010). The VS scale is comprised of three true-false statements, each worth one-point, such as: *weightlifting helps to tone and/or build muscle*. The empirically derived cut-score (VS $<$ 2) reflects the low base rate of incorrect responses on the VS items (Rosenbaum & Arnett, 2010). Participants were recruited via snowball sampling, commencing with the distribution of the study information to staff and students at the host university followed by broader distribution to the general population via social media. The data were collected between November 2019 and May 2020.

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Measures

Sports fans

Sports fans were identified with the following yes/no question: *Do you follow a sporting team or watch sport on a regular basis?* A visual analogue scale (slider) assessed the strength of this identity from 0, '*never watch sport*' to 100, '*fanatic, never miss a game!*'. Wagering sports fans were identified with the yes/no question: *Do you gamble on sport?* The sports that fans watched and wagered on were also queried.

Concussion knowledge

Concussion knowledge was assessed via self-report (*How do you rate your knowledge of concussion: low, medium or high?*) and the RoCKAS (Rosenbaum & Arnett, 2010). The RoCKAS is a 55-item psychometrically tested survey designed to measure knowledge of and attitudes towards concussion across three indices, the Concussion Knowledge Index (CKI), the Concussion Attitudes Index (CAI), and the VS (Chapman et al., 2018). For this study, only the CKI and the VS were used. The RoCKAS was administered with minor changes to the item wording (see Kinmond et al., 2021). These changes followed advice for adaptations of the measure (i.e., retaining the original wording and adding the local term as a qualifier; Sullivan 2021). Item-level responses (e.g., answers to 14 true/false questions; three applied true/false questions; and recognition of eight common concussion symptoms) were used to calculate the total CKI out of a possible 25 points. Higher scores indicate more concussion knowledge.

Procedure

The data for this study were drawn from a larger study (Sullivan, Kinmond & Jaganathan, under review) delivered using Qualtrics (Qualtrics Version May, 2019, professional license). Participants entered the study via an online link and informed consent was gained. The survey comprised questions to determine sports fan status, wagering status, and concussion knowledge as by the RoCKAS CKI. In the larger study, the RoCKAS was administered three times; twice in the initial sitting (T1 and T2) and once seven days after (T3). For this survey only T1 RoCKAS data were used. As a token of appreciation, participants had the opportunity to enter the draw to win a voucher or gain course credit upon study completion.

Data analysis

All data were analysed using the IBM SPSS statistics for Windows, Version 27.0 (IBM Corp, Armonk, New York). The data were screened for missing values. Since this was minimal (see below), imputation was not used. To explore group differences in self-rated knowledge (categorical data), a two-sided Chi-squared test (or Fisher's exact test of independence) was used (depending on the cell sizes). To explore group differences in concussion knowledge (RoCKAS CKI, continuous data), with or without prior education adjustments, a one-way ANOVA or ANCOVA was used, respectively. For ANOVA comparisons, eta squared was used to measure effect size, with values interpreted according to standard guidelines (Lakens, 2013). A non-parametric test of association (Spearman's Rho) was used to test the association between self-rated and actual concussion knowledge (Field, 2018). The item-level analysis of the RoCKAS was performed by calculating the percent correct for each item, with a misconception defined as any item answered correctly by <50% of the sample. A p-value of 0.05 was used to determine statistical significance, unless otherwise stated.

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Table 1. Demographic Characteristics of the Sample

Characteristic	Value
Age, *years M (SD) [Range]*	27.50 (12.12) [18–76]
Sex	
Male, *n (%)*	1012 (23%)
Female, *n (%)*	341 (77%)
Education, *highest level n (%)*	
High school and below	191 (43)
TAFE/Certificate/Diploma	84 (19)
3- or 4-year Bachelor degree	125 (28)
Post-graduate degree	43 (10)
Residence, *n (%)*	
QLD	411 (93)
NSW	16 (4)
VIC	7 (2)
WA	5 (<1)
TAS	2 (1)
SA	5 (1)
ACT	1(<1)
SA	1(<1)
Sports fan, *n (%)*	
Yes	157 (35%)
No	286 (65%)
Engage in sports wagering, *n (%)*	34 (8%)

TAFE = Technical and further education; QLD = Queensland; NSW = New South Wales; VIC = Victoria; WA = Western Australia; TAS = Tasmania; ACT = Australian Capital Territory; SA = South Australia.
$N = 443$.

Results

Sample characteristics

Five hundred and twenty-five participants submitted a survey. Eighty-two submissions were excluded for the following reasons: underage (<18 years old, $n = 29$); not resident of Australia ($n = 31$); or invalid response ($n = 22$). The demographic characteristics of the final sample are shown in Table 1 ($n = 443$). Almost two thirds of the sample (65%) did not self-identify as sports fans, whereas 157 participants did so (see Table 1). Among fans, the average sport fan identity strength was 67 ($SD = 23$; range 13–100), including 15 people who identified as *fanatics*. Sports fans reported watching various sports (see Table 2). Four percent of non-sports fans ($n = 10$) and 15% of sports fans ($n = 24$) wagered on one or more sport.

Self-rated and actual concussion knowledge among sports and non-sports fans

A chi-square test was used to compare the self-rated concussion knowledge of sports versus non-sports fans, irrespective of wagering. A significant difference in the self-rated concussion

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Table 2. Sports Watched and Wagered on by Self-Identified Sports Fans

Sport	Enjoy watching	Wager on
Rugby union or league	84	15
Australian rules football	41	5
Football (soccer)	39	6
Basketball	31	5
Boxing, Martial arts	22	5
Tennis	12	2
Hockey/Ice Hockey	10	0
Cricket	8	2
Netball	7	0
Volleyball	3	0
Baseball	2	1
American football	1	2
Surfing	1	0
Mountain biking	1	0
Gymnastics	1	0
Triathlon	1	0
Swimming	1	0
Figure skating	1	0
Climbing	1	0
Horse racing	0	4
Motor sports	0	1
Total	267	48

$N = 157$. Multiple responses allowed. Respondents nominated the sports that they enjoy watching the most ($n = 157$), and that they wager on ($n = 24$).

knowledge by groups was found, $\chi^2(2) = 8.402$, $p = .015$. This difference was due to the higher percentage of sports (10%) versus non-sports fans (4%) in the high knowledge category ($p < .05$).

A one-way ANOVA was used to compare the actual concussion knowledge of the groups. The dependent variable was the aggregate measure of concussion knowledge, the CKI. There was no significant difference in the concussion knowledge of sports ($M = 19.63$, $SD = 2.63$) and non-sports fans ($M = 19.90$, $SD = 2.57$), $F(1,441) = 1.082$, $p = .299$, $\eta^2 = .002$, small effect. This result was unchanged when prior (general) education was entered as a covariate, $F(1,440) = 1.019$, $p = .313$. In the RoCKAS item analysis, five misconceptions were identified for sport and non-sports fans (Supplemental Digital Content: Tables 3a and 3b). These included the misidentification of a distractor item as a genuine indicator of concussion (i.e., difficulty speaking); false beliefs that having a concussion does not increase the risk for another concussion; incorrect assumptions that neurological deficits after a concussion will be visible on neuroimaging; not being able to identify that an athlete who loses consciousness after a concussion is experiencing a coma and; a concussion only affects memory and the ability to recognise other people.

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Spearman's Rho was used to examine the relation between self-rated and actual concussion knowledge. There was a weak, positive correlation between the variables in each group. This was not statistically significant for sports fans, $\rho = .06$, $p = .314$, nor non-sports fans, $\rho = .07$, $p = .383$.

Wagering and non-wagering sports fans

The analyses were repeated for wagering and non-wagering sports fans. This revealed: a) a non-significant group difference in self-rated concussion knowledge, Fisher's exact test, $p = .764$; b) a significant group difference in actual concussion knowledge, $F(1,155) = 4.983$, $p = .027$, $\eta^2 = .031$ (small-to-medium effect), with wagering sports fans scoring lower ($M = 18.54$, $SD = 2.90$) than non-wagering sports fans ($M = 19.83$, $SD = 2.54$), even when adjusted for prior education ($p = .029$); c) no significant correlation between self-rated and actual concussion knowledge (non-wagering sports fans, $\rho = .07$, $p = .409$; wagering sports fans, $\rho = .02$, $p = .930$); and d) four misconceptions amongst wagering sports fans, plus two borderline misconceptions relating to long-term health outcomes of multiple concussions (percent correct = 50%).

Discussion

This study investigated the concussion knowledge of sports fans, non-sports fans and wagering sports fans. Sports fans are a known source of concussion underreporting pressure on athletes (Anderson et al., 2021; Kroshus et al., 2015; O'Connor et al., 2020); but sports fans could also be poorly informed about concussion. Athletes might be better able to resist such pressures if they understand these links.

The primary focus of this study was to compare the concussion knowledge of sports and non-sports fans. This study did not find sports fans to be less knowledgeable about concussion than non-sports fans. Indeed, both groups were relatively well-informed about concussion, as compared to prior reports (Kinmond et al., 2021); but misconceptions were still identified in the overall sample. This suggests that sports fans do not need a specific concussion education programme, but there is scope to address some of these misconceptions. Tailored concussion education programmes for specific groups have been called for (Provvidenza et al., 2013), and this recommendation could guide future education programmes to address specific issues such as the way in which concussion can affect player function, risks of re-injury, and better identification of symptoms.

It was presumed that sports fans, who rely on sports media coverage as a concussion information source (Gardner et al., 2017), could have less concussion knowledge than non-sports fans. Sports fans may have increased (and inaccurate) exposure to the injury via commentaries and visual media (watching sports; Ahmed & Hall, 2017). This could render sports fans more tolerant of or desensitised to the injury (Daniel et al., 2018), and more likely to underestimate its seriousness, which in turn could lower their concussion knowledge scores. However, this idea was not supported in this study. This could suggest that the media exposure is not a factor in sports fans' concussion knowledge, or perhaps that the recommendations to improve the written media commentary around concussion have proved successful; for example, through the consistent use of injury nomenclature, such as *brain injury* (Ahmed & Hall, 2017).

Despite this, wagering sports fans, who arguably have *higher* media exposure than non-wagering sports fans, were less informed about concussion. If media exposure is a contributing factor to concussion knowledge in this group, then the use of an expanded media strategy may be warranted. For example, in addition to the recommdendations of Ahmed and Hall (2017), the media coverage of concussion could consider the framing of the injury as an isolated or connected episode (Mirer & Mederson, 2017), and; the availability of injury footage, including slow-motion replays of head impacts. As noted previously, sports fans who are exposed to footage of violence in sports may be pre-disposed to underrate the seriousness of sports injuries (Daniel et al., 2018); thus, recommendations for media coverage of this injury could be extended to visual media.

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This study found a significant difference in the self-rated knowledge of sports and non-sports fans. Sports fans rated their concussion knowledge as higher than non-sports fans. However, they were poor judges of their own knowledge since sports fans were not actually more knowledgeable about concussion than non-sports fans. This result could partly explain why fans, as opposed to the general public, are experienced by athletes as a source of concussion nondisclosure pressure. Fans who over-estimate their concussion knowledge may be more confident of their views on or advice to athletes, and athletes might find it harder to resist the comments of a confident fan. It may be possible to develop athlete education programmes that articulate the nondisclosure pressures, including from fans, and consider the ways of responding to over-confidence and pressure from fans. Given that injury disclosure by athletes is unlikely to be improved by education-only programmes (Ferdinand Pennock, McKenzie, McClemont & Mainwaring, 2020), programmes that target the sociocultural factors that contribute to underreporting, including how to resist, limit, or contextualise fan pressure, must now be explored.

This study is the first to examine the concussion knowledge of wagering versus non-wagering sports fans, and to draw a distinction between these groups as potentially responsible for different pressures. Wagering sports fans scored significantly lower than their non-wagering counterparts on the RoCKAS by an average of almost 1.5 (out of a possible 25) points. It could be supposed that this is because wagering sports fans have increased exposure to inaccurate media portrayals of concussion relative to non-wagering sports fans, but as already noted, this requires further investigation. A targeted concussion education programme for wagering sports fans, or changing the media depictions of concussion in different modalities (as proposed), might improve concussion knowledge, which in turn might change their interactions with athletes and reduce the concussion nondisclosure pressure felt by athletes.

This study has several limitations. This study did not directly test if fan knowledge of concussion is linked to the nondisclosure pressure on athletes or their injury reporting. Fan knowledge may not be a significant factor in this pressure; in which case, improving it may not change the pressure on athletes or their reporting. This is an empirical question and further research on the proposed links is warranted. This study investigated wagering sports fans' concussion knowledge on the assumption that they belong to the pressure source that others have labelled as 'fans' (Kroshus et al., 2015). Related, this study only included 24 wagering sports fans, and minimal data was collected on their wagering. Thus, the findings may not be representative of all wagering sports fans, and given that sports betting may be higher in Australia than overseas (Gainsbury & Russell, 2015); the findings may not generalise. Despite this, we suggest that the role of wagering sports fans as a specific source of pressure on athletes deserves attention in future research. Finally, this study was an online survey of Australian residents; however, most of the participants were from one Australian state (Queensland). Because some sports are more popular in some Australian states than others, and some sports are changing their concussion management faster than others (e.g., Pearce et al., 2021), this could have affected some results (e.g., the preference for watching and wagering on particular sports).

A strength of this study was the use of a standardised measure of concussion knowledge with known psychometric properties and a VS (Chapman et al., 2018). The use of an aggregate score to assess concussion knowledge (across multiple items and item types) adds confidence in the findings. Further, to our knowledge this is the first study of self-rated and actual concussion knowledge among sports fans, and the first study to investigate if wagering impacts these relations.

Conclusion

Anderson et al. (2021) and others (Kerr et al., 2014; Lininger et al., 2019; Stephenson et al., 2021) have argued for efforts to improve the concussion reporting culture that go beyond teaching concussion facts. This could include through targeted programmes that help athletes resist the *play on*

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pressure that they feel from sources including fans. This study has shown that sports fans, non-sports fan, and wagering sports fans still hold misconceptions about concussion, and this demonstration may be important to encourage athletes to resist fan pressure. The finding that sports fans and wagering sports fans are poor judges of their concussion knowledge may also help athlete's weigh this input into their injury disclosure decisions.

Supplementary material. For supplementary material for this article, please visit https://doi.org/10.1017/BrImp.2022.2

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Ethical standards. The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008.

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