



LJMU Research Online

Petrie, Freja J., Howarth, Nathan, Bureau, Samantha C., Nowinski, Chris J., Woodward, James S. and Lockett, Isaac

E-concussion? an investigation of the representation of head impact events and concussion within popular sport-based video games

<https://researchonline.ljmu.ac.uk/id/eprint/26813/>

Article

Citation (please note it is advisable to refer to the publisher's version if you intend to cite from this work)

Petrie, Freja J., Howarth, Nathan, Bureau, Samantha C., Nowinski, Chris J., Woodward, James S. ORCID logoORCID: <https://orcid.org/0000-0002-6402-2554> and Lockett, Isaac ORCID logoORCID: <https://orcid.org/0009-0005-6235-4538> E-concussion? an investigation of the representation of head

LJMU has developed **LJMU Research Online** for users to access the research output of the University more effectively. Copyright © and Moral Rights for the papers on this site are retained by the individual authors and/or other copyright owners. Users may download and/or print one copy of any article(s) in LJMU Research Online to facilitate their private study or for non-commercial research. You may not engage in further distribution of the material or use it for any profit-making activities or any commercial gain.

The version presented here may differ from the published version or from the version of the record. Please see the repository URL above for details on accessing the published version and note that access may require a subscription.

For more information please contact researchonline@ljmu.ac.uk

<http://researchonline.ljmu.ac.uk/>

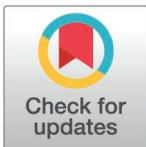
RESEARCH ARTICLE

E-concussion? an investigation of the representation of head impact events and concussion within popular sport-based video games

Freja J. Petrie¹, Nathan Howarth², Samantha C. Bureau³, Chris J. Nowinski³, James S. Woodward^{4,5*}, Isaac Lockett⁶

1 Assistive Technology Innovation Centre (ATiC), University of Wales Trinity St David, Swansea, Wales, **2** University of Exeter Medical School, University of Exeter St Luke's Campus, Exeter, England, **3** Concussion Legacy Foundation Canada, Toronto, Canada, **4** School of Sport and Exercise Sciences, Faculty of Health, Liverpool John Moores University, Liverpool, England, **5** Sport and Exercise Sciences Research Institute, Ulster University, Belfast, Ireland, **6** School of Life Sciences, Pharmacy and Chemistry, Faculty of Health, Science, Social Care and Education, Kingston University, London, England

* j.s.woodward@ljmu.ac.uk



OPEN ACCESS

Citation: Petrie FJ, Howarth N, Bureau SC, Nowinski CJ, Woodward JS, Lockett I (2025) E-concussion? an investigation of the representation of head impact events and concussion within popular sport-based video games. *PLoS One* 20(7): e0328627. <https://doi.org/10.1371/journal.pone.0328627>

Editor: Mohamed Ahmed Said, King Faisal University, SAUDI ARABIA

Received: March 5, 2025

Accepted: July 3, 2025

Published: July 22, 2025

Copyright: © 2025 Petrie et al. This is an open access article distributed under the terms of the [Creative Commons Attribution License](https://creativecommons.org/licenses/by/4.0/), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Data availability statement: All relevant data are within the paper and its [Supporting Information](#) Files. Data is also available upon reasonable request.

Funding: The author(s) received no specific funding for this work.

Abstract

Guidelines have been produced to support the management of concussion, an injury commonly experienced in amateur and elite sports. To improve adherence to concussion guidelines, there is a need to improve their dissemination to the public. Mass media is inherently well positioned to distribute this information; however, concussion must be framed accurately and appropriately to avoid the spread of misinformation. To date the extent to which concussion is depicted in video games is unknown, despite their widespread audience and evidenced use as educational tools. Therefore, this study investigated the representation of concussion (and head impact events) in four sport-based video games. Matches from EA Sports FC 24 (EA Sports, n = 16), EA Sports FC 25 (EA Sports, n = 16), Rugby League Live 4 (Tru Blu, n = 18) and Rugby 22 (Nacon and Bigben Interactive S.A, n = 18) were simulated via a Playstation 5 (Sony Interactive Entertainments). Frequency of direct head impact events and references to concussion were reported. Head impact events were observed in all games (EA Sports FC 24 n = 253, EA Sports FC 25 n = 331, Rugby League Live 4 n = 93, Rugby 22 n = 215). A single concussion was reported in Rugby League Live 4 via a dialogue box. No references to medical intervention or concussion protocols were made in any games analysed. The lack of reference to concussion protocols is a missed opportunity to exemplify appropriate concussion behaviours.

Introduction

Industry forecasts project that the video game market will reach a value of £516.61 billion by 2029, with the number of active users predicted to rise to three billion [1].

Competing interests: I have read the journal's policy and the authors of this manuscript have the following competing interests: CJN is a volunteer member of the Mackey-White Health & Safety Committee of the National Football League Players Association for which he receives travel support; he has received travel support from the NFL, NFL Players Association, World Rugby, WWE, Total Nonstop Action and AEW for lectures or conferences. CJN is an advisor and options-holder with Oxeia Biopharmaceuticals, LLC, and StataDx; and CJN has served as an expert witness in cases related to concussion and CTE and is compensated for speaking appearances and serving on the Players Advocacy Committee for the NFL Concussion Settlement. CJN is employed by the Concussion Legacy Foundation, a 501(c)(3) non-profit which receives charitable donations. This does not alter our adherence to PLOS ONE policies on sharing data and materials.

In parallel with this growth, recent literature has explored the educational potential of video games [2,3] and the relationship between Sport-based Video Games (SBVGs) and real-world sporting events [4–6]. Notably, video games are increasingly recognised as educational tools that enhance engagement with physical activity and promote positive lifestyle choices [6,7] while offering an accessible and enjoyable medium through which individuals can participate in sport [4,5,8]. In light of these developments, SBVGs designed to provide realistic representations of sporting experiences may offer a novel opportunity to model appropriate concussion behaviours, aiding concussion recognition.

Concussion can occur when impulsive forces are transmitted to the brain [9]. This transmission of forces may result from a direct blow to the head (commonly referred to as a Head Impact Event, HIE [10]) or from an indirect blow to the body [9]. The term Head Acceleration Event (HAE) encompasses both types of force transmission to the head, irrespective of whether a concussion diagnosis is confirmed [11]. When players exhibit signs of suspected concussion, sporting governing bodies and national health authorities advise that established concussion protocols are followed to minimise the risk of further injury [12–14]. These guidelines are widely available online, written in accessible language, and are frequently linked to free online courses offering more detailed information. Despite the availability of this information, access to and engagement with concussion education remains inconsistent. Some professional athletes demonstrated “moderate” knowledge of concussion and “good” knowledge of concussion symptoms [15], but this is contrasted by reports that 74% of Jordanian, 24% of Irish, and 9% of American collegiate athletes had never received concussion information [16], while 65% of American and 42% of Japanese high school students had not accessed any concussion education [17,18].

In many cases, the onus is on the individual to actively seek out concussion information. In the absence of structured delivery of education, concussion-related knowledge may instead be acquired through passive exposure to mass media. The importance of passive media in disseminating health information can be examined through the Media System Dependency Model [19], highlighting the public’s increasing reliance on media to understand complex social issues. To apply this model within a sporting context, it could be posited that individuals increasingly depend on media coverage to track developments in sport and interpret emerging concerns about athlete wellbeing. Consequently, the media’s role in shaping public understanding of concussion and appropriate care practices has grown in significance. For example, a survey of parents of student-athletes (n = 1083) found that parent’s primary sources of concussion information were local news (31%), national news (24%), and sport-specific media (24%), with most respondents perceiving these sources as trustworthy [20]. However, the credibility assigned to such media may be misplaced. Media coverage of concussion often lacks clinical precision, employs narrative-driven reporting, or editorial decisions that prioritise drama over accuracy [21–23]. A case study examining media reports of a goalkeeper’s concussion during the 2018 Champions League Final revealed that 38% of articles either downplayed or misrepresented the injury [24]. Similarly, an analysis of online rugby articles found

that the term “*head knock*” was used in 29% of cases to describe concussion [25], illustrating the persistence of colloquial and minimising language.

To date, the portrayal of concussion within SBVGs has not been examined. This gap is noteworthy given the potential of video games, like other forms of media, to influence public perceptions of health and safety issues [26,27]. Drawing on Cultivation Theory and Social Learning Theory [28,29], researchers have argued that media representations can normalise risky behaviours, particularly amongst younger audiences [30–32]. For example, many of the world’s most popular video games omit basic safety precautions, such as helmet or seatbelt use, and depict injury events without realistic consequences or protective responses [33]. Similarly, examination of how mental illness is portrayed in video games highlights a broader pattern of problematic health depictions, including violent stereotypes and exaggerated narratives [34]. Within this context, an analysis of how concussion is represented in SBVGs is essential to evaluate whether these games reinforce safe norms or promote unhealthy behaviours. Broader media effects frameworks, including Cultivation theory [35,36] and the Entertainment-Education model [37], underscore the role of realism in shaping player’s understanding of health issues. This raises broader ethical and social considerations. As technology advancements enable increased realism, there is an argument that injuries could warrant depiction based on their capacity to impact real-life outcomes. Should this be the case, the ethical responsibility of the video game industry to engage with health issues becomes a topic of importance, particularly given heightened awareness around player safety in both professional and youth sport [38].

The educational potential of SBVGs has been explored from multiple perspectives, with research noting their capacity to engage learners and encourage self-reflection. In secondary school settings, an ethnographic investigation highlighted how students became immersed in the gameplay, often identifying with virtual athletes by referring to them in the first person: “*I’m playing*”, “*I am (example team)*” [39]. The authors highlighted that this immersivity underscored the educational potential of SBVGs as students could make choices in an extended reality and reflect on the resulting actions of these choices [39]. In more experimental contexts, the playing of SBVGs has been shown to improve knowledge of sport-specific rules and procedures. Experimental groups who played “*Madden NFL*” (American football) or “*Don Bradman Cricket 14*” had significantly greater knowledge of field layout and player positioning and the rules and terminology, respectively [40,41]. Whilst examined primarily with marketing implications in mind, in-game adverts were shown to improve brand awareness further illustrating the educational potential of these games [42]. This realism contributes positively to user enjoyment, which in turn prolongs engagement with these games, and therefore learning [43].

An understanding of how video games currently represent concussion is a necessary first step to determine whether the potential of video games to disseminate appropriate information is being realised. Therefore, this study aimed to investigate the frequency at which concussions were represented in four popular sports-based video games.

Methods and materials

The gameplay of four SBVGs was analysed in an observational content analysis to explore how concussions were represented. These games were selected for their popularity and their replication of real-life athletes, tournaments, and sporting environments. Football and rugby were chosen due to their global cultural significance. Football remains the most popular sport worldwide [44], while rugby continues to grow in both participation and global reach [45]. The inclusion of games that are licensed through official governing bodies supports their relevance as meaningful case studies in evaluating how concussion is portrayed in SBVG’s. These games were EA Sports FC 25 (EAFC25), the newest release of a football game published by EA Sports (released in September 2024); EA Sports FC 24 (EAFC24, released in September 2023); Rugby League Live 4 (RLL4) a rugby league game published by Tru Blu Entertainment and Home Entertainment Suppliers in 2017; and Rugby 22 (R22), a rugby union game published by Nacon, Bigben Interactive S.A in 2022. Initially, EAFC24, RLL4 and R22 were investigated, however, EAFC25 was released during the drafting of this manuscript and therefore was included. All games were rated “3” on the Pan European Game Information (PEGI) scale, indicating that they are suitable

for all age groups [46]. Both rugby games were the latest release of their respective series at time of analysis and all the sports had a corresponding concussion protocol published by their respective governing bodies [14,47,48].

Adherence to the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines was maintained throughout to promote transparency and maintain thorough reporting of the research process [49].

An equal amount of gameplay was analysed for each game. As the game time for rugby union and league is 80 minutes and football is 90 minutes, a common denominator of 1440 minutes of gameplay of each SBVG was analysed. This equated to 16 matches for EAFC24 and EAFC25 and 18 matches each for R22 and RLL4. During the simulation of all games default gameplay settings were applied and injury sliders (that dictate the propensity at which injuries occur) were not adjusted. Simulations for EAFC24, EAFC25 and RLL4 were conducted with both teams controlled by in-game artificial intelligence. R22 did not have this functionality, therefore one team was controlled by a researcher who was familiar with the game (IL) and the other by in-game artificial intelligence. Each game was screen-recorded using the built-in feature on the PlayStation5 (Sony; Tokyo, Japan) and were subsequently stored on a separate hard drive.

A framework to code visual and audio references to concussion and concussion protocols was developed by collating relevant definitions from pre-existing literature and adapting them for use in video games (Table 1). The resulting framework was then piloted against one match from each game by IL and the frequencies were recorded within a Microsoft Excel spreadsheet (Microsoft Corporation, USA). This pilot testing confirmed the framework's suitability and it was implemented as per its original form during the main analyses. A random number generator was used to determine the order at which games were coded to reduce order effects. All games were coded by IL, who had considerable video analysis experience. To test interrater reliability, one match from each SBVG was selected (using a random number generator) for re-coding by FJP who was similarly experienced and was blinded to the outcomes of the initial coding. FJP's primary research area is sport-related concussion and both FJP and IL have personal experience of the injury. IL has additional familiarity with video games, offering insight into gaming mechanics and user experience, whereas FJP approaches the subject without a gaming background, providing a contrasting perspective. Descriptive statistics were calculated using Python (Anaconda 3). Cohen's Kappa [52] was calculated for EAFC25, EAFC24, R22 and RLL4, which returned values of

Table 1. Coding framework.

Variable	Definition	Notes
Head Impact Event (HIE)	'A clear head impact sustained by a player [...], reviewed on video footage' [10].	Only direct head impacts were coded in this work, therefore the term HIEs, rather than HAEs is used. Headers, defined by Peek et al., [50] as "an integral skill where players deliberately use their heads to re-direct the ball", were not included within the data set due to their intentional nature, and any HIEs associated with glitches were excluded from the data set. Only HIEs associated with a direct impact to the head were coded in this study. McLeod et al's [10] definition of HIE was specific to rugby, but for the purposes of this study the phrase "in the tackle" has been removed to broaden this definition for use in football.
Commentator reference to concussion	'Explicit statements regarding observable concussive injuries by the sports commentators were recorded' [51]	To be manually transcribed verbatim.
Reports of injury	Explicit reports of injury via commentator reference or dialogue boxes.	To be manually transcribed verbatim.

<https://doi.org/10.1371/journal.pone.0328627.t001>

$k=0.81$, $k=0.93$, $k=0.86$ and $k=0.81$ respectively. As per the thresholds described by [52], interrater reliability can be considered ‘almost perfect’ for EAFC24, ‘strong’ for EAFC25 and R22, and ‘moderate’ for RLL4. A deductive content analysis was planned to analyse any references to concussion or HIEs within in-game dialogue [53]. However, due to the absence of qualitative references to concussion in the data collected, this form of analysis was not possible and is therefore not reflected in the results.

Results

A total of 892 head impact events (HIEs) and 27 injuries were observed across the 68 simulated matches, representing 1440 minutes of gameplay per sport (Table 2). HIEs were caused via head-to-head, head-to-body, head-to-ground and ball-to-head mechanisms (i.e., unintentional impacts where the ball strikes the head, as opposed to deliberate headers).

Injuries were reported in all four games, primarily via in-game dialogue boxes and visual sequences, depending on the game. In EAFC25, four injuries were reported via a dialogue box. One of these injuries was named and referred to by a commentator as a “twisted knee”, one was unspecified but was reported to occur after the player was “trodden on”, with the remaining two injuries being unspecified and described via dialogue boxes. In EAFC24, three out of the four injuries observed were reported via dialogue boxes and referred to as “injuries”. Substitutes for these injuries were not made and no further detail regarding the injury type or severity was reported. The fourth injury in EAFC24 was communicated with the video game player via a video sequence where the affected player clutched his leg in pain and the referee and teammates approached during a stoppage in play. This video sequence then ended as the referee signalled for medical attention. Although no medical staff were shown in EAFC24, two separate dialogue boxes indicated that the player had been substituted and had suffered an “injury”. In R22 a single injury was communicated via an in-game dialogue box and referred to as a “minor injury”. The affected player was not substituted. In RLL4, 18 injuries were reported and named via a dialogue box: “ankle sprain, corked thigh (n=2), back muscle strain, bulging disk, neck sprain, broken arm, thigh sprain, adductor tendinopathy, concussion, rotator cuff tear, posterior cruciate ligament injury (n=2), labral tear and hamstring”. Overall, a greater number of HIES were observable in the football-based games, while more injuries were reported in the rugby-based games, with RLL4 being identified as having the highest number of injuries, including one instance of concussion. A single “concussion” was reported in the 78th minute of a RLL4 match via a dialogue box. Whilst the affected player was not observable in gameplay following this event, no notifications referenced the player being removed from play or substituted. No subgroup or sensitivity analyses were applicable within the scope of this work.

Discussion

This study analysed four popular SBVGs and found that HIEs and injuries were observable within their gameplay. However, the representation of concussion within these SBVGs was limited to a single instance within RLL4 that was unaccompanied by any reference to, or enactment of concussion guidelines or protocols. There were no indications to suggest that the concussed player was removed from the field following the announcement of the injury. This is in contrast to the

Table 2. Head Impact Events observed during gameplay.

Video Game	Total number of HIEs observed (n)	Median number of HIEs observed per match (n, (IQR))	Total number of injuries reported during gameplay (n)	Injury diagnosis
EAFC25	331	21 (18-23)	4	3 were not specified, 1 was reported as a twisted knee by the commentators
EAFC24	253	16 (13-19)	4	Not specified
Rugby 22	215	11 (10-13)	1	Not specified
Rugby league live 4	93	5 (3-7)	18	Specified

<https://doi.org/10.1371/journal.pone.0328627.t002>

Rugby Football League Concussion Statement that states that “*Players must be removed from play if diagnosed with concussion OR if they have any signs or symptoms of concussion OR if the medical staff suspect they may have concussion*” [54], highlighting a disconnect between real-life policy and in-game practice within SBVGs. The omission of real-life injury protocols is in contrast with the attention to detail in other areas, such as handshakes prior to kick-off and the accurate rendering of sponsor logos.

A Missed Opportunity...

The absence of concussion and associated protocols within SBVGs, despite the depiction of HIEs by which a concussion could feasibly occur, can be considered a missed opportunity to promote appropriate concussion behaviours. Awareness of concussion protocols is necessary to enact them, however, literature consistently cites broad knowledge gaps within athletic populations, spanning adult, youth, female and male populations across numerous sports and countries [55–60]. Concussion management protocols are variable across sports and playing levels, however, they consistently emphasise the need to remove players with a suspected concussion from play [12,14]. This shared foundation provides a valuable opportunity for SBVGs to raise awareness of concussion management protocols.

Beyond improving player’s awareness of concussion management protocols, there is also a need to improve player’s engagement with these protocols. This need is exemplified across sport: in adolescent rugby and hockey, adherence to concussion management protocols was reported at 30.4% and across Division I and II of the National Collegiate Athletic Association, 16% of athletes reported that they had previously sustained a concussion and not reported it [61,62]. Reasons for this non-adherence to concussion management protocols included not wanting to be ruled out of matches or training, a desire to “*not let the team down*”, ignorance and peer-pressure [62,63]. There is potential that depiction of concussion management protocols in SBVGs could act to address this need. SBVGs often enable players to select digital avatars of real-life, high-profile athletes, individuals who are frequently regarded as role models [64]. These digital avatars could support the uptake of appropriate behaviours through role-model theory, where individuals are influenced by observing and imitating admired figures [65–67]. There is a need for further research to understand if role-modelling effects extend to digital versions of role models; however, this theory posits that players are more likely to adhere to guidelines if they observe role models doing the same. It must be acknowledged that the harnessing of SBVGs to raise awareness of concussion information is not a catch-all solution for the challenges associated with the portrayal of concussion in the media. Nevertheless, SBVGs are positioned to supplement existing efforts to raise awareness, particularly as they are cited as a preferred source of concussion information [17].

These findings of this study should be viewed within the broader context of harnessing the potential of SBVGs to aid the knowledge transfer of concussion management protocols. SBVGs can complement traditional methods of education given their broad audiences and high levels of user engagement. For example, people can watch SBVGs freely as streamers broadcast themselves playing in real-time to an online audience via public platforms such as Twitch (Twitch Interactive, Inc. USA). These streams are publicly accessible, available globally, and attract audiences of millions [68]. The international breadth of SBVG’s further strengthens their capacity to share concussion information. For example, EAFC25 has obtained licences from international federations, competition rights holders and individual teams to portray a broad range of professional leagues, such as the Premier League, LA LIGA, Serie A, Bundesliga, Ligue 1, and Major League Soccer, as well as UEFA [69]. Supported in 19 languages across interface, audio, and subtitles, the game is designed for accessibility and cross-cultural engagement [69]. This level of global reach provides a unique opportunity for concussion messaging to be embedded within a familiar and immersive format. Given the trust placed in such games to accurately reflect the professional game [8], the inclusion of realistic concussion protocols, such as visible player removal following suspected head injuries, could help to normalise safer behaviours. By leveraging the existing infrastructure and appeal of SBVGs, it is possible to deliver targeted health messages to a geographically and linguistically diverse audience, offering a scalable and culturally sensitive tool to support concussion education and behavioural change.

Limitations

As the first study to examine the depiction of concussion in SBVGs, this research is exploratory in nature. While the number of analysed matches aligns with existing rugby-specific video analysis literature [70], the potential for further concussions to be observed within a larger sample of matches or video game titles cannot be ruled out. The authors acknowledge that there is a need to understand the perspectives of video game players and those who develop SBVGs to contextualise these findings and implications for future work. Collaboration with developers, medical professionals, and sporting governing bodies, teams and their sponsors is necessary to utilise the potential of SBVGs and ensure that the educational content is accurate and delivered in an ethical manner.

Conclusion

This study found that one concussion was represented on a single occasion across a total of 68 virtual football, rugby union, and rugby league matches. This depiction was not accompanied with any reference to relevant guidelines or simulation of medical care. Enhancing the representation of concussion and its management within SBVGs could contribute to improved public understanding and encourage more appropriate responses to suspected concussions within real-world settings. Including concussion protocols within SBVGs should be viewed as part of a broader commitment within the video game industry to fulfil the social responsibility of sports teams and licence holders to raise awareness of public health issues and promote community welfare.

Supporting information

S1 File. EConcussion_Manuscript_Supplementary_Data.
(XLSX)

Author contributions

Conceptualization: Freja J Petrie, Isaac Lockett.

Data curation: Freja J Petrie, Isaac Lockett.

Formal analysis: Freja J Petrie, James S. Woodward, Isaac Lockett.

Investigation: Freja J Petrie, James S. Woodward, Isaac Lockett.

Methodology: Freja J Petrie, James S. Woodward, Isaac Lockett.

Project administration: Nathan Howarth.

Resources: Isaac Lockett.

Validation: Freja J Petrie.

Visualization: Freja J Petrie.

Writing – original draft: Freja J Petrie, James S. Woodward, Isaac Lockett.

Writing – review & editing: Freja J Petrie, Nathan Howarth, Samantha C. Bureau, Chris J. Nowinski, James S. Woodward, Isaac Lockett.

References

1. Games - Worldwide | Statista Market Forecast. <https://www.statista.com/outlook/amo/media/games/worldwide?currency=USD>. 2025.
2. Cole C, Parada RH, Mackenzie E. A scoping review of video games and learning in secondary classrooms. *Journal of Research on Technology in Education*. 2023;56(5):544–77. <https://doi.org/10.1080/15391523.2023.2186546>
3. Martinez L, Gimenes M, Lambert E. Entertainment Video Games for Academic Learning: A Systematic Review. *Journal of Educational Computing Research*. 2022;60(5):1083–109. <https://doi.org/10.1177/07356331211053848>

4. García J, Murillo C. Sports video games participation: what can we learn for esports?. *SBM*. 2020;10(2):169–85. <https://doi.org/10.1108/sbm-01-2019-0006>
5. Pizzo AD, Baker BJ, Na S, Lee MA, Kim D, Funk DC. eSport vs. Sport: A Comparison of Spectator Motives. 2018.
6. Soltani P, Figueiredo P, Vilas-Boas JP. Does exergaming drive future physical activity and sport intentions?. *J Health Psychol*. 2021;26(12):2173–85. <https://doi.org/10.1177/1359105320909866> PMID: [32114831](https://pubmed.ncbi.nlm.nih.gov/32114831/)
7. Chan G, Huo Y, Kelly S, Leung J, Tisdale C, Gullo M. The impact of eSports and online video gaming on lifestyle behaviours in youth: A systematic review. *Comput Human Behavior*. 2022;126:106974. <https://doi.org/10.1016/j.chb.2021.106974>
8. Crawford G, Muriel D, Conway S. A feel for the game: Exploring gaming 'experience' through the case of sports-themed video games. *Convergence: The International J Res into New Media Technologies*. 2018;25(5–6):937–52. <https://doi.org/10.1177/1354856518772027>
9. Patricios JS, Schneider KJ, Dvorak J, Ahmed OH, Blauwet C, Cantu RC, et al. Consensus statement on concussion in sport: the 6th International Conference on Concussion in Sport-Amsterdam, October 2022. *Br J Sports Med*. 2023;57(11):695–711. <https://doi.org/10.1136/bjsports-2023-106898> PMID: [37316210](https://pubmed.ncbi.nlm.nih.gov/37316210/)
10. McLeod S, Tucker R, Edwards S, Jones B, Page G, Spiegelhalter M, et al. A case-control study of tackle based head impact event (HIE) risk factors from the first three seasons of the National Rugby League Women's competition. *Front Sports Act Living*. 2023;5:1080356. <https://doi.org/10.3389/fspor.2023.1080356> PMID: [37334015](https://pubmed.ncbi.nlm.nih.gov/37334015/)
11. Tierney G. Concussion biomechanics, head acceleration exposure and brain injury criteria in sport: a review. *Sports Biomech*. 2024;23(11):1888–916. <https://doi.org/10.1080/14763141.2021.2016929> PMID: [34939531](https://pubmed.ncbi.nlm.nih.gov/34939531/)
12. The Football Association. Concussion in Football. 2024 [cited 6 Oct 2024]. Available: <https://www.EnglandFootball.com/participate/learn/Brain-Health/Concussion>
13. UK Government. UK Concussion Guidelines for Non-Elite (Grassroots) Sport Contents. 2023. <http://sramedia.s3.amazonaws.com/media/documents/9ced1e1a-5d3b-4871-9209-bff4b2575b46.pdf>
14. World Rugby. Concussion guidance. <https://www.world.rugby/the-game/player-welfare/medical/concussion/concussion-guidelines>. 2023. Accessed 2023 January 19.
15. Williams JM, Langdon JL, McMillan JL, Buckley TA. English professional football players concussion knowledge and attitude. *J Sport Health Sci*. 2016;5(2):197–204. <https://doi.org/10.1016/j.jshs.2015.01.009> PMID: [30356509](https://pubmed.ncbi.nlm.nih.gov/30356509/)
16. Beidler E, Wallace J, Alghwiri AA, O'Connor S. Collegiate Athletes' Concussion Awareness, Understanding, and -Reporting Behaviors in Different Countries With Varying Concussion Publicity. *J Athl Train*. 2021;56(1):77–84. <https://doi.org/10.4085/1062-6050-0575.19> PMID: [33259602](https://pubmed.ncbi.nlm.nih.gov/33259602/)
17. Beakey M, Keenan B, Tiernan S, Collins K. Is It Time to Give Athletes a Voice in the Dissemination Strategies of Concussion-Related Information? Exploratory Examination of 2444 Adolescent Athletes. *Clin J Sport Med*. 2020;30(6):562–7. <https://doi.org/10.1097/JSM.0000000000000653> PMID: [30119086](https://pubmed.ncbi.nlm.nih.gov/30119086/)
18. Suzuki K, Nagai S, Nishida S, Iwai K, Takemura M. Reasons for the Reporting Behavior of Japanese Collegiate Rugby Union Players Regarding Suspected Concussion Symptoms: A Propensity Analysis. *Int J Environ Res Public Health*. 2023;20(3):2569. <https://doi.org/10.3390/ijerph20032569> PMID: [36767935](https://pubmed.ncbi.nlm.nih.gov/36767935/)
19. Ball-Rokeach S, DeFleur M. A Dependency model of mass-media effects. *Communic Res*. 1976;3:3–21.
20. Kerr ZY, Chandran A, Nedimyer AK, Rothschild AE, Kay MC, Gildner P, et al. Use of sport-related concussion information sources among parents of United States middle school children. *J Sport Health Sci*. 2022;11(6):716–24. <https://doi.org/10.1016/j.jshs.2020.04.008> PMID: [32417468](https://pubmed.ncbi.nlm.nih.gov/32417468/)
21. Nesbitt M. Media interpretation of sports-related concussion in Irish rugby union: reinforcing or reshaping the sport ethic?. *Sport in Society*. 2024;27(6):907–23. <https://doi.org/10.1080/17430437.2024.2334597>
22. Parrott S, Billings AC, Boyd B, Arenberg T, Bureau S. Training Sports Communicators to Report Concussions Accurately and Responsibly: Evidence From the Concussion Legacy Foundation Media Project Workshops. *Journalism & Mass Communication Educator*. 2024;79(3):274–86. <https://doi.org/10.1177/10776958241242646>
23. Venkataraman H, Bellacicco N, Yogan W, Hillen M. Hit Hard! Analysis of Newspaper Concussion Descriptions in National Football League Players from 1980–2022 (P4-11.011). *Neurology*. 2025;104(7_Supplement_1). <https://doi.org/10.1212/wnl.000000000000212593>
24. White AJ, D. Parry K, Humphries C, Phelan S, Batten J, Magrath R. Duty of Karius: Media Framing of Concussion Following the 2018 UEFA Champions League Final. *Communication & Sport*. 2020;10(3):541–63. <https://doi.org/10.1177/2167479520948048>
25. Ahmed OH, Hall EE. "It was only a mild concussion": Exploring the description of sports concussion in online news articles. *Phys Ther Sport*. 2017;23:7–13. <https://doi.org/10.1016/j.pts.2016.07.003> PMID: [27639135](https://pubmed.ncbi.nlm.nih.gov/27639135/)
26. Pentz MA, Hieftje KD, Pendergrass TM, Brito SA, Liu M, Arora T, et al. A videogame intervention for tobacco product use prevention in adolescents. *Addict Behav*. 2019;91:188–92. <https://doi.org/10.1016/j.addbeh.2018.11.016> PMID: [30477819](https://pubmed.ncbi.nlm.nih.gov/30477819/)
27. Zurita-Ortega F, Chacón-Cuberos R, Castro-Sánchez M, Gutiérrez-Vela FL, González-Valero G. Effect of an Intervention Program Based on Active Video Games and Motor Games on Health Indicators in University Students: A Pilot Study. *Int J Environ Res Public Health*. 2018;15(7):1329. <https://doi.org/10.3390/ijerph15071329> PMID: [29941811](https://pubmed.ncbi.nlm.nih.gov/29941811/)
28. Akers RL, Jennings WG. Social Learning Theory. *The Handbook of Criminological Theory*. Wiley. 2015. 230–40. <https://doi.org/10.1002/9781118512449.ch12>

29. Busselle R, Van den Bulck J. Cultivation Theory, Media, Stories, Processes, and Reality. *Media Effects*. Routledge. 2019. p. 69–82. <https://doi.org/10.4324/9780429491146-5>
30. Gramacho W. É perigoso: a glorificação do risco na mídia e as atitudes dos jovens em relação à direção no trânsito. *Intercom, Rev Bras Ciênc Comun*. 2022;45. <https://doi.org/10.1590/1809-58442022114pt>
31. Hull JG, Brunelle TJ, Prescott AT, Sargent JD. A longitudinal study of risk-glorifying video games and behavioral deviance. *J Pers Soc Psychol*. 2014;107(2):300–25. <https://doi.org/10.1037/a0036058> PMID: 25090130
32. Urschler DF, Heinrich H, Hechler S, Fischer P, Kessler T. The higher they go the harder they could fall: The impact of risk-glorifying commercials on risk behavior. *PLoS One*. 2019;14(12):e0225884. <https://doi.org/10.1371/journal.pone.0225884> PMID: 31794575
33. Karazsia B, Muller A. Depictions of Injuries and Safety Gear Usage in the World's Most Popular Video Games. *Journal of Media Psychology*. 2014;26(1):4–9. <https://doi.org/10.1027/1864-1105/a000091>
34. Shapiro JR, Klein SL, Morgan R. Stop “controlling” for sex and gender in global health research. *BMJ Glob Health*. 2021;6(4):e005714. <https://doi.org/10.1136/bmjgh-2021-005714> PMID: 33846145
35. Dutta MJ, Kaur-Gill S, Tan N. Cultivation in Health and Risk Messaging. *Oxford Research Encyclopedia of Communication*. Oxford University Press. 2017. <https://doi.org/10.1093/acrefore/9780190228613.013.289> <http://dx.doi.org/10.1093/acrefore/9780190228613.013.289>
36. Merskin DL. *The SAGE International Encyclopedia of Mass Media and Society*. SAGE Publications, Inc. 2020. <https://doi.org/10.4135/9781483375519>
37. Frank LB, Falzone P. *Entertainment-Education Behind the Scenes*. Springer International Publishing. 2021. <https://doi.org/10.1007/978-3-030-63614-2>
38. Adams WM, Casa DJ, Drezner JA. Sport Safety Policy Changes: Saving Lives and Protecting Athletes. *J Athl Train*. 2016;51(4):358–60. <https://doi.org/10.4085/1062-6050-51.4.14> PMID: 27002249
39. Castillo H del, Herrero D, Monjelat N, Garcia-Varela AB, Checa M, Castillo H del, et al. Identity & performance: Developing innovative educational settings through sport videogames. In: *ICERI2011 Proceedings*, 2011. 236–43. <https://library.iated.org/view/DELCASTILLO2011IDE>
40. Jenny SE, Schary D. Exploring the Effectiveness of Learning American Football through Playing the Video Game “Madden NFL”. *International J Technol Teaching Learning*. 2014;10:72–87.
41. Jenny S, Chung J, Rademaker S, Schary D. Learning a sport through video gaming: a mixed-methods experimental study. *J Can Game Stud Assoc*. 2017;10.
42. Cianfrone BA, Trail GT, Zhang JJ, Lutz RJ. Effectiveness of In-Game Advertisements in Sport Video Games: An Experimental Inquiry on Current Gamers. *International J Sport Communication*. 2008;1(2):195–218. <https://doi.org/10.1123/ijsc.1.2.195>
43. Clavio G, Geurin AN. Exploring the antecedents and consequences of personalizing sport video game experiences. *Sport Marketing Quarterly*. 2010;19:217–25.
44. Li Y, Mateos G. Networks of international football: communities, evolution and globalization of the game. *Appl Netw Sci*. 2022;7(1). <https://doi.org/10.1007/s41109-022-00498-4>
45. World Rugby. Global rugby participation increasing ahead of Rugby World Cup 2023. <https://www.rugbyworldcup.com/2023/news/836825/global-rugby-participation-increasing-ahead-of-rugby-world-cup-2023>. 2023. Accessed 2023 November 10.
46. Pan European Game Information. What do the labels mean?. <https://pegi.info/what-do-the-labels-mean>. 2025.
47. Rugby Football League. Concussion. <https://www.rugby-league.com/governance/medical/concussion>. 2023.
48. The Football Association. *The FA Concussion Guidelines*. 2023.
49. Cuschieri S. The STROBE guidelines. *Saudi J Anaesth*. 2019;13(Suppl 1):S31–4. https://doi.org/10.4103/sja.SJA_543_18 PMID: 30930717
50. Peek K, Meyer T, Beaudouin F, McKay M. Heading incidence in boys' football over three seasons. *Sci Med Footb*. 2021;5(3):175–80. <https://doi.org/10.1080/24733938.2020.1849783> PMID: 35077286
51. Kennard M, Mclellan T, Mckinlay A. Sports Media Representations of Concussions in the National Rugby League. *Australian Psychologist*. 2018;53(1):97–102. <https://doi.org/10.1111/ap.12272>
52. McHugh ML. Interrater reliability: the kappa statistic. *Biochem Med (Zagreb)*. 2012;22(3):276–82. <https://doi.org/10.11613/bm.2012.031> PMID: 23092060
53. Elo S, Kyngäs H. The qualitative content analysis process. *J Adv Nurs*. 2008;62(1):107–15. <https://doi.org/10.1111/j.1365-2648.2007.04569.x> PMID: 18352969
54. Rugby L. Concussion statement head injuries & concussion in rugby league - media position statement. <https://www.rugby-league.com/governance/medical/concussion/concussion-statement>. 2023.
55. Black AM, Yeates KO, Babul S, Nettel-Aguirre A, Emery CA. Association between concussion education and concussion knowledge, beliefs and behaviours among youth ice hockey parents and coaches: a cross-sectional study. *BMJ Open*. 2020;10(8):e038166. <https://doi.org/10.1136/bmjopen-2020-038166> PMID: 32830117
56. De Araújo AVL, Areza-Fegyveres R, Guariglia CC, Ianof JN, Baratho RM, Demario JLC, et al. Level of knowledge and misconceptions about brain concussion in Brazilian adults. *Arq Neuropsiquiatr*. 2021;79(6):469–77. <https://doi.org/10.1590/0004-282X-ANP-2019-0436> PMID: 34320052

57. Heck SJ, Acord-Vira A, Davis DR. Sex differences in college students' knowledge of concussion and concussion education sources. *Concussion*. 2023;8(3):CNC108. <https://doi.org/10.2217/cnc-2023-0001> PMID: [37691852](https://pubmed.ncbi.nlm.nih.gov/37691852/)
58. Malcolm D, Hardwicke J, Kenyon JA. Concussion knowledge, attitudes and reporting intention amongst UK university student-athletes: Implications for institutions, coaches and future research. *International Journal of Sports Science & Coaching*. 2023;19(1):88–98. <https://doi.org/10.1177/17479541231190154>
59. Oliver B, Ashton J, Welsby G, Simpson A. A comparison of the knowledge and attitudes of concussion within higher and lower leagues of the community rugby union game. *Phys Ther Sport*. 2022;58:151–9. <https://doi.org/10.1016/j.ptsp.2022.10.009> PMID: [36332355](https://pubmed.ncbi.nlm.nih.gov/36332355/)
60. van Vuuren H, Welman K, Kraak W. Concussion knowledge and attitudes amongst community club rugby stakeholders. *International Journal of Sports Science & Coaching*. 2020;15(3):297–305. <https://doi.org/10.1177/1747954120913175>
61. Anderson M, Petit KM, Wallace J, Covassin T, Beidler E. Factors Associated With Concussion Nondisclosure in Collegiate Student-Athletes. *J Athl Train*. 2021;56(2):157–63. <https://doi.org/10.4085/1062-6050-0102-20> PMID: [33596598](https://pubmed.ncbi.nlm.nih.gov/33596598/)
62. John Taft S, Ennion L. Prevalence of concussion and adherence to return-to-play guidelines amongst male secondary school rugby and hockey players. *S Afr J Physiother*. 2021;77(1):1477. <https://doi.org/10.4102/sajp.v77i1.1477> PMID: [33604476](https://pubmed.ncbi.nlm.nih.gov/33604476/)
63. Tadmor D, Till K, Phillips G, Brown J, Fairbank L, Hendricks S, et al. I won't let you down; why 20% of Men's and Women's Super League players underreported suspected concussions. *J Sci Med Sport*. 2023;26(12):688–93. <https://doi.org/10.1016/j.jsams.2023.09.015> PMID: [37813720](https://pubmed.ncbi.nlm.nih.gov/37813720/)
64. Midgley C, DeBues-Stafford G, Lockwood P, Thai S. She Needs to See it to be it: The Importance of Same-Gender Athletic Role Models. *Sex Roles*. 2021;85(3–4):142–60. <https://doi.org/10.1007/s11199-020-01209-y>
65. Piccolo G. The effects of professional athletes as role models on high school students. 2020. https://digitalcommons.brockport.edu/pes_synthesis/111
66. Ronkainen NJ, Kavoura A, Ryba TV. A meta-study of athletic identity research in sport psychology: Current status and future directions. *International Review of Sport and Exercise Psychol*. 2015;9(1):45–64. <https://doi.org/10.1080/1750984x.2015.1096414>
67. Wicker P, Frick B. The inspirational effect of sporting achievements and potential role models in football: a gender-specific analysis. *Managing Sport and Leisure*. 2016;21(5):265–82. <https://doi.org/10.1080/23750472.2016.1265461>
68. Twitch Tracker. Twitch Channels, Games and Global Statistics. <https://twitchtracker.com/>. 2025.
69. Electronic Arts. EA SPORTS FC 25 | Clubs Deep Dive. <https://www.ea.com/en/games/ea-sports-fc/fc-25/news/pitch-notes-fc-25-clubs-deep-dive>. 2025.
70. den Hollander S, Jones B, Lambert M, Hendricks S. The what and how of video analysis research in rugby union: a critical review. *Sports Med Open*. 2018;4(1):27. <https://doi.org/10.1186/s40798-018-0142-3> PMID: [29916055](https://pubmed.ncbi.nlm.nih.gov/29916055/)