

Athlete Enjoyment of Prior Education Moderates change in Concussion-Reporting Intention after Interactive Education

INQUIRY: The Journal of Health Care
Organization, Provision, and Financing
Volume 58: 1–8
© The Author(s) 2021
Article reuse guidelines:
sagepub.com/journals-permissions
DOI: 10.1177/00469580211022641
journals.sagepub.com/home/inq



Daniel H. Daneshvar, MD, PhD^{1,2,3,4}, Christine M. Baugh, PhD, MPH^{5,6},
Maya Yutsis, PhD⁷, Roy D. Pea, DPhil⁸, Shelley Goldman, EdD⁸,
Gerald A. Grant, MD⁷, Robert C. Cantu, MD^{4,9},
Lee M. Sanders, MD, MPH⁷, Christine L. Chen, BS,¹⁰, Roberto D. Lama⁸,
Ross D. Zafonte, DO^{1,2,3,11}, and Piya Sorcar, PhD⁷

Abstract

Undiagnosed concussions increase risk of additional injuries and can prolong recovery. Because of the difficulties recognizing concussive symptoms, concussion education must specifically target improving athlete concussion reporting. Many concussion education programs are designed without significant input from athletes, resulting in a less enjoyable athlete experience, with potential implications on program efficacy. Athlete enjoyment of previous concussion education programs moderates the improvement in concussion-reporting intention after experiencing the research version of CrashCourse (CC) concussion education. Prospective cohort study. Level of evidence: Level IV. Quantitative assessment utilizing ANOVA with moderation analysis of 173 male high school football players, aged 13 to 17, who completed baseline assessments of concussion knowledge, concussion reporting, and attitudes about prior educational interventions. Athletes were subsequently shown CC, before a follow-up assessment was administered assessing the same domains. At baseline, only 58.5% of athletes reported that they enjoyed their previous concussion education. After CC, athletes were significantly more likely to endorse that they would report a suspected concussion (from 69.3% of athletes to 85.6%; $P < .01$). Enjoyment of previous concussion education moderated concussion-reporting intention after CC ($P = .02$), with CC having a greater effect on concussion-reporting intention in athletes with low enjoyment of previous concussion education ($b = 0.21$, $P = .02$), than on individuals with high enjoyment of previous concussion education ($P = .99$). Enjoyment of CC did not have a moderating effect on concussion-reporting intention. Athletes who previously did not enjoy concussion education exhibited greater gains in concussion-reporting intention than athletes who enjoyed previous education. Given the potential risks associated with undiagnosed concussions, concussion education has sought to improve concussion reporting. Because most athletes participate in concussion education programs due to league or state mandates, improving concussion-reporting intention in these low-enjoyment athletes is of particular relevance to improving concussion-reporting intention broadly.

Keywords

concussion, traumatic brain injury, education, enjoyment, knowledge

What do we already know about this topic?

Millions of concussions remain undiagnosed, representing a significant public health issue that can be addressed by targeted education.

How does your research contribute to the field?

Improving understanding of the factors relevant to concussion reporting can help inform and improve concussion educational programs.

What are your research's implications toward theory, practice, or policy?

The present study reports the first examination of the role that educational enjoyment plays on concussion reporting intention, which can be used to develop and assess educational programs.



Introduction

Although there are an estimated 1.1 to 1.9 million concussions annually in children 18 years or younger, the majority of concussions are thought to remain undiagnosed.¹⁻⁵ These undiagnosed concussions represent a significant public health issue, as there is a substantial risk of subsequent and/or prolonged injury associated with continued play after a concussion.⁶⁻⁸ The majority of concussions are limited to acute symptoms that resolve in days or weeks; however, serious acute and chronic neurological consequences are possible, especially when repeated untreated concussions occur because an athlete continues to engage in high impact activities.⁹⁻¹¹

Unfortunately, despite these risks, athletes continue to underreport and play through concussions.^{10,12} Concussion education has sought to target concussion reporting to address these issues.¹³ Improving athlete reporting of concussions is particularly important because the signs of concussions are often difficult to observe, particularly during an often chaotic game environment.² To change concussion reporting outcomes requires an environment of behavioral expectation that rewards early and appropriate reporting. It has also been suggested that education administered at a single time-point may be insufficient to generate long-standing behavior change; encouraging perennial conversations about concussion may result in more meaningful and long-lasting improvements in concussion reporting.¹⁴

Several studies have examined the relationship between concussion education and concussion-reporting intention, utilizing theories of behavior change.^{4,15,16} Specifically, these studies have sought to apply a theoretical framework, gleaned from other health disciplines, to identify the factors most proximally related to behavior change. Although these constructs provide useful targets to maximize changes in health behaviors, a learner's degree of positive engagement with an educational program likely exerts direct influence on these constructs. In other contexts, studies have sought to identify the relationship between enjoyment and behavior change.¹⁷⁻²⁰

To date, factors related to engagement in the educational activity, including enjoyment, have not been evaluated as a factor influencing behavior change in the context of concussion education. In the context of concussion, the role of educational enjoyment is likely more significant, as most learners experience education due to mandate, either as a result of league rules or state laws.^{21,22}

In November 2018, a free video-based concussion education program called CrashCourse (CC) was released by the 501(c)3 nonprofit TeachAids. This program has been adopted by the majority of youth football organizations (eg, USA Football, American Youth Football and Pop Warner), various USA Olympic Committee Partnerships (eg, USA Speedskating, USA Field Hockey, USA Wrestling), several medical organizations (eg, Brain Injury Association of America, Lucile Packard Children's Hospital Stanford) and high school partnerships (eg, state high school athletic associations of North Carolina and Arkansas).²³ Recently, a randomized clinical trial evaluated 118 athletes who received either CC or 1 of the 2 most commonly used concussion education programs, video and written materials provided by the Centers for Disease Control (CDC). This study found that the 40 athletes randomized to CC reported greater intent to report concussion, more knowledge, and improved concussion-reporting attitudes, when compared to CDC video and written materials.²⁴ However, the reason for this efficacy is unclear.

The present study sought to further evaluate the factors related to concussion-reporting intention, specifically focusing on enjoyment of the education module. Specifically, the study examined how athlete enjoyment of previous education programs, and enjoyment of the CC curriculum, influenced changes in concussion-reporting intention. Enjoyment was defined based on whether or not the athlete reported they "liked" each of the respective education programs. This study also assessed athlete's enjoyment of the educational curriculum, by looking at their perceptions of the value of the education, as well as their stated interest in sharing this education with others. To address these questions, the present

¹Harvard Medical School, Boston, MA, USA

²Massachusetts General Hospital, Boston, MA, USA

³Spaulding Rehabilitation Hospital, Boston, MA, USA

⁴Boston University School of Medicine, Boston, MA, USA

⁵University of Colorado Denver Anschutz Medical Campus, Aurora, CO, USA

⁶University of Colorado School of Medicine, Aurora, CO, USA

⁷Stanford School of Medicine, Palo Alto, CA, USA

⁸Stanford University, Stanford, CA, USA

⁹Emerson Hospital, Concord, MA, USA

¹⁰University of Texas Southwestern Medical Center, Dallas, TX, USA

¹¹Brigham and Women's Hospital, Boston, MA, USA

Received 12 February 2021; revised 28 April 2021; revised manuscript accepted 13 May 2021

Corresponding Author:

Daniel H. Daneshvar, Harvard Medical School, 300 First Avenue, Boston, MA 02129, USA.

Email: ddaneshvar@mgh.harvard.edu

study enrolled a larger group of participants than the previous CC study, with single cohort design.

Methods

Participants and Design

Participants were 181 football players from 5 California high schools, recruited through each school's football coach. Educational sessions took place either before or after a practice in a group setting. All participants completed a baseline study assessment, then CC education, followed immediately by a follow-up assessment, between May and June 2018. Assessments were conducted on personal devices and education was shown on a large screen, unlike in prior work where the educational interventions were also administered on personal devices.²⁴ Participants were included in the study if they were present on the study date and provided assent for the study. The study was discussed with the Stanford University IRB Manager and was determined to not require IRB review. Of 181 athletes enrolled in the study, 8 did not complete the follow-up study assessment, and were thus not included in the present analysis. Study funding was provided by Taube Stanford Concussion Collaborative with Lucile Packard Children's Hospital Stanford. Funding agency was not involved with data acquisition, data analysis, or reporting.

Educational Intervention

CC was informed by user-centered formative design research studies and created via an iterative process incorporating feedback from various stakeholders, including clinicians, coaches, and athletes. The research version of the curriculum, which preceded the launch version, was utilized for the present study. The curriculum consists of a 12-minute video-based educational program which incorporates first and third-person experiential perspectives. The program specifically aims to teach concussion signs and symptoms, correct myths and misconceptions, inform athletes about the seriousness of reporting, and convey the value of clinical management to maximize improvement following a concussion. CC integrates these topics to maximize engagement and enthusiasm for the curriculum by placing learners in a simulation of a real-life, high-stakes sports scenario with guidance by near-peer Division I collegiate football athletes.²³

Outcome Measures

All participants completed a brief demographic survey consisting of age, sex, grade, race/ethnicity, previous concussion history in self and family/friends, and duration of football career. Participants were then asked a series of questions to assess key reporting behaviors, both before and after

receiving education: specifically whether they "would tell anyone if [they] thought [they] had a concussion" (on a 3-point Likert scale of definitely/maybe/definitely not), and whether they "would continue playing if [they] thought [they] had a concussion" (on a binary yes/no scale) specifically at 5 key timepoints during the season (ie, beginning of season, practice, middle of season, championship game, and end of season). At baseline, they were also asked whether they received previous concussion education (yes/no) and, if so, the format of the previous education (ie, PDF, poster, video, PowerPoint, lecture, other), as well as an open-ended question to assess whether they "liked the concussion education." At follow-up, they were asked an open-ended question to assess whether they "liked the overall experience of watching the video." Enjoyment was ascertained via review of these open ended questions by 2 researchers, who independently categorized responses on a 3-point Likert scale ("did not like," "neutral," and "liked") and any discrepancies were resolved via discussion. They were also asked whether they were "confident in [their] knowledge about concussions," on a 5-point Likert scale. Because attitudes regarding the CC curricula were of particular interest, athletes were also asked at follow-up whether they "feel other high school athletes would learn from this program," whether they "learn[ed] more about concussion safety through this video than previous concussion education," whether they would "forward this video to others [they] care about" (all on binary yes/no scales), and, if so, "whom would [they] want to share it with" (checkboxes including a "teammate," "friend," "parent," "sibling," "teacher," and "someone else").

Statistical Design

For the primary outcome, simple moderation analysis was performed to assess whether enjoyment of concussion education, both prior to receiving CC and after receiving CC, had a moderating effect on concussion-reporting intention. Specifically, if R represents concussion-reporting intention, b_0 represents the intercept, b_1 represents the regression weight for R , E represents enthusiasm for concussion education, and e represents error,

$$R_{p,t} = b_{0,t} + b_{1,t}E_p + e_{p,t}$$

represents a model of concussion-reporting intention moderated by enthusiasm, for a given participant p and timepoint t . The difference in concussion-reporting intention between follow-up and baseline, can therefore be shown as:

$$R_{p,2} - R_{p,1} = b_{0,2} - b_{0,1} + (b_{1,2} - b_{1,1})E_p + e_{p,2} + e_{p,1}$$

$$R_{p,D} = b_0 + b_{1,D}E_p + e_p$$

where D represents the difference between follow-up and baseline. For instances with no moderating effect of enthusiasm (E), the follow-up intercept ($b_{1,2}$) would equal the

Table 1. Participant Demographic Information.

Age	15.6 (SD = 1.1)
Grade	
Freshman	29 (16.8%)
Sophomore	38 (22.0%)
Junior	65 (37.6%)
Senior	41 (23.7%)
Duration of football	3.5 (SD = 3.5)
Race/ethnicity	
Hispanic	60 (34.7%)
African American/Black	12 (6.9%)
Asian/Pacific Islander	32 (18.5%)
Native American	2 (1.2%)
White	55 (31.8%)
Other	12 (6.9%)

baseline intercept ($b_{1,1}$), resulting in a difference of intercepts ($b_{1,D}$) equal to zero. Conversely, for intercept (b) 95% confidence intervals that do not include zero, there must be a moderating effect of enthusiasm on concussion-reporting intention. These tests were conducted using the MEMORE macro for SPSS.²⁵ Because of the study's non-parametric repeated-measures design, McNemar test was used to assess changes from baseline to follow-up for all binary variables. For the same reason, Sign test was used to assess changes from baseline to follow-up for all ordinal variables. Bonferroni corrections were applied to all secondary analyses to account for multiple comparisons. All analyses were conducted with IBM SPSS Statistics Version 20.0 or R Version 3.6.

Results

Sample characteristics are shown in Table 1. A total of 173 male high school football players, aged 13 to 17 (mean = 15.6, SD = 1.1), participated in the present study. Of these 61 participants (33.9%) reported Hispanic ethnicity. The 12 participants (6.7%) identified as African American/Black, 32 participants (17.8%) identified as Asian/Pacific Islander, 2 participants (1.1%) identified as Native American, 61 participants (33.9%) identified as White, and 12 participants (6.7%) identified as Other. Participants had played football for 0 to 12 years (mean = 3.5, SD = 3.5). About 46 participants (25.6%) reported that they had experienced a previous concussion, while 30 participants (16.7%) were unsure. A total of 146 participants (81.1%) reported that they had a friend or relative who experienced a previous concussion. About 115 participants (63.9%) reported that they had been given concussion education in the past. For athletes who had experienced concussion education previously, the format of the previous education included a PDF for 5 athletes, poster for 10 athletes, video for 69 athletes, PowerPoint for 8 athletes, lecture for 72 athletes, and other for 6 athletes.

At baseline, 58.5% of athletes reported that they enjoyed their previous concussion education. After CC, 87.9% of athletes reported that they enjoyed CC ($P < .01$). There were no significant differences in enjoyment, of previous education or CC, and demographic variables including age, race, duration of football exposure, or previous concussion history (all $P > .05$). There were also no significant differences in enjoyment of previous education and the format of the previous education (PDF $P = .84$; poster $P = .84$; video $P = .86$; PowerPoint 0.68; lecture $P = .37$; other $P = .25$). The number of athletes who responded that they would report a suspected concussion increased from 69.3% to 85.6% after CC ($P < .01$). Enjoyment of previous concussion education moderated concussion-reporting intention ($P = .02$), with CC having a significant effect on concussion reporting in athletes with low initial enjoyment of previous concussion education ($b = 0.21$, $P = .02$), but not on individuals with high initial enjoyment of concussion education ($P = .99$; Figures 1A and 2A). Further examination found that enjoyment of CC was not moderator of concussion-reporting intention ($P = .38$, Figures 1B and 2B).

The number of athletes who reported that they would play through a suspected concussion at the beginning of the season decreased following CC from 38.9% to 18.1% ($P < .01$), in practice decreased from 28.6% to 13.6% ($P < .01$), in the middle of the season decreased from 41.1% to 20.9% ($P < .01$), during a championship game decreased from 74.9% to 39.8% ($P < .01$), and at the end of the season decreased from 50.8% to 33.9% ($P < .01$).

Athletes' confidence in their knowledge about concussion on a 5-point Likert scale improved after CC from an average of 3.2 (SD = 0.96) to an average of 4.0 (SD = 0.66) after CC ($P < .01$). At follow-up, 97.2% of athletes responded that other high school athletes would learn from CC. The vast majority of athletes (90.1%) reported that they had learned more from CC compared to previous concussion education programs.

When asked whether they would share the CC curriculum with someone they care about, 74.3% indicated that they would. When asked about specific sharing modalities, 22.9% reported that they would share via email, 7.1% via Facebook, 44.3% via Snapchat, 5.7% via Twitter, 41.4% via text message, and 4.3% via another modality. When asked with whom they would share the CC curriculum, 72.7% said they would share CC with a teammate, 66.7% said a friend, 33.3% said a parent, 37.9% said a sibling, 12.1% said a teacher, and 12.1% said someone else.

Discussion

Following CC concussion education, athletes in this study had both improved concussion-reporting intention and decreased intent to play through a suspected concussion. Because of the difficulty diagnosing concussion, compounded by the potential significant negative sequelae of

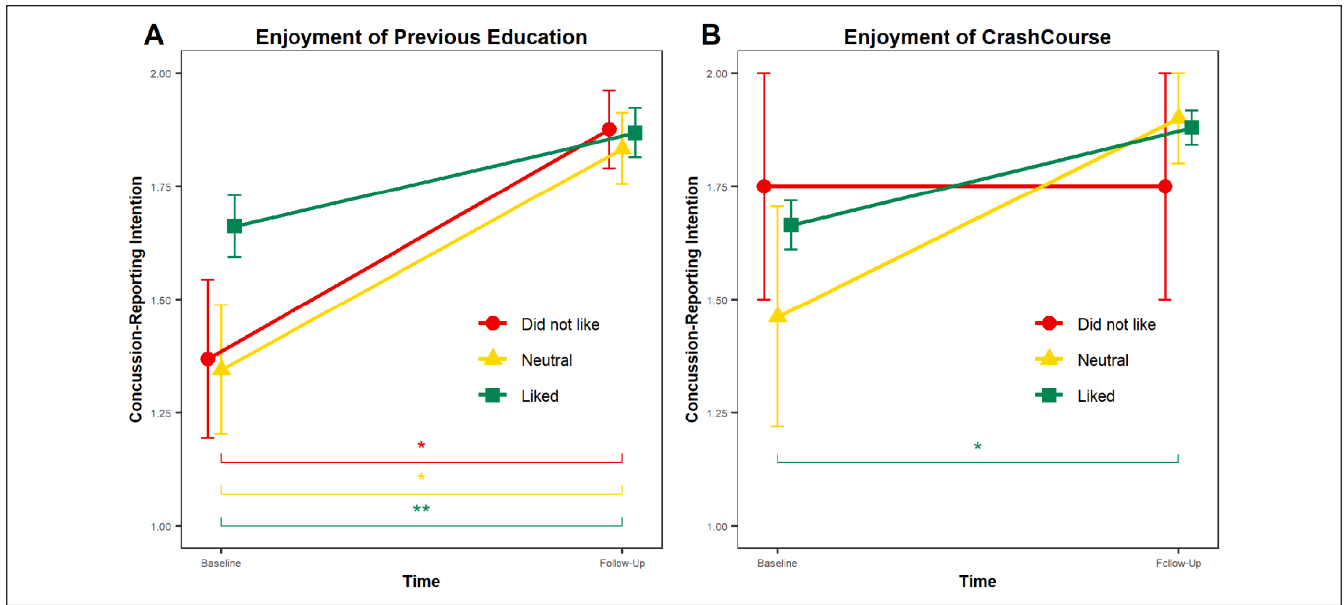


Figure 1. The relationship between enjoyment of concussion education and concussion-reporting intention following CrashCourse: (A) enjoyment of previous education and (B) enjoyment of CrashCourse.

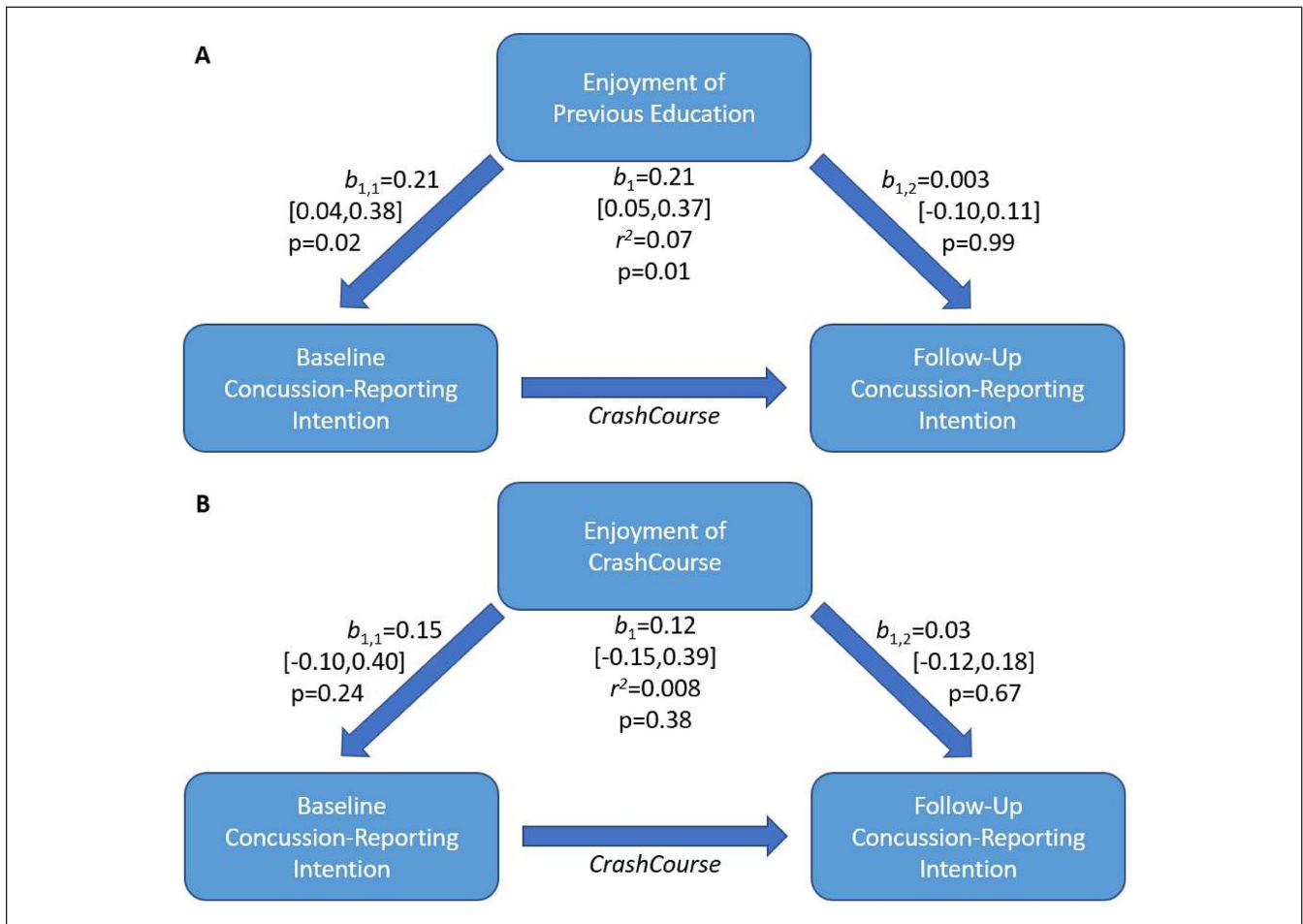


Figure 2. Modeling enjoyment as a moderator of concussion-reporting intention following CrashCourse. Enjoyment of previous education (Panel A) is a significant moderator of the observed change between baseline and follow-up concussion-reporting intention, whereas enjoyment of CrashCourse (Panel B) was not a moderator.

undiagnosed concussion, any increase in concussion-reporting intention would have significant public health benefits. Of note, however, the differences were not only statistically significant but are also clinically relevant given the magnitude of change; the number of athletes who indicated that they would not report a concussion decreased by over half (from 30.7% to 14.4%). CC also significantly improved athletes' confidence in their knowledge about concussion, which is important given that an athlete's knowledge plays a significant role in their likelihood of reporting concussion.²⁶

The data further substantiate the relationship between enjoyment and behavioral outcomes. Specifically, the extent to which athletes enjoyed their previous concussion education had a direct moderating effect on their concussion-reporting intention. Although there were significant improvements in concussion-reporting intention after CC across all athletes, the athletes who did not enjoy their previous concussion education programs had a significantly greater improvement in their concussion-reporting intention. The athletes who did not like their prior concussion education, or who were neutral about it, were less likely to indicate that they would report a concussion before CC, but this difference did not persist after CC. Stated anew, athletes who disliked previous concussion education started with lower concussion-reporting intention than their concussion-education liking peers, but achieved parity with their peers after CC. This effect was not simply driven by an athlete's attitudes about CC; whether an athlete enjoyed CC had *no* moderating effect on his concussion-reporting intention. Taken as a whole, these findings show that CC results in *greater* improvements in an athlete's intent to report a suspected concussion in athletes who disliked previous concussion education, regardless of feelings about CC. It is therefore, perhaps, unsurprising that 90.1% of athletes felt that they had learned more from CC as compared to previous concussion educational programs.

These findings are important as most athletes experience concussion education due to mandate from an athletic or legislative governing body. As a result, many athletes may approach the concussion learning environment with a predisposition toward negative beliefs; an obligation is likely viewed as more intrusive than an activity an athlete chooses. The fact that CC preferentially improves concussion-reporting intention in the subset of athletes with negative attitudes about concussion education, regardless of their enjoyment of CC, is therefore important as this trend may reflect many athletes in the general population.

It is remarkable that nearly all athletes felt that their peers would learn from CC, and a significant majority indicated that they would share the CC curriculum with someone they care about. This interest in sharing concussion curricula is of critical importance, because a single time-point education is less likely to result in sustained behavioral change without altering an athlete's perceived norms. Athletes are more likely to report a concussion if they feel their teammates

would report a concussion.^{4,15} CC targets this construct directly with the use of near-peer educators during the module, but when athletes share the CC curriculum afterwards, this promotes *de novo* conversations and more directly promotes the belief that teammates would report suspected concussions as well. It is, therefore, plausible, that the true effect of these conversations on changing concussion-reporting intention was not captured in the present study, which assessed athletes immediately after the education, and did not allow for the measurement of these organically emergent conversations. The present study did not collect personally identifiable information and therefore could not track athlete responses over time; however, identifying longitudinal effects would be a valuable future research question.

There are many reasons why CC may have these bold effects on concussion-reporting intention, several of which due to the CC development process. CC was developed with input from hundreds of athletes, to ensure that the education felt relevant to the learner, and addressed specific questions and misperceptions that athletes expressed.²⁷ Additionally, by speaking directly to athletes, changes could be made to ensure the curriculum felt authentic, in terms of language, resonance, and relatability. Through similar dialogues with concussion experts, the information which public health and medical experts considered essential was also incorporated.²⁷ CC also incorporated insights from the learning sciences, utilizing analogies and mnemonic devices to convey information more readily to the athlete. The interactive aspects of CC may also confer an emotional salience to the subject matter and provide more realism to the module. Although CC was developed after the recent National Collegiate Athletic Association and Department of Defense Mind Matters Research & Education Grand Challenge consensus recommendations, this development process incorporates many of the recommendations that resulted from this conference.²⁸ It is not clear that this same moderating effect would persist with other educational formats, as this relationship has never previously been assessed.

Limitations

There are several limitations to the present study. Although athletes' concussion-reporting intentions improved regardless of enjoyment of previous concussion education, the moderating effect of enjoyment on reporting intention may be in part due to a ceiling effect; the athletes who previously enjoyed education may have simply had less room to improve on their baseline concussion-reporting intention than athletes who previously did not enjoy their concussion education. Additionally, the study only examined effects immediately after the educational intervention; it is not clear how the observed effect on concussion-reporting intention would change with time. A longitudinal study would determine the resilience of the observed change in behavioral intention. The study also is potentially confounded by positive response

bias, namely that athletes might be more inclined to provide an answer that they feel is socially appropriate. However, respondents most at-risk of this bias would likely falsely indicate that they enjoyed previous concussion education, as well as that they would report concussion; the reported effect was actually that athletes who did not enjoy previous education prior to CC reported greater changes in concussion-reporting intention than other athletes. Additionally, although concussion-reporting intention is the most proximally related measure to true reporting, the present study does not measure reporting behavior directly. Finally, the reasons why prior education was not enjoyed, and duration since prior education, were not directly assessed.

Conclusion

Athletes who experienced CC had significant improvement in concussion-reporting intention and confidence in their concussion knowledge. Athletes who previously did not enjoy concussion education exhibited the greatest gains in concussion-reporting intention, compared to athletes who enjoyed their previous education. Most athletes who participate in concussion education are required to participate as a result of league or state-wide mandate. As a result, improving concussion-reporting intention in low-enjoyment athletes is of particular relevance to improving concussion-reporting intention for all athletes. Future research is necessary to understand the relationship between emotional and cognitive outcomes (enjoyment, knowledge) and behavioral outcomes (self efficacy, hours of play), as well as the roles of race, ethnicity, gender, geography, and other SES factors as moderators of these outcomes.

Acknowledgments

Special thanks to: Coach Dick Gould, for his fearless leadership and determination to bring concussion education to the global sports community. In addition, thanks the research team who made this study possible: Noura Bou Zeid and Krishna Teja Gorrepati.

Declaration of Conflicting Interests

The author(s) declared the following potential conflicts of interest with respect to the research, authorship, and/or publication of this article: PS is Founder and CEO for the non-profit, TeachAids, where she receives a salary of \$1/year. The following authors have a non-reimbursed relationship as medical advisors for CrashCourse: DHD, MY, RDP, SG, GAG, JG, and LMS. In addition, SG has a non-reimbursed relationship as a member of the Board of Directors for TeachAids. CMB previously received funding from the NCAA as a graduate student research grant recipient, the Datalys Center for Sports Injury Research and Prevention as a graduate student research grant recipient, and through the Football Players' Health Study at Harvard, which is funded by the NFL Players' Association. RC is a paid consultant to the NFL Head Neck and Spine Committee, NOCSAE, Concussion Legacy Foundation, royalties from book publications, and compensation from expert legal opinion. He is a member of the Mackey-White Committee of the NFL Players

Association. RZ serves on scientific advisory boards for Oxeia BioPharma, EIMIndA, and MYOMO; serves on the editorial board of *Journal of Neurotrauma*; receives publishing royalties for *Brain Injury Medicine: Principles and Practice* (Demos, 2013) and *Physical Medicine and Rehabilitation—A Comprehensive Review* (Oakstone); and receives research support from NIH, NIDILRR, USARMC, and the Football Players Health Study at Harvard funded in part by the NFLPA. Study funded by: Taube Stanford Concussion Collaborative with Lucile Packard Children's Hospital Stanford. Funding agency was not involved with study design; the collection, analysis, and interpretation of data; the writing of the report; or the decision to submit the manuscript for publication.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: Several of the authors serve as unpaid medical advisors to the non-profit TeachAids, which created the free education program CrashCourse (DHD, MY, RDP, SGO, GAG, RAC, and LMS), but have no financial relationship with TeachAids. One author is Founder and CEO of TeachAids (PS), where she receives a salary of \$1/year. One author (CMB) previously received funding from the NCAA as a graduate student research grant recipient, the Datalys Center for Sports Injury Research and Prevention as a graduate student research grant recipient, and through the Football Players' Health Study at Harvard, which is funded by the NFL Players' Association. We report no other disclosures.

ORCID iDs

Daniel H. Daneshvar  <https://orcid.org/0000-0003-3691-9513>

Christine M. Baugh  <https://orcid.org/0000-0002-9340-6338>

Christine L. Chen  <https://orcid.org/0000-0003-4377-8245>

References

1. Bryan MA, Rowhani-Rahbar A, Comstock RD, Rivara F, Collaborative on behalf of the SSCR. Sports- and Recreation-Related Concussions in US Youth. *Pediatrics*. 2016;138(1):e20154635. doi:10.1542/peds.2015-4635
2. Daneshvar DH, Nowinski CJ, McKee A, Cantu RC. The epidemiology of sport-related concussion. *Clin Sports Med*. 2011;30(1):1-17. doi:10.1016/j.csm.2010.08.006
3. McCrea M, Hammeke T, Olsen G, Leo P, Guskiewicz K. Unreported concussion in high school football players: implications for prevention. *Clin J Sport Med*. 2004;14(1):13-17. doi:10.1097/00042752-200401000-00003
4. Register-Mihalik JK, Linnan LA, Marshall SW, Valovich McLeod TC, Mueller FO, Guskiewicz KM. Using theory to understand high school aged athletes' intentions to report sport-related concussion: implications for concussion education initiatives. *Brain Inj*. 2013;27(7-8):878-886. doi:10.3109/02699052.2013.775508
5. Wallace J, Covassin T, Nogle S, Gould D, Kovan J. Knowledge of concussion and reporting behaviors in high school athletes with or without access to an athletic trainer. *J Athl Train*. 2017;52(3):228-235. doi:10.4085/1062-6050-52.1.07
6. Daneshvar DH, Riley DO, Nowinski CJ, McKee AC, Stern RA, Cantu RC. Long term consequences: effects on normal

- development profile after concussion. *Phys Med Rehabil Clin N Am*. 2011;22(4):683-700. doi:10.1016/j.pmr.2011.08.009
7. Howell DR, Kriz P, Mannix RC, Kirchberg T, Master CL, Meehan WP. Concussion symptom profiles among child, adolescent, and young adult athletes. *Clin J Sport Med*. 2019; 29(5):391-397. doi:10.1097/JSM.0000000000000629
 8. McPherson AL, Nagai T, Webster KE, Hewett TE. Musculoskeletal injury risk after sport-related concussion: a systematic review and meta-analysis. *Am J Sports Med*. 2019; 47(7):1754-1762. doi:10.1177/0363546518785901
 9. Cover R, Roiger T, Zwart MB. The lived experiences of retired collegiate athletes with a history of 1 or more concussions. *J Athl Train*. 2018;53(7):646-656. doi:10.4085/1062-6050-338-17
 10. Meehan WP, Mannix RC, O'Brien MJ, Collins MW. The prevalence of undiagnosed concussions in athletes. *Clin J Sport Med*. 2013;23(5):339-342. doi:10.1097/JSM.0b013e318291d3b3
 11. Giza CC, Hovda DA. The new neurometabolic cascade of concussion. *Neurosurgery*. 2014;75(suppl 4):S24-S33. doi:10.1227/NEU.0000000000000505
 12. Sabatino MJ, CCRP, Zynda AJ, Miller S. Same-day return to play after pediatric athletes sustain concussions. *Pediatrics*. 2018;141(1 Meeting Abstract):203-203. doi:10.1542/peds.141.1_MeetingAbstract.203
 13. Caron JG, Bloom GA, Falcão WR, Sweet SN. An examination of concussion education programmes: a scoping review methodology. *Inj Prev*. 2015;21(5):301-308. doi:10.1136/injuryprev-2014-041479
 14. Kroshus E, Chrisman SPD. A new game plan for concussion education. *Health Educ Behav*. 2019;46(6):916-921. doi:10.1177/1090198119859414
 15. Kroshus E, Baugh CM, Daneshvar DH, Viswanath K. Understanding concussion reporting using a model based on the theory of planned behavior. *J Adolesc Health*. 2014;54(3):269-274.e2. doi:10.1016/j.jadohealth.2013.11.011
 16. Chrisman SP, Quitiquit C, Rivara FP. Qualitative study of barriers to concussive symptom reporting in high school athletics. *J Adolesc Health*. 2013;52(3):330-335.e3. doi:10.1016/j.jadohealth.2012.10.271
 17. Chao C-M. Factors determining the behavioral intention to use mobile learning: an application and extension of the UTAUT model. *Front Psychol*. 2019;10:1652. doi:10.3389/fpsyg.2019.01652
 18. Perski O, Lumsden J, Garnett C, Blandford A, West R, Michie S. Assessing the psychometric properties of the digital behavior change intervention engagement scale in users of an app for reducing alcohol consumption: evaluation study. *J Med Internet Res*. 2019;21(11):e16197. doi:10.2196/16197
 19. Takacs ZK, Kassai R. The efficacy of different interventions to foster children's executive function skills: a series of meta-analyses. *Psychol Bull*. 2019;145(7):653-697. doi:10.1037/bul0000195
 20. Tibubos AN, Rohrmann S, Ringeisen T. How students learn to moderate group work: the role of enjoyment and boredom. *J Psychol*. 2019;153(6):628-648. doi:10.1080/00223980.2019.1586630
 21. Arakkal AT, Barón AE, Lamb MM, Fields SK, Comstock RD. Evaluating the effectiveness of traumatic brain injury state laws among high school athletes. *Inj Epidemiol*. 2020;7:1-12. doi:10.1186/s40621-020-00241-6
 22. Sullivan L, Harvey HH, Smith GA, Yang J. Putting policy into practice: school-level compliance with and implementation of state concussion laws. *J Public Health Manag Pract*. 2020; 26(suppl 2):S84-S92. doi:10.1097/PHH.0000000000001128
 23. TeachAids - CrashCourse free concussion education products. TeachAids. 2020. Accessed June 27, 2020. <https://teach aids.org/for-concussions/products/>
 24. Daneshvar DH, Yutsis M, Baugh CM, et al. Evaluating the effect of concussion education programs on intent to report concussion in high school football. *J Athl Train*. Published online January 6, 2021. doi:10.4085/509-20
 25. Montoya AK. Moderation analysis in two-instance repeated measures designs: probing methods and multiple moderator models. *Behav Res Methods*. 2019;51(1):61-82. doi:10.3758/s13428-018-1088-6
 26. Taylor ME, Sanner JE. The relationship between concussion knowledge and the high school athlete's intention to report traumatic brain injury symptoms: a systematic review of the literature. *J Sch Nurs*. 2017;33(1):73-81. doi:10.1177/1059840515619683
 27. TeachAids - CrashCourse concussion research. TeachAids. 2021. Accessed April 28, 2021. <https://teach aids.org/for-concussions/research/>
 28. Kroshus E, Cameron KL, Coatsworth JD, et al. Improving concussion education: consensus from the NCAA-department of defense mind matters research & education grand challenge. *Br J Sports Med*. 2020;54(22):1314-1320.