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Development, implementation and assessment of a concussion education programme for high school student-athletes

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ABSTRACT

Although experts have noted that adolescent athletes should be educated about concussions to improve their safety, there is no agreement on the most effective strategy to disseminate concussion education. The purpose of this study was to develop, implement and assess a concussion education programme. More precisely, four interactive oral presentations were delivered to high school student-athletes ($N = 35$, $M_{\text{age}} = 15.94$, $SD = 0.34$) in a large urban centre. Participants completed a questionnaire at three time-points during the season to measure changes in their knowledge (CK) and attitudes (CA) of concussions, and focus group interviews were conducted following the concussion education programme. Questionnaire data revealed participants' post-intervention CK scores were higher than their pre-intervention scores. During the focus groups, the student-athletes said they acquired CK about the role of protective equipment and symptom variability, and in terms of CA, they intended to avoid dangerous in-game collisions in the future. Our study was the first to create and deliver a concussion education intervention across multiple time-points, and to use mixed-methods in its assessment. These findings may be of interest to researchers, practitioners and stakeholders in sport who are invested in making the sport environment safer through concussion education and awareness.

ARTICLE HISTORY

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KEYWORDS

Concussion education; intervention; adolescent; mixed method; knowledge translation; injury prevention

Approximately 54% of Canadians aged 15–19 participate in organised sport each year (Canadian Heritage, 2013). Sport participation has long been advocated as a way for youth and adolescents to acquire important life skills such as leadership and teamwork and to contribute to their physical and psychosocial well-being (Côté, Bruner, Erickson, Strachan, & Fraser-Thomas, 2010). However, adolescents who participate in high school athletics commonly suffer musculoskeletal injuries (e.g., Swensen et al., 2013). Concussions are one type of injury that has an elevated incidence rate in high school athletics (Marshall, Guskiewicz, Shankar, McCrea, & Cantu, 2015). In fact, researchers have found that concussions are particularly problematic for high school athletes because they tend to underreport symptoms (Register-Mihalik et al., 2013) and because their symptoms are more severe and persistent compared to older athletes (Williams, Puetz, Giza, & Broglio, 2015). Given that researchers are now linking multiple concussive and subconcussive head impacts with dementia and chronic cognitive impairment (Stein, Alvarez, & McKee, 2015), there is a need to educate high school athletes about concussions in order to improve their safety and reduce the occurrence of this injury of epidemic proportion.

Researchers have estimated that 1.6–3.8 million concussions occur annually in sports and recreation in the United States alone (Langlois, Rutland-Brown, & Wald, 2006). These

statistics likely underestimate the true occurrence of concussions because signs of the injury (i.e., transient loss of consciousness) are rarely observable after acute injury (McCrary et al., 2013). As a result, many athletes are not evaluated for a concussion because they do not seek medical care for reasons that range from deliberately hiding symptoms from teammates, coaches and/or medical professionals, to inadvertently ignoring concussion symptoms due to a lack of knowledge about the injury (e.g., Davies & Bird, 2015; Delaney, Lamfookon, Bloom, Al-Kashmiri, & Correa, 2015; Kroshus, Baugh, Daneshvar, & Viswanath, 2014; Register-Mihalik et al., 2013). For example, Delaney et al. (2015) found that student-athletes did not report concussion symptoms because they did not believe they had suffered a serious enough injury to warrant medical attention. Underreporting concussions has been a consistent finding across studies, despite the fact that large-scale concussion education initiatives such as the US Centers for Disease Control and Prevention's "HEADS UP to concussions" campaign have existed for more than a decade (Sarmiento, Hoffman, Dmitrovski, & Lee, 2014).

Experts have highlighted the importance of improving concussion education initiatives (McCrary et al., 2013). Despite this recognition, little is known about the most effective ways to educate athletes about concussions (Caron, Bloom, Falcão, & Sweet, 2015). Large-scale concussion education initiatives

have typically employed passive dissemination strategies, such as fact sheets and other printed materials (e.g., Sarmiento et al., 2014). Although these strategies are cost-effective and allow for information to be widely distributed to diverse populations, evidence suggests there may be negative effects associated with delivering passive educational materials (cf. Kroshus, Baugh, Hawrilenko, & Daneshvar, 2015) and that general knowledge of concussions remains “substantially inaccurate” (McKinlay, Bishop, & McLellan, 2011, p. 761). Consequently, researchers should explore other strategies to improve the reach and effectiveness of concussion education initiatives.

Concussion education programmes (i.e., initiatives beyond passive dissemination) are another strategy that aims to educate adolescent athletes about concussions (Caron et al., 2015). In Caron et al.’s (2015) review, the authors found three types of concussion education programmes that have been used to educate a variety of populations about the injury: *interactive oral presentations* (e.g., Manasse-Cohick & Shapley, 2014), *educational videos* (e.g., Cusimano, Chipman, Donnelly, & Hutchinson, 2014) and *computer-based learning programmes* (e.g., Glang, Koester, Beaver, Clay, & McLaughlin, 2010). Overall, these programmes reported short-term improvements in participants’ knowledge, attitudes and behaviours about concussions (Caron et al., 2015). To date, concussion education programmes have been limited by the delivery of education at just one time-point and the nearly exclusive use of quantitative methods to evaluate these interventions (Caron et al., 2015). Moreover, researchers have postulated that concussion education programmes should be developed in line with principles of knowledge translation (KT) to improve their reach and effectiveness (Mrazik et al., 2015). KT is the science of bridging the gap between the scientific community and knowledge users by adapting knowledge to the local context (Straus, Tetroe, & Graham, 2013). Thus, adopting principles of KT and adapting the content and delivery of concussion education programmes could improve their reach and effectiveness by making concussion information more accessible for non-scientific populations. More information about KT will be provided in the “Methods” section.

The purpose of the present mixed method study was to build on research in this domain by developing, implementing and assessing a concussion education programme for high school student-athletes. More precisely, the concussion education programme consisted of four interactive oral presentations that were developed in concert with principles of KT. Two hypotheses guided the quantitative aspect of this study. First, we hypothesised that high school student-athletes’ knowledge of concussions would improve after exposure to the concussion education programme. Second, we hypothesised that participants’ attitudes regarding concussions would improve following the concussion education programme. In addition, there were three research questions guiding the qualitative portion of this study. First, what types of knowledge did the student-athletes acquire through participation in the concussion education programme? Second, in what ways did the concussion education programme influence participants’ attitudes towards concussions? Third, what were the

student-athletes’ impressions of the delivery of the concussion education programme?

Methods

Mixed method designs incorporate quantitative and qualitative research in the same report; this approach differs from multimethod designs that are restricted to either qualitative or quantitative traditions (Tachakkori & Teddlie, 2010). Tachakkori and Teddlie (2010) guidelines for implementing a mixed method design were followed. Specific to the present study, the quantitative data provided an objective measure to test the effect of the concussion education programme on student-athletes’ Concussion Knowledge (CK) and Concussion Attitudes (CA), while the qualitative data allowed student-athletes to use their own words to describe their experiences in the intervention (Morse, 2010). A more detailed description of the mixed methods used in this study is provided later in this section.

Participants

Male and female athletes from a private (i.e., fee-paying) high school in a large urban Canadian city were invited to participate in the current study. The participants were 35 male student-athletes, aged 15–17 years ($M_{\text{age}} = 15.94$, $SD = 0.34$) in grades 10 and 11, who were members of the senior basketball ($n = 14$) or ice hockey team ($n = 21$). Athletes with a documented concussion at the time of the study were excluded from participation. None of the athletes reported previous exposure to a concussion education programme.

Procedures

Upon obtaining approval from our university research ethics council and permission from a local high school, the school’s Athletic Director (AD) was contacted and agreed to serve as third party. Purposive sampling was used to select participants for the present study. More specifically, the AD informed members of the school’s senior athletic teams about the purpose of the study. Student-athletes who were interested in participating in this study collected a sealed envelope from the AD’s office, which contained parent/legal tutor consent and athlete assent forms, and returned them in the same sealed envelope to the AD’s office. Only the student-athletes who returned signed consent and assent forms prior to the first scheduled presentation of the concussion education programme were involved in the present study.

Intervention

The concussion education programme in the present study consisted of four interactive oral presentations. Each presentation lasted approximately 30 min and was delivered to the basketball and hockey student-athletes ($n = 35$) by the first author in approximately one-week intervals. The first three presentations were delivered to both teams concurrently, whereas the final presentation occurred separately due to conflicting practice and game schedules.

The concussion education programme in the present study was developed in concert with a KT framework called the knowledge to action cycle (Graham et al., 2006). Designed to examine the knowledge gap, the knowledge to action cycle consists of two sections: (a) the knowledge funnel, in which researchers refine information and create a knowledge tool/product and (b) the action cycle, in which researchers implement and evaluate the knowledge tool/product (Graham et al., 2006). In line with the knowledge funnel, consensus concussion guidelines (McCrory et al., 2013), peer-reviewed concussion articles (e.g., Delaney et al., 2015) and literature on the psychology of injuries (e.g., Podlog, Dimmock, & Miller, 2011) were refined and then adapted to meet the participants' needs through interviews with athletes and coaches at the high school (Caron, Bloom, & Bennie, 2015).

Specific to the action cycle, interactive oral presentations were implemented and consisted of a slideshow, videos, pictures and animations, case studies, and group discussions. The content of the presentations is outlined briefly as follows:

- Presentation #1 informed participants about the signs and symptoms of concussions, as well as the return to play protocol.
- Presentation #2 introduced student-athletes to the role of protective equipment, risk compensation, as well as underreporting and the long-term implications of concussions.
- Presentation #3 focused on the psychological aspects of athletic injuries and concussions, such as how emotions and behaviours can impact injuries and the rehabilitation process.
- Presentation #4 highlighted how student-athletes could create a safe and healthy sporting environment through the mutual respect of teammates, opponents, officials and coaches.

Details about the evaluation of the concussion education programme (i.e., the action funnel; Graham et al., 2006) are presented later in the "Data collection" and "Data analysis" sections.

Data collection

Quantitative data

The Rosenbaum Concussion Knowledge and Attitudes Survey-Student Version (RoCKAS-ST; Rosenbaum & Arnett, 2010) was used in the current study. The RoCKAS-ST was developed to assess 13–20 year-old students' knowledge (CK) and attitudes (CA) of concussions and has previously been used to assess the effectiveness of concussion education programmes with high school athletes (e.g., Manasse-Cohick & Shapley, 2014). Rosenbaum and Arnett (2010) reported "satisfactory" test-retest reliability (CK items, $r = .67$; CA items, $r = .79$) and "adequate" internal consistency (Cohen's α range = .59–.72) of the instrument. The RoCKAS-ST contains 55 items and is divided into five sections. Sections 1, 2 and 5 measure CK and consist of true and false questions, graded 1 (*correct*) or 0 (*incorrect*), for a possible total score of 37. Sections 3 and 4 measure CA

and consist of 5-point Likert-style questions, graded on a scale from 1 (*most unsafe*) to 5 (*most safe*), for a possible total score of 90. High scores on CK (e.g., 33) and CA (e.g., 75) provide an indication of better knowledge of and attitudes towards concussions.

All 35 participants completed pen-and-paper versions of the RoCKAS-ST at three time-points: immediately prior to Presentation #1 (Time 1), immediately following Presentation #4 (Time 2) and two months after Presentation #4 (Time 3). The time-points were selected to measure pre-post changes in CK and CA were consistent with previous concussion education programmes (e.g., Cusimano et al., 2014).

Qualitative data

Focus group interviews have been used in the social sciences to gather group members' perceptions of an intervention (e.g., Kipping, Jago, & Lawlor, 2011). Group interviews are different than individual interviews because a moderator poses questions to all group members, who can then agree, disagree or offer additional explanations based on the other participants' comments (Rubin & Rubin, 2012). A focus group interview guide was created for the current study. Implementing focus group interviews allowed participants to use their own words to articulate the types of knowledge they acquired, express their attitudes towards concussions and describe their overall perceptions of the intervention.

While participants were completing the RoCKAS-ST at the end of Presentation #4, a sign-up sheet was circulated to invite student-athletes to participate in a focus group interview with the lead author. Two focus group interviews were conducted with basketball ($n = 6$) and hockey ($n = 5$) student-athletes approximately two weeks following the conclusion of Presentation #4. Focus group participants included a mix of grade 10 and 11 student-athletes. The focus groups were audio-recorded and lasted 27 min (basketball) and 33 min (hockey), respectively.

Data analysis

Quantitative data

Participants were assigned a code (BB for basketball athletes and H for hockey athletes) and a number to protect their anonymity and track their scores across the three time points (e.g., BB5, H5). Participants' RoCKAS-ST surveys were graded at each time point. Prior to running the main analyses, a missing data analysis was performed. No data were missing. Visual inspection of histograms and descriptive statistics suggested the presence of a univariate outlier. Inspecting the z-scores for CK and CA confirmed a univariate outlier (i.e., $z > 3.29$) for BB15 at CK Time 3. Tabachnick and Fidell (2007) recommended changing the scores of univariate outliers "so they are deviant, but not as deviant as they were" (p. 77) in order to reduce the impact of the variable on the analysis. Accordingly, BB15's score of 10 at CK Time 3 was transformed to a score of 29, a value one unit larger than the next most extreme score (cf. Tabachnick & Fidell, 2007). Following this transformation, data were assessed for violations of normality, homogeneity of

variance and sphericity. No violations were found for homogeneity of variance or sphericity. Despite having values for skewness and kurtosis within the normal range, Kolmogorov–Smirnov test results suggested violations of normality at CK Time 3 ($D = .27, p < .001$). Nonetheless, researchers have supported using analysis of variance (ANOVA) in the presence of non-normally distributed data because of the robustness of the test (cf. Schmider, Ziegler, Danay, Beyer, & Bühner, 2010). As a result, one-way repeated measures ANOVAs were conducted to compare the effect of a concussion education programme on CK and CA at three time-points.

Qualitative data

The audio recordings of the focus groups were transcribed verbatim and stored using Version 10 of the NVivo software package. The current study followed a modified version of Braun and Clarke (2013) guidelines for conducting a thematic analysis. That is, the focus group data were analysed abductively, which is a combination of deductive (top down) and inductive (bottom up) approaches (Tavory & Timmermans, 2014), and allows for compatibility between the quantitative and qualitative data. The first step of the analysis involved deductively organising the focus group data into three higher-order themes: “Concussion Knowledge”, “Concussion Attitudes” and “Perceptions of the Concussion Education Programme”, which were consistent with the research questions (and hypotheses) identified for this study. To organise the focus group data into these higher-order themes, the focus group interview transcripts were read several times to gain familiarity with the data. Next, data extracts, which are blocks of text that encapsulate a coherent idea or piece of information from a single focus group participant (Braun & Clarke, 2013), were organised into the above-mentioned higher-order themes. Once all focus group data were separated into data extracts and organized into the three higher-order themes, an inductive analysis was performed to search for lower-order themes. That is, data extracts within each

higher-order theme that had similar meaning were grouped into lower-order themes. Two lower-order themes were identified for each of the higher-order themes. A brief overview of the qualitative data is provided in the “Results” section. A more detailed description of the data, in the form of direct quotations from the participants, is provided as supplemental online material.

Results

Quantitative data

Reliability analyses of the RoCKAS-ST revealed that the subscales for CK (Cronbach’s $\alpha = .713$) and CA (Cronbach’s $\alpha = .882$) were within the acceptable range. Mauchly’s test indicated that the assumption of sphericity was not violated for CK, $\chi^2(2) = 1.85, p = .397$ or for CA, $\chi^2(2) = 1.603, p = .449$, therefore no corrections were made when reporting degrees of freedom. Results of a one-way repeated measures ANOVA indicated that scores for CK were significantly different across time $F(2, 68) = 19.079, p < .001, \eta^2_p = .359$. Pairwise comparisons revealed a significant difference in CK between Times 1 and 2 ($t = -2.000, p < .001, d = -.884$) and Times 1 and 3 ($t = -1.971, p < .001, d = -.831$). No significant difference was found between Times 2 and 3 ($t = .029, p = .931, d = .014$). Scores for CA did not differ significantly across time $F(2, 68) = .540, p = .947, \eta^2_p = .002$. Table 1 provides the mean scores and standard errors for CK and CA across the three time points. Figure 1 illustrate the average scores on CK and CA at each time-point using histograms.

Table 1. Descriptive statistics for Concussion Knowledge and Concussion Attitudes across time points.

Time	1	2	3
Concussion Knowledge	30.80 (0.312)	32.80 (0.280)	32.77 (0.281)
Concussion Attitudes	75.40 (1.423)	75.57 (1.118)	75.20 (1.077)

The mean scores for Concussion Knowledge and Concussion Attitudes are presented for each time point. The standard errors are presented in parentheses.

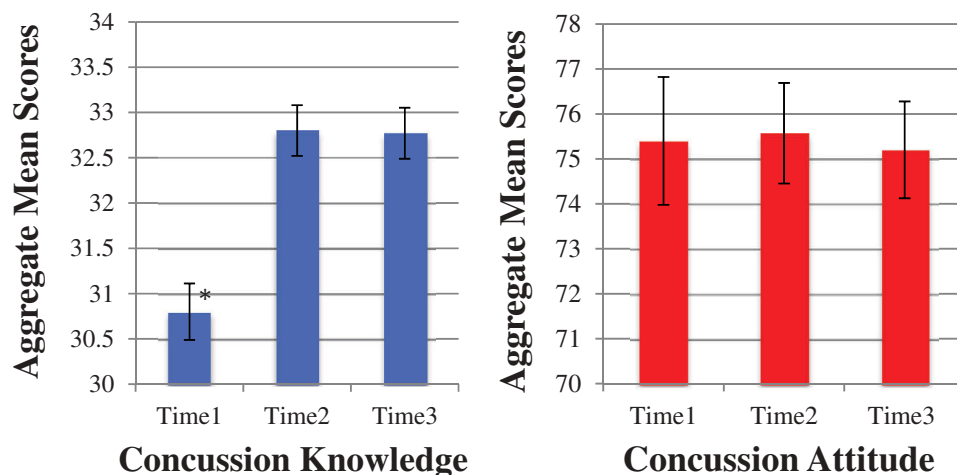


Figure 1. Mean scores for Concussion Knowledge (CK) and Attitude (CA). Error bars represent the 95% confidence intervals around the means. Mean scores for CK Time 1 were significantly lower than Times 2 and 3. The mean scores for CA Times 1, 2, 3 did not differ significantly. Time 1 = immediately prior to Presentation #1; Time 2 = immediately following Presentation #4; Time 3 = two-months after Presentation #4.

* = $p < .05$

Qualitative data

Overall, the athletes who participated in the focus groups said their knowledge of concussions improved as a result of participating in the concussion education programme. More precisely, the participants indicated they were surprised to learn that helmets and mouthguards were not designed to prevent concussions and that there is no definite timeline for recovery. In terms of CA, the participants said they were unsure whether the presentations would encourage the reporting of concussions in the future. More specifically, some of the participants were unsure if their teammates would report concussion symptoms during important games (i.e., play-offs). Although participants were unsure whether concussion awareness would influence the reporting of concussions on their teams, there was some evidence to suggest that it might influence preventative behaviours. For instance, some athletes indicated they intended to avoid dangerous in-game collisions in the future. Finally, the participants said they enjoyed the interactive nature of the concussion education programme, which included the audiovisual presentation and discussions with the presenter, as well as the use of case studies that highlighted athletes who had concussions.

Discussion

The purpose of this study was to develop, implement and assess a concussion education programme for high school student-athletes. In this first subsection, we will discuss findings in relation to the hypotheses and research questions from our mixed-methods design, and in the second we will cover how the concussion education programme contributes to the development, assessment and dissemination of research.

Hypotheses and research questions

Results from this study supported the first hypothesis, whereby the participants' RoCKAS-ST scores for CK were higher post-intervention compared to pre-intervention. These findings were reinforced by the qualitative data, whereby the participants said they acquired CK regarding the role of protective equipment and symptom variability (i.e., research question 1). Researchers have previously reported short-term improvements in athletes' CK after exposure to a concussion education programme (e.g., Bagley et al., 2012; Kurowski, Pomerantz, Schaiper, Ho, & Gittelman, 2015). However, researchers have rarely measured CK beyond immediate post-intervention assessment (i.e., CK retention) and the few studies that have assessed participants' CK over time have not used standardised measures (Cook, Cusimano, Tator, Chipman, & Macarthur, 2003; Cusimano et al., 2014). Consequently, results from the present study build on existing research, as the participants appeared to retain CK for 2 months following the intervention (i.e., no significant difference between Time 2 and Time 3), as measured by a standardised instrument (i.e., RoCKAS-ST). Nonetheless, more research is needed to understand the impact of concussion education programmes on CK retention. Randomised controlled designs and assessment strategies that involve standardised instruments, measured

across longer periods of time (i.e., 6- and 12-months post-intervention) should be used to guide future research and intervention in this area.

Researchers have suggested that improved CK does not automatically lead to improvements in athletes' CA (Kroshus et al., 2014; Register-Mihalik et al., 2013). As a result, it was not surprising that no significant differences were found in participants' RoCKAS-ST scores for CA (i.e., hypothesis 2). Moreover, student-athletes in the focus groups also felt their teammates would continue to underreport concussions following the intervention (i.e., research question 2), a finding that has previously been reported in the literature (Kroshus et al., 2015). More precisely, Kroshus et al. (2015) found no improvements in adolescent male ice hockey athletes' concussion-reporting behaviours after exposure to their concussion education programme. The authors attributed their finding to the fact that all of their participants were in the play-offs when data were collected. Given that our participants were also in play-offs at the time of data collection, future research should consider the potential association between participants' responses and timing of data collection. Previous research has also found the most common reason for underreporting concussion symptoms was due to a lack of CK (Davies & Bird, 2015). Because participants in the present study demonstrated improved CK, it is more likely their unwillingness to report future concussions stemmed from other factors. For example, concerns over the perceived negative consequences associated with reporting a concussion, such as losing their status on the team (Delaney et al., 2015), might have concerned the participants. Researchers have postulated that concussion education programmes could include content to help mitigate athletes' perceived negative consequences associated with concussions reporting (Kroshus et al., 2014; Register-Mihalik et al., 2013). Kroshus et al. (2014) suggested that part of concussion education could involve encouraging teams to develop a protocol for concussed athletes to ensure they have an opportunity to re-establish their position on the team after returning from a concussion. Taken together, our results highlight a need for concussion education programmes to specifically target athletes' CA during interventions, which may involve working with coaches and athletes to develop strategies to help diminish the negative perceptions associated with accurately reporting concussion symptoms.

Although the findings suggested our concussion education programme did not improve the participants' CA towards post-concussion behaviours (i.e., concussion reporting), results from the focus group interviews indicated that some of the participants *intended* to protect themselves from future concussions by modifying their in-game behaviours. Social-cognitive theorists have long debated whether individuals' intention to change health behaviour is the best predictor of actual change (see Schwarzer, 2008). While the present study was not designed to measure athletes' intentions or in-game behaviours, it would be interesting for future studies to look more closely at the intention-behaviour relationship. The Theory of Planned Behaviour has been used to frame much of the research on health behaviour change over the past

30 years; however, it has been criticised for being unable to account for the complexity of the intention–behaviour relationship (Sniehotta, Presseau, & Araújo-Soares, 2014). Schwarzer (2008) suggested the Health Action Approach Model (HAPA) offers a better theoretical explanation of the health behaviour change process, as it proposes two volitional phases (e.g., maintenance, action planning) to bridge the intention–behaviour relationship. Researchers have begun investigating the intention–behaviour relationship with concussions (Kroshus et al., 2014; Register-Mihalik et al., 2013); however, this research has largely been based off TPB and has not been integrated into concussion education programmes. As such, there is an opportunity for researchers to begin integrating other health behaviour change theories (e.g., HAPA) into concussion education programming as a way to better understand the intention–behaviour relationship with concussions.

Concussion education programme

Principles of KT informed the development of our concussion education programme (Graham et al., 2006). To date, concussion education initiatives have minimally applied principles of KT (Mrazik et al., 2015), despite the fact that (a) KT is a common practice in health-related fields (Straus et al., 2013) and (b) because developing interventions in concert with KT has been recommended as a strategy to make concussion information more accessible to non-scientific populations (Caron et al., 2015; McCrory et al., 2013). Findings from the present study reinforce the value of using principles of KT to develop and implement a concussion education programme for a specific audience. However, researchers have noted that KT should be viewed as an ongoing process that involves continued dialogue and interaction between knowledge creators and users (Mrazik et al., 2015). As a result, researchers are encouraged to continuously refine the content of their concussion education programmes so it is up-to-date with contemporary evidence (e.g., McCrory et al., 2013) and to work collaboratively with knowledge users to ensure that the delivery of knowledge is appropriately adapted to meet audiences' ever-evolving needs.

Researchers have rarely assessed concussion education programmes using qualitative methods (Caron et al., 2015). Focus group interviews are a type of qualitative method that have been implemented to assess interventions in the social sciences (Kipping et al., 2011) and have been recommended as a strategy to evaluate KT interventions (Straus, Tetroe, Bhattacharyya, Zwarenstein, & Graham, 2013). Participants in the focus group interviews said they enjoyed the interactive nature of the presentations and the use of case study examples (i.e., research question 3), which are insights that could be used to inform future research and interventions in this domain (Caron et al., 2015). Given that researchers have reported few benefits from didactic (i.e., lecture only) concussion education (Kurowski et al., 2015), results from our focus group interviews contribute to a body of research that supports interactive forms of concussion education. Moreover, these findings demonstrate the types of results that can be

gleaned from using qualitative methods to evaluate concussion education programmes.

The use of four interactive oral presentations in the present study differed from previous concussion education programmes, which have disseminated knowledge at one time-point only (Bagley et al., 2012; Kurowski et al., 2015; Manasse-Cohick & Shapley, 2014). Given that the present study did not compare different types of concussion education programmes (e.g., interactive oral presentations vs. educational videos), it would be premature to conclude that interactive oral presentations are *more* effective than other interventions. However, disseminating information across multiple educational sessions may be a beneficial strategy to help reduce feelings of being overwhelmed with content, which might occur in single-session educational interventions. Additionally, implementing multiple educational sessions allowed for information to be presented that is unique from previous concussion education programmes (Caron et al., 2015). More precisely, information about psychosocial aspects of injuries and concussions, as well as creating a safe sporting environment through respect was disseminated to the student-athletes. Taken together, our results suggest that multiple educational sessions are an effective strategy to disseminate and acquire information about concussions.

Limitations and recommendations for the future

Given that all participants attended the same private high school in a large urban Canadian city, the generalizability of the present findings could be limited to student-athletes from comparable socio-economic contexts and geographical locations. Relatedly, there appeared to be ceiling effects of the RoCKAS-ST for both CA and CK (see Table 1). Specific to CK, the results suggest that our sample was already quite knowledgeable about concussions prior to participating in the concussion education programme. As such, it would be interesting for future research to use a sample with greater variability in pre-intervention concussion knowledge to possibly gain a better understanding of the benefits of concussion education programmes. Additionally, the present study did not have a control condition. As a result, it is possible that improvements in CK might have resulted from the concussion education programme *and* external factors. Future studies are encouraged to implement a control and/or attentional control condition. Furthermore, the present sample consisted of all males. Given that researchers have found that female athletes tend to report more concussion symptoms than their male counterparts of the same age (e.g., Covassin, Elbin, Harris, Parker, & Kontos, 2012), future concussion education programmes should include female athletes as another way to address the generalisability of these findings. Future research should also investigate other types of interactive concussion education strategies. For example, information and image-sharing websites such as Twitter, YouTube, Pinterest and Instagram (e.g., Ahmed, Lee, & Struik, 2016) may be particularly effective concussion education strategies for younger generations, as they may enjoy (or even prefer) learning through these mediums. Additionally, researchers may consider the largely unknown impact of sports media reports and movies (e.g., "Concussion") on general knowledge and attitudes of concussions. Researchers have also suggested that teammates could play an important role in improving athletes' concussion-reporting

behaviours (Kroshus, Garnett, Baugh, & Calzo, 2015). As such, concussion education programmes may consider developing segments within interventions that teach athletes specific strategies to facilitate or encourage teammates to report suspected concussions. Finally, researchers should investigate participants' preferred facilitator of concussion education, which may include a researcher, health professional or other. It is possible that the individual who delivers the concussion education programme can influence both the participants' perceptions of the intervention and their acquisition of concussion information. Taken together, we propose the following suggestions to further improve research in this domain:

- Utilise theories of KT throughout the development, implementation and assessment of concussion education programmes;
- Incorporate pre-post measures of intentions and behaviours;
- Implement randomised controlled designs to concurrently test several types of concussion education programmes;
- Develop and empirically test the effectiveness of concussion education programmes that are based on face-to-face and web-based (e.g., Facebook, Twitter, Instagram, Pinterest) components;
- Develop concussion education programmes that include both male and female participants of varying ages, socio-economic status and geographical location;
- Ensure that facilitators of concussion education have domain-specific knowledge and expertise, acquired through a medical/health degree and/or graduate training in a health-related field (e.g., kinesiology);
- Use mixed method designs;
- Integrate case studies of professional athletes who experienced concussions and then follow-up with age, sport and gender appropriate examples.

Disclosure statement

No potential conflict of interest was reported by the authors.

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