

Concussion Education in Children and Youth: A Scoping Review

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Abstract

Introduction: Sports-related concussions in children and youth are a significant health concern. There is increasing literature pertaining to levels of knowledge about concussion and the effects of educational interventions, but the literature has not yet been synthesized for the subpopulation of children and youth. Therefore, the purpose of this review was to identify and summarize the current state of the literature on concussion knowledge, and the effect of concussion education on the knowledge, attitudes, and behaviors of children and youth who engage in sports.

Methods: A scoping review was conducted, guided by Joanna Briggs Institute methodology. Two databases, MEDLINE and CINAHL (Cumulative Index to Nursing and Allied Health Literature), and reference lists were searched to identify relevant studies that focused on children and youth less than 19 years of age who engage in sports. We also searched Google Scholar for gray literature.

Results: Of the 21 articles that met inclusion criteria, 15 focused on levels of concussion knowledge, and 6 examined the effects of educational interventions. Children and youths' level of knowledge and exposure to prior concussion education varied, although more of the studies found a lack of concussion knowledge. Educational interventions of various types have been associated with short-term increases in knowledge and intention to report, but few of the studies found sustained effects.

Conclusions: Findings highlight the need for improved concussion education for children and youth engaged in sports. Findings also indicate a need for further research using more rigorous methods, and studies that examine subgroup differences in knowledge and factors that may moderate the effects of educational interventions.

Keywords

concussion, education, knowledge, youth, children

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Introduction

Concussions are a major public health concern. The Centers for Disease Control and Prevention has estimated that 3.4 million cases of sports-related concussions occurred in the United States from 2001 to 2012, with persons under 20 years accounting for roughly 70% of concussions each year (Coronado et al., 2015). More recent statistics indicate that between 1.1 and 1.9 million concussions occur annually in children aged 18 years and younger (Bryan et al., 2016). Physical and developmental differences place children and youth at greater risk for sustaining a concussion (Rajabali et al., 2012) and more pronounced effects. Specifically, an immature central nervous system, larger head-to-body ratio, thinner cranial bones, larger subarachnoid space, and differences in

cerebral blood volume influence susceptibility to a concussion. These differences contribute to greater cellular damage in children and youth (Karlin, 2011), more complex management after injury, and the likelihood of a subsequent concussion (Norton et al., 2013).

Sports are a significant contributing factor to concussion in children. The prevalence of concussions from sports is so high that specific terminology has been developed: Sports-related concussion is now recognized as a

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traumatic brain injury caused by biomechanical energies (McCrorry et al., 2017). Eliminating concussions in sports is impossible given the nature of sports but education may be able to reduce the incidence of concussion and its severity in child and youth athletes and counter the problem of poor recognition and underreporting of concussive injuries (Norton et al., 2013). Concussion-related education is important for multiple reasons. Increased knowledge about the critical nature of concussion may contribute to decreased risk taking (Taylor & Sanner, 2017), increased knowledge about the symptoms of concussion, potential long-term consequences, and heightened risk for a second concussion during a period of vulnerability following concussion may contribute to increased reporting and adherence to return to play (RTP) protocols (Norton et al., 2013). The importance of education was highlighted by the 5th *International Conference on Concussion in Sport* consensus statement, which outlines that there should be “... education on SRC [sports-related concussion] prevention and management for teachers, staff, students and parents ...” (McCrorry et al., 2017, p. 844).

Two recent systematic reviews (Emery et al., 2017; Taylor & Sanner, 2017) summarized the existing evidence related to the effects of concussion education and knowledge. Emery et al. (2017) investigated the effectiveness of various prevention strategies in reducing concussion risk in sport but found little evidence supporting the use of education as a standalone strategy for concussion prevention. However, the authors gave only minor attention to educational interventions and did not explore age-related differences though their review included studies of children, adolescents, and adults. In their review, Taylor and Sanner (2017) examined the impact of concussion knowledge but limited their outcomes to an intention to report concussion symptoms. Only four articles were included in their review and the age range of study participants was limited to high school students. Despite the differences in these two reviews, both provided some evidence of the importance of knowledge and education targeted to the needs of youth who engage in sports; this study builds on those findings.

The aim of this study was to identify and summarize the current state of the literature on level of concussion knowledge and the effects of educational interventions among children and youth who participate in sporting activities. For the purpose of this study, a child is any individual aged 5 to 11 years (Canadian Pediatric Society, 2018), while a youth is any individual aged 12 to 18 years. The general research questions that guided this scoping review were as follows: (a) What is the level of concussion knowledge among children and youth engaged in sports, and what factors are associated with their knowledge? (b) What is the impact of educational

interventions on child and youth athletes' concussion knowledge, attitudes, and behaviors? Knowledge, for the purpose of this study, is defined as the condition of having information or of being learned (Merriam-Webster Dictionary, 2018), whereas attitude encompasses the evaluation of an object or concept that is either good or bad, liked or disliked (Ajzen & Fishbein, 2000). Education pertains to the process of delivering or acquiring knowledge through a variety of methods including face-to-face presentations, educational videos, web-based resources, and outreach programs (McCrorry et al., 2017). It is expected that the findings of this review will be helpful to health-care professionals, public health organizations, and public policy makers working with child and youth athletes, and other researchers involved within this area.

Methods

We used a scoping review methodology guided by the Joanna Briggs Institute (JBI, 2015) *Methodology for JBI Scoping Reviews* to explore and summarize the literature relevant to our two research questions. Scoping reviews are appropriate when the body of literature is relatively new and the goal is to map the literature or address broad rather than specific questions (JBI, 2015). Scoping reviews are also useful for summarizing existing evidence from disparate types of studies. The objectives, inclusion criteria, and methods for this scoping review were specified in advance as documented in this study.

Data Sources and Search Strategy

Two electronic databases, MEDLINE and CINAHL (Cumulative Index to Nursing and Allied Health Literature), were searched to identify relevant studies for review. A search for gray literature was conducted in Google Scholar, up to page five; studies beyond this did not pertain to the research questions. We also examined the reference lists of articles selected for review. The search strategy and comprehensive list of search terms were developed by the authors in consultation with the university librarian. We searched on the following general terms: brain concussion, education, knowledge, attitude, child, and adolescence(t). The term “brain concussion” was used to capture sports-related concussions in the pediatric population as there are other forms of mild traumatic brain injury that occur in this population that are not sport induced. The search was conducted in August 2018 with no limitation on publication dates, as to yield all possible articles on the subject. Table 1 identifies the specific search strategies used for each database and search engine and number of hits.

Table 1. Search Strategy and Number of Hits for Each Database.

Source	Search strategy	N
CINAHL	(MH "Brain Concussion+") AND (MH "Knowledge+") OR (MH "Education+") OR (MH "Attitude+") AND (MH "Child+") OR (MH "Adolescent+")	n = 340
MEDLINE (EBSCOhost)	(MH "Brain Concussion+") AND (MH "Knowledge") OR (MH "Education+") OR (MH "Attitude+") AND (MH "Child+") OR (MH "Adolescent")	n = 311
Total		N = 651

Note. CINAHL = Cumulative Index to Nursing and Allied Health Literature; MH = Mesh Heading.

Inclusion and Exclusion Criteria

All research literature describing concussion knowledge or the effects of concussion education among children and youth who engage in sports was considered. The inclusion criteria were (a) full-text empirical articles with an abstract, (b) published in English, (c) studies of athletes less than 19 years of age, and (d) reported on at least one of knowledge, education, or their effects pertaining to concussion. Systematic reviews, epidemiological studies, and case studies were excluded. We also excluded studies focused solely on child and youth athletes' reporting of concussion or their attitude toward concussion. Two studies that were not specific to young athletes but provided separate analysis for the subgroup of children and adolescents were included in the review.

Screening and Study Selection

The search strategy was conducted by one author (S. R.) yielding 651 articles from the two databases for possible inclusion in this review. No further articles were identified through the Google Scholar search or hand searching of reference lists. After 44 duplicates were removed, 607 articles were reviewed for the appropriateness of their titles and abstracts, which resulted in 571 articles being removed. Thirty-six full text articles were assessed by S. R., in consultation with the second author (S.D.), for eligibility using the inclusion and exclusion criteria; 15 articles that did not meet the inclusion criteria were excluded from the scoping review. Thus, 21 peer-reviewed, empirical studies pertaining to concussion knowledge and education in children and youth athletes were included in this review (see Figure 1).

Data Extraction and Analysis

Descriptive data were extracted from the 21 selected articles by both authors. The extracted data include purpose of the study, setting and sample characteristics, research design and methods, and reported findings. The extracted data were discussed between both authors

until agreement was reached. These data are reported in Tables 2 and 3, sorted alphabetically by author name within each of the sections pertaining to research questions one (level of knowledge and associated factors) and two (evaluation of educational interventions). Given that this was a scoping review, the strengths and limitations of the studies were not formally assessed (JBI, 2015). A descriptive approach was used to summarize findings of the articles according to the questions of this review.

Results

The 21 articles selected for this scoping review were published between 2003 and 2017. Notably, 18 of the 21 studies had been published since 2011, suggesting that that this is a relatively new area of research, Study designs varied: Seventeen of the articles reported on studies that used quantitative methods; two studies used qualitative methods, and two used mixed methods. Of the 17 quantitative studies, 13 were descriptive studies with cross-sectional survey data, 3 used quasi-experimental designs with pretest-posttest data, and 1 was a randomized controlled trial (RCT) with posttest data only. Both of the mixed methods studies included an RCT component. None of the experimental studies collected posttest data beyond 4 months.

Thirteen of the 21 studies were from the United States, 5 were from Canada, and there was 1 study from each of England, Ireland, and New Zealand. Sample sizes varied from 43 to 599 in the quantitative studies and from 20 to 50 in the qualitative studies. The mixed methods studies had 12 to 25 participants in the qualitative aspects of the studies and up to 4,800 in the experimental aspects of their studies. Participants in the studies were between 6 and 18 years of age, although the majority of the studies focused on high school aged participants. Only 13 studies identified females as participants and all of these studies had a higher percentage of male participants. Parents and coaches were also included as participants in some of the studies.

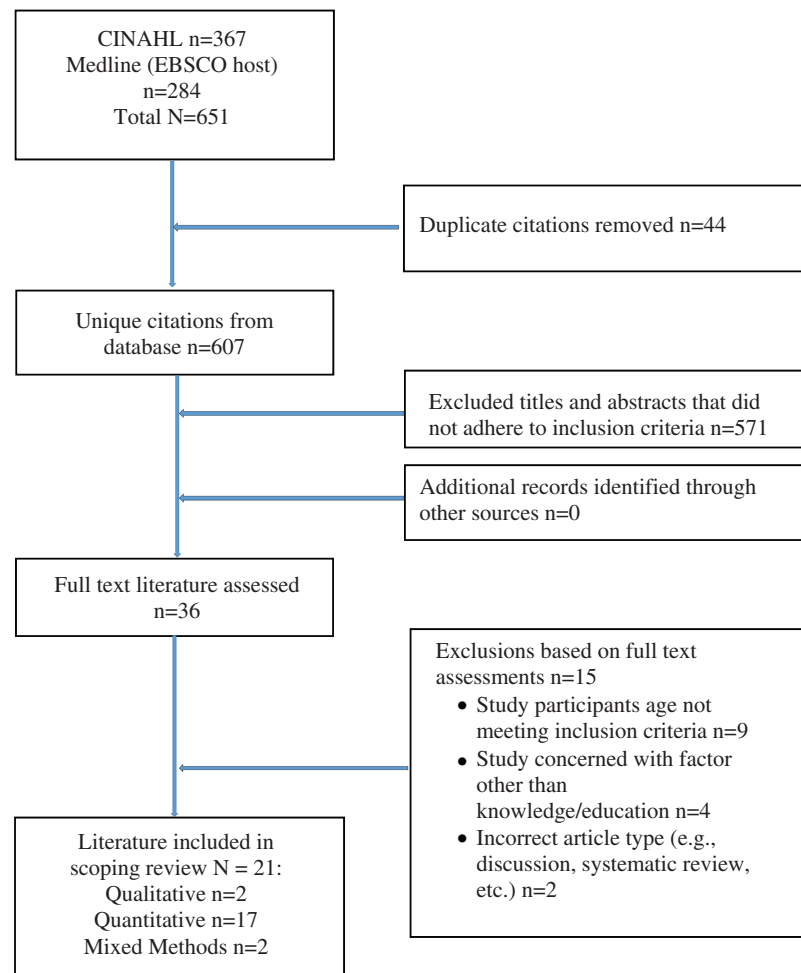


Figure 1. Flowchart of Article Selection.

Level of Knowledge Among Children and Youth Engaged in Sports

Fifteen of the articles in this review discussed levels of concussion knowledge among children and youth who engage in sports (see Table 2). Two of the studies used qualitative designs (Chrisman et al., 2013; Kroshus et al., 2017); the other 13 used quantitative methods—but notably, all studies used convenience sampling. Although findings varied, more of the studies found that children and youth had limited concussion knowledge or significant gaps in their knowledge. Findings also indicate that there had been variation in the children's and youths' exposure to concussion education, but there was no apparent link between knowledge and having received formal concussion education, and no trend in regard to publication date or country.

Studies conducted in the United States have yielded mixed findings regarding level of concussion knowledge. Three studies concluded that there was a satisfactory (Sye et al., 2006) or high level of awareness (Chrisman

et al., 2013; Myrdal et al., 2017) about concussion and its signs, symptoms, and dangers among the high school age athletes. However, other studies have found a more limited level of knowledge. For example, a study by Cusimano et al. (2009) found that 25% to 50% of Canadian youth hockey players were aware of only one symptom or less of a concussion. In another study, published in 2013, the majority of the high school age athletes had heard of concussion, but only one quarter demonstrated a basic understanding of a concussion (Bloodgood et al., 2013). Similar results were obtained in another large study published in 2014. Although 60% of participants had received formal concussion education in class or online, and 54% had received education from their parents (with only 25% of participants reporting that they had received no education). Overall, participants displayed a limited knowledge of signs, symptoms, and consequences of concussion (Cournoyer & Tripp, 2014). Two other studies described the participants' knowledge as fairly high but with some significant gaps regarding common

Table 2. Description of Studies and Study Findings Pertaining to Research Question 1 (Level of Knowledge and Associated Factors).

Authors (year) Country	Purpose	Sample and setting	Research design and methods	Findings: knowledge
Bloodgood et al. (2013) United States	To explore awareness, knowledge, and perceptions of traumatic brain injury among young athletes and their parents	N = 252 Convenience sample of young athletes, 13–18 years of age. Male: 46% Female: 54% N = 300 Parents or guardians of youth	Quantitative—descriptive cross-sectional data Online survey to measure: knowledge and attitudes	<ul style="list-style-type: none"> Majority of youth (84%) reported hearing about concussion, but only one quarter demonstrated a basic understanding of concussion.
Bramley et al. (2012) United States	To determine high school soccer players past concussion education and the likelihood of notifying their coach of concussion symptoms	N = 60 Convenience sample of high school soccer players in Grades 9 to 12.	Quantitative—descriptive cross-sectional data Mailed survey to measure: behavioral intentions	<ul style="list-style-type: none"> More players with concussion education reported they would always notify someone of a concussion compared with those without concussion education (72% vs. 36%). Concussion education was associated with intentions to report a concussion during a championship game ($p = .01$).
Chrisman et al. (2013) United States	To identify barriers to concussive symptom reporting in high school athletics	N = 50 Convenience sample of high school varsity athletes. Mean ages in years: Female soccer: 16.2 Male soccer: 17.5 Male football: 16.4 Male: 60% Female: 40%	Qualitative—descriptive focus groups interviews Thematic analysis Focus group interviews to assess concussion knowledge and identify barriers in behavioral intentions to report concussion	<ul style="list-style-type: none"> Participants were able to describe numerous signs and symptoms of concussion and were aware of the dangers and possible long-term effects of concussions. However, most participants said that they would not cease playing when concussed and would be hesitant to report symptoms to coaches if they did not result in significant pain or disability because both female and male athletes had received negative messages from coaches when reporting injuries.
Cournoyer & Tripp (2014) United States	To determine concussion level of school football players after the initiation of new concussion-education legislation	N = 313 Convenience sample of high school football players. Mean age = 16.3 years	Quantitative—descriptive cross-sectional data Written survey to measure: knowledge	<ul style="list-style-type: none"> Twenty-five percent of participants reported having received no education; 60% had received formal concussion education in class or online, and 54% had received education from their parents. Overall, displayed limited knowledge of signs, symptoms, and consequences of concussion. Concussion symptoms of headache, dizziness, and confusion were identified by 97%, 93%, and 90% of participants, respectively, but few participants correctly identified symptoms such as behavior and personality change, trouble falling asleep, being more emotional, and being nervous or anxious.

(continued)

Table 2. Continued

Authors (year) Country	Purpose	Sample and setting	Research design and methods	Findings: knowledge
Cusimano et al. (2009) Canada	To assess minor hockey participants' knowledge about concussion	N = 267 Convenience sample of minor hockey players, 10 to 14 years of age. N = 142 Adults (coaches, parents, trainers)	Quantitative—descriptive cross-sectional data In person survey to measure: knowledge	<ul style="list-style-type: none"> • Knowledge varied by age. • Fourteen-year old players were more knowledgeable than 10-year old players, and elite players were more knowledgeable than nonelite players, but many participants had misconceptions about concussions. • More 10-year olds than 14-year olds did not know how a concussion occurred (63% vs. 25%). • Twenty-five percent to 50% of players were only aware of one symptom or less of a concussion, and almost half of players (48% of 10-year olds and 44% of 14-year olds) misidentified concussion treatment.
Delahunty et al. (2015) Ireland	To assess incidence of concussion and attitudes about concussion in Irish schools' rugby union players	N = 304 Convenience sample young rugby players, 12 to 18 years of age.	Quantitative—descriptive cross-sectional data Written survey to measure: knowledge and attitudes	<ul style="list-style-type: none"> • Sixty-one percent of players had received some information about concussion and 25% had specific knowledge about return-to-play protocols. • A majority of players identified concussion as a serious health risk (82%). • More players with past diagnosis with a concussion reported they would play an important match even if they were concussed than those who had never experienced a concussion (82% vs. 70%). • Most participants (90%) reported that they would benefit from further concussion education, with most preferring a booklet (36%) or presentation (45%).
Kearney & See (2017) England	To explore the knowledge of, and attitudes toward, concussion within an English youth rugby population	N = 255 Convenience sample of young rugby players, 11 to 17 years of age. Male: 93% Female: 7%	Quantitative—descriptive cross-sectional data Written survey to measure: knowledge and attitudes	<ul style="list-style-type: none"> • The majority of participants were able to identify a concussion as a brain injury (99%) and were aware that suffering a concussion is a risk for another (91%), and that losing consciousness was not required to suffer a concussion (82%). • Gaps in knowledge: incorrect belief that concussion could occur only from a hit to the head (80%) and being able to identify rest as the appropriate treatment for concussion (only 2%). • Ninety-seven percent of participants reported they would tell their coach if hit in the head, but 20% reported that they would continue to play.

(continued)

Table 2. Continued

Authors (year) Country	Purpose	Sample and setting	Research design and methods	Findings: knowledge
Kroshus et al. (2017) United States	To understand young children's scope of knowledge about concussion and identify what they believe to be strategies for risk reduction	N = 20 Convenience sample of children 6 to 8 years of age. Male: 60% Female: 40%	Qualitative descriptive Individual interviews to assess concussion knowledge	<ul style="list-style-type: none"> • Most participants reported having heard the word concussion and had a general sense of the nature of injury. • Half the children knew that concussions could be incurred through sport. • The authors concluded that children between 6 and 8 years of age "tend to have a reasonably accurate, although limited, conceptions about concussions," and that study findings could be used to inform the development of age appropriate educational interventions.
Kurowski et al. (2014) United States	To identify factors that influence concussion knowledge and self-reported attitudes in high school athletes	N = 496 Convenience sample of high school athletes, 13 to 18 years of age. Male: 77.4% Female: 22.6%	Quantitative—descriptive cross-sectional data Written survey to measure: knowledge, attitudes, behavioral intentions	<ul style="list-style-type: none"> • Knowledge and attitudes (intention to report) varied by age. • Older age, female gender, basketball and soccer participation, and previous concussion education were associated with higher levels of knowledge. • Younger age, female gender, and soccer participation were associated with more positive intended concussion reporting behaviors. • Higher concussion knowledge was not associated with higher intended self-reported behaviors.

(continued)

Table 2. Continued

Authors (year) Country	Purpose	Sample and setting	Research design and methods	Findings: knowledge
Mrazik et al. (2015) Canada	To evaluate minor hockey players' knowledge and attitudes toward concussion	N = 183 Convenience sample of 57 minor hockey players, 11 to 17 years of age, and 126 nonhockey students, 11 to 15 years of age. Male: 78.5% Female: 22.5%	Quantitative—descriptive cross-sectional data Written survey to measure: knowledge, attitudes, behavioral intentions	<ul style="list-style-type: none"> • Knowledge varied by age and participation in hockey. • Almost all players had foundational concussion knowledge but 56% underestimated the prevalence and 30% lacked awareness of return to play protocols. • Hockey players demonstrated significantly higher knowledge of the cause and prevalence of concussion than nonhockey players. • Younger hockey players were less able to correctly identify the cause of concussions than older hockey players. • Despite the high level of knowledge about reporting and ceasing to play when hit in the head (95%), only 78% stated that they would stop and report a concussion; and only 43% of those who had received a concussion had stopped playing and reported it. • No gender differences in knowledge of return to play protocols or following protocol when concussed, although the reasons given varied by age and gender.
Myrdal et al. (2017) United States	To compare knowledge, perceptions and attitudes of concussion in previously concussed versus nonconcussed youth soccer players	N = 90 Convenience sample of young soccer players, 14 to 18 years of age. Male: 57% Female: 43%	Quantitative—descriptive cross-sectional data Written survey to measure: knowledge and attitudes	<ul style="list-style-type: none"> • Results indicated a high level of concussion knowledge but with some need for additional education • Knowledge varied by gender: Females had higher knowledge scores than males. • There were no significant differences in knowledge scores or attitude scores for concussed versus nonconcussed participants.
Register-Mihalik et al. (2013) United States	To examine the influence of knowledge and attitude on concussion reporting among a sample of high school athletes	N = 167 Convenience sample of high school athletes (10% response rate), 14 to 18 years of age. Male: 58% Female: 33% Undisclosed: 9%	Quantitative—descriptive cross-sectional data Survey Mailed survey to measure: knowledge, attitudes, and behaviors	<ul style="list-style-type: none"> • Higher concussion knowledge scores were associated with more frequent reporting of concussion and <i>bell-ringer</i> events in practice and all <i>bell-ringer</i> events overall. • Attitude scores and prevalence of athletes reporting were associated with a decreased participation in games and practices while concussed.

(continued)

Table 2. Continued

Authors (year) Country	Purpose	Sample and setting	Research design and methods	Findings: knowledge
Register-Mihalik et al. (2017) United States	To examine the association between self-reported concussion history and measures of concussion knowledge, attitude, and disclosure behavior	N = 167 Convenience sample of high school athletes, 14-18 years of age. Male: 61% Female: 39%	Quantitative—descriptive cross-sectional data Survey Written survey that measures: knowledge, attitudes, and behaviors	<ul style="list-style-type: none"> • Number of past concussions was not associated with level of concussion knowledge. • A higher number of concussions were associated with having a less positive attitude, as there was a decrease in the self-reported proportion of concussion events disclosed, and an increase in self-reported participation while experiencing signs and symptoms of concussion. • Majority of players were aware of the term “concussion” and most had reasonable knowledge of the signs and symptoms of concussion; although 25% thought “being knocked out cold” was the best descriptor of a concussion. • Only half were aware of concussion guidelines; and only 61% reported they understood concussion. • Twenty-seven percent of players agreed that a player with a suspected concussion should play in an important game. • There were gaps in knowledge, with 50% or fewer participants able to identify four common signs and symptoms. • Many gender differences were found for knowledge. • Females showed higher concussion symptom knowledge than males. • Males were less likely than females in intending to report a concussion because they thought their coach would get mad; their teammates would think that they were weak; their coach would think that they were weak; their parents would be upset; they did not want to miss a game; they did not want to lose playing time; their team was going to the playoffs when it happened; or they did not want to let their team down.
Sye et al. (2006) New Zealand	To document high school players’ understanding and attitudes toward concussion return to play guidelines	N = 477 Convenience sample of high school rugby players. Mean age = 17.05 years	Quantitative—descriptive cross-sectional data Survey to measure: knowledge and behavioral intentions	
Wallace et al. (2017) United States	To examine sex differences in high school athletes’ knowledge of sport-related concussion symptoms and reporting behaviors	N = 288 Convenience sample of high school athletes, in Grades 8 to 12. Male: 69% Female: 31%	Quantitative—descriptive cross-sectional data Survey In person survey to measure: knowledge and behavioral intentions	

signs and symptoms (Register-Mihalik et al., 2013; Wallace et al., 2017).

Five studies found that children and youth lacked knowledge about the correct treatment or RTP guidelines after sustaining a concussion. One study conducted in Canada with minor hockey participants found that almost half of the players misidentified proper concussion treatment (Cusimano et al., 2009). A more recent study, conducted in England in 2017, found that only 2% of the 11- to 17-year-old rugby players were able to identify rest as an appropriate treatment for concussion (Kearney & See, 2017). Three studies found significant gaps in knowledge about RTP protocols. For example, a study conducted in Ireland in 2015 found that although 61% of the rugby players had received some information about concussion, only 25% had specific knowledge about RTP protocols (Delahunty et al., 2015). A Canadian study found that although most of the players had foundational concussion knowledge, about one third were not familiar with the RTP protocols (Mrazik et al., 2015). These results are similar to an older study that found that only half of the 477 participants were aware of concussion guidelines concerning RTP (Sye et al., 2006).

Some of the studies also examined factors that may be associated with level of concussion knowledge: age, gender, and history of concussion. Three studies found that athletes aged 14 years and older had significantly better scores on concussion knowledge than younger athletes (Cusimano et al., 2009; Kurowski et al., 2014; Mrazik et al., 2015) although Kroshus et al. (2017) highlighted that some younger children had a reasonable knowledge of concussion. Among the three studies that examined gender differences, there were consistent findings that females showed higher levels of concussion knowledge than males (Kurowski et al., 2014; Myrdal et al., 2017; Wallace et al., 2017). Finally, two studies examined but failed to find an association between having a history of concussion and increased concussion knowledge (Myrdal et al., 2017; Register-Mihalik et al., 2017).

Seven studies examined the relationships between concussion knowledge and behavior or behavioral intentions, also with mixed findings. Four studies found a gap between youth's knowledge and their intention to report or to stop playing, or their actual behavior. For example, Mrazik et al. (2015) found that although 95% of the hockey players in their study knew that they should stop playing and report a concussion, only 79% stated that they would do so; and only 43% of those who had received a concussion had stopped playing and reported it. Similar results have been obtained other studies. A 2006 study (Sye et al., 2006) found that over a quarter of the rugby players thought that a player should continue in a game after a concussive injury, while in a more

recent smaller qualitative study, the majority of high school varsity athletes stated that they would not stop playing in a game even though most were knowledgeable of the signs, symptoms, and dangers of a concussion (Chrisman et al., 2013). A fourth study found no association between higher knowledge levels and intent to report (Kurowski et al., 2014). In contrast, three studies found that having had concussion education in the past was associated with a greater likelihood of athletes intending to report (Bramley et al., 2012; Kearney & See, 2017) or actually reporting the occurrence of a concussion or ceasing to play (Register-Mihalik et al., 2013).

There were some limitations to these studies. For example, many studies used instruments that were not specific to children and youth (i.e., Bramley et al., 2012; Kurowski et al., 2014; Mrazik et al., 2015), raising questions about the construct and internal validity of the studies. External validity may also have been weakened due to convenience sampling.

The Impact of Educational Interventions on Knowledge of Concussion

Six articles examined the effectiveness of various educational interventions as a means of improving concussion knowledge (see Table 3). One was an RCT; three were quasi-experimental studies (two used a single group pretest-posttest design [which weakens study validity]) and two used mixed methods that included an RCT component. The study by Glang et al. (2015) was the strongest study in terms of sampling, with 4,800 randomly selected youth participants from 25 schools; however, no long-term follow-up was conducted. Two of the studies had sample sizes under 100 (Cook et al., 2003; Eagles et al., 2016); the other three studies had sample sizes of 267 (Cusimano et al., 2014), 496 (Kurowski et al., 2015), and 599 (Bagley et al., 2012).

Although the educational interventions varied in format from lecture-style presentations (Eagles et al., 2016; Kurowski et al., 2015) to videos (Cook et al., 2003; Cusimano et al., 2014), and online web programs (Glang et al., 2015), as well as, curricula consisting of interactive demonstrations, case studies, and personal testimony (Bagley et al., 2012), findings were consistent. In each of the six studies, there were positive effects immediately following the intervention. Child and youth athletes' concussion knowledge either increased after receiving an educational intervention (Bagley et al., 2012; Eagles et al., 2016) or was higher in the treatment group (Cook et al., 2003; Cusimano et al., 2014; Glang et al., 2015; Kurowski et al., 2015). Age differences were found in one study: Athletes 13 years and older had significantly higher concussion knowledge scores after an educational intervention than 9- and 10-year-olds (Bagley et al., 2012). This was also the only

Table 3. Description of Studies and Study Findings Pertaining to Research Question 2 (Evaluation of Educational Interventions).

Authors (Year) Country	Purpose	Sample and setting	Research design, intervention, and methods	Findings Impact of interventions on knowledge, attitudes, and behaviors
Bagley et al. (2012) United States	To evaluate the effectiveness of the Sports Legacy Institute Community Educators (SLICE) program for youth concussion learning and knowledge	N = 599 Convenience sample of elementary, middle, and high school student athletes, 9 to 18 years of age. Male: 52% Female: 48%	Prospective cohort study (a single-group quasi-experimental pretest–posttest design) Intervention: SLICE workshop administered at high school; learning activities included interactive demonstrations, case studies, and personal testimony. Measures: Knowledge measured immediately before and after the presentation.	<ul style="list-style-type: none"> Improvements in knowledge varied by age and gender. Posttest knowledge scores improved for all students, but pass rates on the posttest were higher for females and older students (13+ years).
Cook et al. (2003) Canada	To evaluate the ThinkFirst Canada, smart hockey, brain, and spinal cord injury prevention video	N = 75 Random sample of male ice hockey players, 11 to 12 years of age. N = 12 Hockey team coaches	Mixed methods: randomized controlled trial (pretest–posttest) for players and qualitative interviews with coaches Intervention: The Smart Hockey video was shown to experimental teams at mid-season. Measures: Knowledge measured at baseline, 5-minute postvideo, and 3 months postvideo. Behavior (penalties) measured at end of the season.	<ul style="list-style-type: none"> Knowledge levels improved in the treatment group immediately postvideo and was maintained to 3 months (whereas there was no pre–post change in knowledge for the control group). High risk checking penalties decreased for the treatment group. Qualitative data from coaches provided suggestions for improving the video and identified other potential injury preventative initiatives. There was consensus that changing coaching behaviors would have the greatest impact on player behavior.
Cusimano et al. (2014) Canada	To evaluate the effectiveness of an educational video on concussion knowledge in minor league hockey players	N = 267 Cluster random sample of minor league hockey players, 10 to 14 years of age.	Cluster randomized controlled trial Intervention: The Smart Hockey video was shown to teams in the experimental group. Measures: knowledge measured at baseline, postvideo, and 2 months; attitude and behavior measured at baseline and 2 months only.	<ul style="list-style-type: none"> Knowledge scores increased postvideo for the treatment group, but the increase was not maintained to 2 months, and there were no differences between the intervention and control groups at 2 months, after controlling for prior knowledge level, age, and competitive level. Attitude and behavior scores did not differ between groups at 2 months (was not assessed postvideo).

(continued)

Table 3. Continued

Authors (Year) Country	Purpose	Sample and setting	Research design, intervention, and methods	Findings Impact of interventions on knowledge, attitudes, and behaviors
Eagles et al. (2016) Canada	To evaluate the impact of a multimodal concussion education program on knowledge of and attitudes about concussion	N = 43 Convenience sample of Bantam and Midget male hockey players, 13 to 16 years of age.	Prospective, cohort study (a single group quasi-experimental pretest–posttest design) Intervention: At the beginning of season, each team received a 30-minute educational presentation based on materials from Parachute Canada. Measures: knowledge and attitudes measured at baseline, after presentation and 4 to 6 months	<ul style="list-style-type: none"> Concussion knowledge scores increased from pre- to postpresentation and from prepresentation to 4- to 6-month follow-up Only Bantam concussion attitude scores increased from pre- to postpresentation, but the increase was not maintained to follow-up. There was no significant change in the older midget attitude scores.
Giang et al. (2015) United States	To evaluate the effectiveness of a web-based resource in improving post-concussion management in high schools	N = 4,804 Random sample of high school athletes in Grades 9 to 12, from 25 schools. Male: 56% Female: 44% N = 1,004 Parents of athletes N = 25 School administrators	Mixed methods: randomized controlled trial (pretest–posttest) for athletes and parents, and qualitative interviewing with parents and school administrators Intervention: In the fall, athletes were given access to an online interactive module on recognizing and managing sports concussion. Measures: knowledge and behavioral intention among students and parents measured immediately before and after the education intervention and concussion logs	<ul style="list-style-type: none"> The treatment group showed higher posttest scores than the control group on concussion knowledge, knowledge application, and behavioral intention to report concussion. No significant differences in concussion incidence between treatment and control groups. Significant difference between treatment and control groups in knowledge of effective concussion management practices. Qualitative data revealed that the intervention schools were more likely to create a concussion management team and have an assigned coordinator.

(continued)

Table 3. Continued

Authors (Year) Country	Purpose	Sample and setting	Research design, intervention, and methods	Findings Impact of interventions on knowledge, attitudes, and behaviors
Kurowski et al. (2015) United States	To evaluate the impact of preseason concussion education on knowledge, attitudes, and behaviors of high school athletes	N = 496 Convenience sample of high school athletes, 13 to 18 years of age. Male: 79% Female: 21%	Prospective, cohort study (quasi-experimental pretest–posttest with comparison group) Intervention: At the beginning of the season, each team was given a 20-minute educational lecture. Measures: knowledge, attitude, and behaviors measured at baseline (preseason), immediately following the intervention, and postseason.	<ul style="list-style-type: none"> • Knowledge and attitude–behavior scores increased from baseline to postintervention for the treatment group but were not maintained to postseason. • Students in the treatment group were less likely to continue playing with concussion symptoms than those in the control group; however, there was no significant difference in the proportion of students with concussion diagnoses who reported returning to play before their symptoms had resolved.

study to investigate and find gender differences, showing that female participants had higher knowledge scores directly after an educational intervention than the male participants (Bagley et al., 2012). In two of the four studies with longer term follow-up, concussion knowledge continued to be elevated 3 to 6 months after the educational intervention (Cook et al., 2003; Eagles et al., 2016). However, studies by Cusimano et al. (2014) and Kurowski et al. (2012) found that knowledge had returned to pre-intervention levels at the time of the 2-month and postseason follow-up, respectively.

The Impact of Educational Interventions on Attitudes and Behaviors

Five of the six intervention evaluation studies also assessed changes in attitudes and behaviors (see Table 3). Three of the studies investigated and found significant positive effects immediately following the educational intervention. In one study, attitude scores for the younger Bantam players, but not the older Midget players, increased from baseline to postpresentation (Eagles et al., 2016). In the other two studies, children and youth in the intervention group were more likely than those in the control group to indicate that they would report a concussion after being hit in the head and cease playing while symptomatic (Glang et al., 2015; Kurowski et al., 2015). However, similar to the mixed effects found for sustained knowledge, three of the four studies that examined longer term effects found that attitudes and behaviors had returned to pre-intervention levels by 2 to 6 months postintervention (Cusimano et al., 2014; Eagles et al., 2016; Kurowski et al., 2015). Only one study found sustained effects: The mixed methods study by Cook et al. (2003) found that penalties related to high risk checking (i.e., those that can potentially cause a concussion) decreased for the hockey players in the intervention group, suggesting a positive change in behavior over the season.

Discussion

The purpose of this scoping review was to identify and summarize the current state of the literature on concussion knowledge and the effect of concussion education on the knowledge, attitudes, and behaviors of children and youth who engage in sports—a group that accounts for more than two thirds of concussions each year (Coronado et al., 2015). This is an important group to target because of physical and developmental differences that not only place them at greater risk for sustaining a concussion but also for more pronounced effects and more complex management after injury (Karlin, 2011; Rajabali et al., 2012). Therefore, concussion prevention is important among children and youth engaged in

sports, but, to date, there has been limited attempts to summarize the relevant literature.

Study findings showed considerable variation in children and youths' level of concussion knowledge and exposure to prior concussion education, although more of the studies found limitations or significant gaps in concussion knowledge related to signs and symptoms, appropriate treatment, or RTP protocols. Older youth and females showed higher levels of knowledge than younger children and males. In general, participants who were 14 years or older had better knowledge than those who were younger, indicating a particular need for education among younger children who engage in sports. The need to educate this subpopulation is further emphasized by the fact that younger children (i.e., those aged 5–9 years) have a similar, and in some cases higher, incidence of concussive injury compared with older children (Canadian Hospitals Injury Reporting and Prevention Program, 2018). In addition, two studies examined but failed to find an association between having a history of concussion and increased concussion knowledge which suggests that coaches, health-care providers, and parents may be overlooking an opportunity for education. Increased knowledge was not necessarily associated with better attitudes or safer behaviors as four studies found a gap between youth's knowledge and their intention to report or to stop playing or their actual behavior.

A number of concussion researchers have highlighted the importance of education and knowledge. For example, Miyashita et al. (2013) concluded that concussions were underreported due to a lack of education. Other researchers have discussed the relationships between inadequate knowledge and the potential consequences of underreporting (McCrea et al., 2004). The recent consensus statement by McCrory et al. (2017) on concussion in sports identified education as key for the prevention, early identification, and management of sports related concussion in child and adolescent athletes. However, our findings indicate that, overall, educational interventions have not had the desired effect. Although educational interventions of various types have been associated with short-term increases in knowledge, attitudes, and intention to report, few of the studies found sustained effects. This suggests a need for improved educational interventions, which might include changes in content, delivery, dosage, or timing. For example, reinforcements may be needed over time. Intervention studies have given little attention to age and gender differences, with only one study reporting that older participants and females had significantly higher knowledge scores after an educational intervention than younger participants or males. Thus, there seems to be a gap in research pertaining to specific educational strategies that are most effective for various subgroups. Finally,

the gap between knowledge and behavioral intentions and between education and sustained behavioral intentions suggests that there are other factors that may have a direct effect on attitudes and behaviors or may moderate the effects of knowledge or education on attitudes and behaviors.

Implications for Nursing

Despite the shortcomings found for educational interventions, the limitations in young athletes' knowledge and short-term positive effects of education reinforce the potential importance of education at all three levels of prevention (i.e., primary, secondary, and tertiary; Park et al., 2008). Nurses are generally the first point of contact for a concussed child in an emergency or primary care setting and are often part of the interdisciplinary care team during recovery (Worley, 2019). Nurses also play a prominent role in public health and school settings, educating and interacting with children and youth. This places nursing in a critical position to obtain, translate, and implement concussion-related education at all three levels of prevention to children and youth. An intervention that prevents the trauma from occurring is considered primary prevention. An example of primary prevention is teaching the avoidance of risky behaviors, as in the study by Cook et al. (2003) which found that an intervention aimed at educating hockey players about the dangers of high-risk checking resulted in decreased penalties for such behaviors in the treatment group compared with the control group. Efforts at a secondary prevention level include preventive measures that lead to early diagnosis and prompt treatment of a disease, illness, or injury to prevent more severe problems from developing. Teaching children and youth to cease playing and report a suspected concussion is an example of secondary prevention. Nurses can provide comprehensive education on what to do if a child thinks they may be concussed before, during, and after a concussive injury to ensure proper protocols are followed (Norton et al., 2013). Finally, tertiary prevention encompasses those preventive measures aimed at rehabilitation and returning to daily life following significant injury or disease, as in teaching RTP protocols following a concussion.

Emery et al. (2017) found little evidence supporting the use of education as a standalone strategy for concussion prevention, concluding that education was better suited as a secondary prevention strategy. Given our findings that neither early identification (cease playing and report) nor management (understanding and adhering to RTP protocols) was strongly influenced by educational interventions, our study indicates a need for improvements in educational interventions. The purpose and available evidence for the educational intervention

need to be considered when designing and providing concussion education. One of the studies in our review that found a longer term impact on knowledge had utilized a multimodal approach to education (Eagles et al., 2016), suggesting that a multipronged educational approach may be more effective than singular strategies. This multipronged approach consisted of PowerPoint slides, videos, review questions, and personal testimony (Eagles et al., 2016). The last of these approaches, personal testimony, is an undervalued approach, as sharing one's individual concussion experience may help other children and youth appreciate the severity and risk of sustaining a concussion (Kendall & Kendall, 2012). Finally, our review has shown that there is a particular need for effective education among younger children that is currently not being fulfilled (Eagles et al., 2016). Age appropriate content and approaches should be developed by nurses, given they are aware of the wide variation in development and learning styles within children and youth.

Given the significant developmental differences within the population of children and youth who engage in sports, and the limited effectiveness of educational interventions to date, there is a need to identify educational strategies that are most effective for various age- and gender-specific subgroups. This should include investigation of the comparative effectiveness of various methods of delivery, dosage and timing, and content. It is also important to consider other factors that may be influencing concussion reporting behaviors or the effectiveness of educational interventions within this group (Kurowski et al., 2015). For example, future research should investigate or control for the effects of type of sport, school performance, socioeconomic status, and other social factors on concussion reporting behavior in children and youth participating in sports.

In addition to the need for more research, the field also needs improvements in research methods. For example, intervention studies should either employ RCT designs or more rigorously designed quasi-experimental studies. The number of intervention studies in this review was limited, and two of the six studies had used a single group pretest–posttest design which poses numerous threats to study validity. The 15 nonexperimental studies demonstrated a number of weaknesses. First, external generalizability was weakened by a reliance on convenience sampling, and there were gender differentials in most of the samples, with more male than female participants in both the nonexperimental and intervention studies. Both age and gender analysis are important if we are to understand what works best for particular subgroups of children and youth. In addition, some of the studies had poor or unknown response rates. For example, in one study, only 10% of the targeted 1,669 athletes returned the mailed survey

(Register-Mihalik et al., 2013). Mailed surveys may not be an ideal method of recruiting children and youth participants compared with recruitment efforts through coaches or team administrators. Finally, many studies used instruments that were not specific to children and youth, raising questions about the reliability and construct validity of the studies. To gain a more accurate understanding of knowledge and attitudes within these subpopulations, future researchers should develop age- and gender-specific tools informed by qualitative research.

Limitations of the Review

Our review was limited to full text articles published in English and the use of only two databases, which may have resulted in our missing relevant studies. Some of the study findings may be outdated as, in an effort to be comprehensive, our sample of studies included those published as early as 2003. As new legislation, policy, and rules regarding concussion care have been implemented globally since some of the data were collected, prior findings may no longer generalize to current times. Nonetheless, there was no noticeable trend related to publication dates or to country.

Conclusion

This review has characterized the current evidence on the level of concussion knowledge among children and youth engaged in sports, the factors associated with their knowledge, and the impact of educational interventions on their concussion knowledge, attitudes, and behaviors. Despite two systematic reviews previously describing the evidence on education and knowledge in concussion (Emery et al., 2017; Taylor & Sanner, 2017), this review adds important findings to the literature. Children and youth who are engaged in sports and at risk for concussion have limited concussion knowledge, and educational interventions have not been having the desired effect. Our scoping review highlights the need for improved concussion education for children and youth, at all levels of prevention, and for further research using more rigorous methods. Studies are needed that examine subgroup differences in knowledge and factors that may moderate the effects of educational interventions. It is also important to determine whether education is suitable as a single mechanism for injury prevention or if it is better utilized in unison with other strategies. Overall, our review indicates that concussion education is a relatively new field of study, and there are limitations to the existing body of research. Nonetheless, our findings have relevance for health-care professionals, public health organizations, and public policy makers working with

child and youth athletes, and other researchers involved within this area.

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