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A Comparison of Student and Parent Knowledge and Perceived Confidence About Brain Injury and Concussion

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Purpose: The public has long had misconceptions about traumatic brain injury (TBI) and its effects. Concussion education targeted toward athletes has been increasing with passage of return-to-play laws in all 50 states. The current study examined differences in public knowledge about TBI and concussion, and the extent to which students and parents in the general public may have benefited from increased availability of education around concussion. **Methods:** At a public fair, 246 students, parents, and other adults completed a survey adapted from existing TBI and concussion knowledge surveys. Participants also rated their confidence in accuracy of their responses. **Results:** There were no group differences on TBI knowledge or confidence. Parents scored slightly higher on concussion knowledge than students, and knowing someone with a TBI or concussion was also associated with higher scores. Confidence was only weakly related to concussion knowledge. Overall concussion knowledge scores were higher than TBI knowledge scores. Knowledge and confidence were not associated with sports participation. **Discussion:** Given similarities in TBI knowledge across groups, but that parents outpace students in concussion knowledge, parents may have greater exposure or heightened awareness of concussion information education opportunities. Lower confidence in students suggests an openness to education and opportunities for prevention of injuries. **Key words:** *brain injury*, *concussion*, *confidence*, *health knowledge*, *misconceptions*, *pediatric*, *prevention*, *public education*, *public knowledge*, *sports*

AN ESTIMATED 2.8 million people visit emergency departments each year in the United States to seek care for traumatic brain injury (TBI; Taylor, Bell, Breiding, & Xu, 2017), whereas estimates of annual occurrences of concussions, or mild TBI (mTBI), far surpass that figure. For example, it is estimated that, every year, at least 3.8 million people sustain concussions during sports or recreational activities alone (Baldwin, Breiding, & Comstock, 2018; Bryan, Rowhani-Rahbar, Comstock, & Rivara, 2016; Langlois, Rutland-Brown, & Wald, 2006). The two terms, concussion and mTBI, are

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synonymous (Lumba-Brown et al., 2018), and indicate a change in neurological function caused by rapid movement of the brain within the skull that may or may not result in loss of consciousness (Kay et al., 1993). "Concussion" is the term more commonly used by the general public, and has become a frequent focus of media reports, particularly driven by concerns regarding management and risks in sports settings across the lifespan (Ahmed, Blake, & Hall, 2017). Concussion education is frequently included in media reports, and all 50 states now have laws mandating education about concussion as part of return-to-play protocols for youth athletic programs (Baugh, Kroshus, Bourlas, & Perry, 2014; Thompson et al., 2016). However, little is known in regard to whether concussion education is reaching parents and students, how it is understood by the general public, and what effect it has on the public's knowledge about concussion.

TBI KNOWLEDGE

It has been long known that the general public holds misconceptions and inadequate knowledge concerning TBI. In 1988, Gouvier, Prestholdt, and Warner developed a 25-item survey on brain damage; a later, adapted version of this survey was formally titled the "Common Misconceptions about Traumatic Brain Injury Questionnaire" (CM-TBI; Linden, Braiden, & Miller, 2013; Springer, Farmer, & Bouman, 1997). The CM-TBI examines public knowledge of the effects of TBI, including items addressing loss of consciousness, amnesia, recovery, seatbelt use, and exposure to information about brain injury. Using this tool, Gouvier and colleagues (1988) found that the public had considerable misconceptions about brain injury recovery, unconsciousness, and memory. Findings from the CM-TBI have been largely replicated despite numerous adaptions and revisions to various populations and geographic locations (e.g., Chapman & Hudson, 2010; Guilmette & Paglia, 2004; Hux, Schram, & Goeken, 2006; Schellinger, Munson, & Kennedy, 2018; Willer, Johnson, Rempel, & Linn, 1993). Studies of public perception have also employed vignettes to assess public knowledge, identifying some areas of relative strength, such as better knowledge of physical rather than cognitive effects (Aubrey, Dobbs, & Rule, 1989). Qualitative investigations of perceptions of individuals with TBI and family members also support that the public holds misconceptions, particularly with regard to the timeline of recovery, the wide range of potential signs and symptoms, the distinction from mental illness, and the nature of TBI as a hidden disability (Swift & Wilson, 2001).

Prior research conflicts as to whether or not knowing someone with a history of TBI is associated with greater knowledge. Some studies report no impact of personal experience on brain injury knowledge (e.g., Chapman & Hudson, 2010; Ernst, Trice, Gilbert, & Potts, 2009; Gouvier et al., 1988; Schellinger et al., 2018), whereas others indicate that personal experience is associated with better knowledge (e.g., Hux et al., 2006; Linden et al., 2013; O'Jile et al., 1997). When results indicate a link between personal experience and knowledge, the effect is typically small. A recent systematic review found five studies that considered whether age affected knowledge, but found that results were inconsistent or associated with only particular items (Ralph & Derbyshire, 2013). However, all but one of these studies (Gouvier et al., 1988) considered age differences in TBI knowledge within adults, and not age comparisons between children and adults.

CONCUSSION KNOWLEDGE

Much public attention around TBI has now shifted toward concussion (or mild TBI), due in part to increasing concerns about the safety of athletes (e.g., Guskiewicz et al., 2005; Iverson, Echemendia, LaMarre, Brooks, & Gaetz, 2012; Patel, Fidrocki, & Parachuri, 2017). In regard to public knowledge of concussion, there has been some evidence that knowledge of concussion has increased over time more than general knowledge about TBI

(Guilmette & Paglia, 2004). Nevertheless, in an international survey, McKinlay, Bishop, and McLellan (2011) found that the general public still lacked knowledge regarding certain facts about concussion and its management. Structured education around concussion is now available in many formats, but tends to be focused on sports, and robustness of distribution of this education is often limited. In a survey examining the effect of return-to-play laws that mandate education for coaches, athletes, and parents, almost all coaches were exposed to at least two modalities of concussion education and had high knowledge scores. In contrast, coaches reported providing fewer materials to parents and athletes. Coaches provided education to over half of parents by having them sign the required concussion information sheet only, and did not provide any additional education (Chrisman, Schiff, Chung, Herring, & Rivara, 2014).

Research into knowledge about concussion shows uneven patterns of knowledge, and predictors of knowledge are similarly variable. In particular, sports participation and the opportunities for experience with concussion, or access to education around concussion, are not uniformly associated with better knowledge. For example, against their hypothesis that experience with sports or concussion would be associated with higher knowledge scores, Merz, Van Patten, and Lace (2016) reported poorer TBI knowledge among former athletes, as compared with the general public. Over 80% of athletes and parents in another online survey reported being aware of concussions, but only approximately 25% of respondents within that group could give an adequate definition of concussion (Bloodgood et al., 2013).

In a study using the Centers for Disease Control and Prevention Heads Up: Concussion in Youth Sports quiz to assess the knowledge of parents of athletes (Mannings, Kalynych, Joseph, Smotherman, & Kraemer, 2014), only 13% of participants were able to identify all statements regarding concussion accurately. About two thirds of the parents also failed to recognize that a concussion is considered a mild TBI and over half were not aware that a concussion can occur without a direct blow to the head. Athletes can often identify the most common concussion symptoms, such as headache, but score poorly when recognizing lesser known symptoms, like personality changes or difficulty concentrating (Cournoyer & Tripp, 2014). Emotional consequences of concussion—including increased irritability, mood swings, and depression—are also often missed (Cusimano, Zhang, Topolovec-Vranic, Hutchison, & Jing, 2017).

The bulk of the growing literature on concussion knowledge is centered on understanding how attitudes toward concussion are impacted by education and how athletes react to and use knowledge (Manasse-Cohick & Shapley, 2014; Register-Mihalik et al., 2013; Sye, Sullivan, & McCrory, 2006; Torres et al., 2013). The Rosenbaum Concussion Knowledge and Attitudes Survey (RoCKAS; Rosenbaum & Arnett, 2010) was developed specifically to address knowledge and attitudes in high school athletes. Knowledge is assessed in two sections, the first of which has 18 true and false statements, and the second in a symptom recognition checklist. The RoCKAS has fair reliability, and has now been used in a variety of populations, including professional and amateur athletes (e.g., Chapman et al., 2018; Williams, Langdon, McMillan, & Buckley, 2016) and the general public. In the general public, the RoCKAS was used to examine knowledge of parents of children at an orthopedic clinic, finding a positive relationship between knowledge scores and higher education levels and White ethnicity. Attitude scores differed by sex, with females scoring higher, whereas higher income was associated with better knowledge scores. Sports history, personal history of concussion, and history of having a child with a concussion were not associated with knowledge scores (Lin et al., 2015). Using a comparable questionnaire tool developed to assess concussion awareness, knowledge, and experiences, Cusimano and colleagues (2017) found that education and income, along with older age and history of brain injury, similarly predicted higher knowledge scores.

Other public knowledge surveys around concussion have examined recognition of postconcussion syndrome (PCS) or overall symptom knowledge (Mulhern & McMillan, 2006). Using vignettes, Mulhern and McMillan required participants to generate symptoms of PCS, before allowing use of a checklist. Symptom identification was much improved with the checklist supplied, but this large boost in scores when provided with a set of choices suggested that at least some participants might be benefitting from guessing. Thus, such checklists of symptoms should be provided cautiously.

RELATIONSHIP BETWEEN CONFIDENCE AND KNOWLEDGE

Although an individual may view greater feelings of confidence as being associated with greater likelihood of success, much literature across the general population as well as health professions has found that to rarely be the case (e.g., Dunning, Heath, & Suls, 2004; Ehrlinger, Johnson, Banner, Dunning, & Kruger, 2008). Instead, confidence may be linked to a number of false indicators, such as familiarity with the information, whether or not that information is correct (Bjork, 1999; Kelley & Lindsay, 1993). Experts also tend to underestimate their own knowledge (Kruger & Dunning, 1999), although expertise may also be driven by modest confidence, such that lower confidence is associated with a desire for greater knowledge, and higher confidence with reduced information-seeking behaviors (Berner & Graber, 2008; Meyer, Payne, Meeks, Rao, & Singh, 2013).

Confidence has been explored in a handful of studies related to brain injury and concussion, but few have related confidence about knowledge to measurements of knowledge. Weber and Edwards (2012) assessed public knowledge of sports concussion using a survey with definite (*true* and *false*) and indefinite responses (*probably true* and *probably false*). Not only were knowledge scores poor, but participants with a history of concussion were more likely to provide definite responses, even though accuracy was no higher within this group. This effect was interpreted as a false sense of confidence in knowledge.

Several studies have examined confidence among professionals who serve individuals with TBI (e.g., speech–language pathologists, teachers, and nurses). Results revealed that even experienced professionals reported a lack of confidence in their knowledge and skills related to TBI and expressed a desire for more education and training (e.g., Dreer, Crowley, Cash, O'Neill, & Cox, 2016; Hux, Walker, & Sanger, 1996). However, these studies did not compare confidence to knowledge to determine whether those feelings of low or high confidence were founded in actual knowledge and skills. Oyesanya, Brown, and Turkstra (2017) surveyed nurses who worked with adults with TBI and found that the highest levels of confidence were associated with nurses who reported the least experience.

Confidence in concussion and TBI knowledge has not been differentially assessed in parents and students. An investigation of the concussion knowledge of parents of youth football players found that the majority of parents reported high levels of confidence that they could recognize symptoms of a concussion, but actual knowledge was much less consistent (Rieger, Lewandowski, Potts, Potter, & Chin, 2018). Parents were aware that too much activity could exacerbate symptoms, but distractor items were also endorsed, including a quarter of respondents agreeing that certain foods would complicate recovery. In addition, there was low awareness that protocols exist for management of concussion and return-to-play decisions. Parents instead described returning to sports after a specific period of time (such as 1 week), rather than making decisions based on symptom resolution and a return-to-play progression.

CURRENT STUDY

The goals of the current study were to: (1) compare knowledge about TBI and concussion in parents and students, using a sample drawn from the general public that was not necessarily associated with an athletic program; (2) determine whether demographic factors predicted knowledge; and (3) compare confidence ratings with knowledge for both TBI and concussion across types of participants.

METHODS

Participants

Participants older than 10 years were recruited at a state brain injury association booth at a large science expo. The expo is a free, single-day event held each spring that attracts students and parents to see and experience science. Exhibits cover a range of topics from biological, chemical, engineering, and social science fields. Examples of activities include touching reptiles, learning the aerodynamics of jet engines, operating robots, and mixing chemicals to create playdough (Atlanta Science Festival, 2017). It was held in Centennial Park, a large park in downtown Atlanta that was first created during the 1996 Summer Olympic Games, and now serves as public green space and as a venue for music events, fairs, and festivals. It is surrounded on several sides by museums and is considered an anchor of downtown Atlanta. In 2017, there were over 100 exhibitors at the Science Expo, including local universities, associations, and health care facilities. Approximately 19,000 people attended. The event targets populations underrepresented in science, technology, engineering, and mathematics fields, and according to the expo annual report, the overall racial and ethnic makeup of the festival expo reflected similar diversity to the metro area. According to Science Expo data, 36.5% of attendees described themselves as White/Caucasian, 33% Black/African American, 8.6% Hispanic/Latino, 8.9% Asian, and 13% other (Atlanta Science Festival, 2017). Census data from 2018 for this area lists White/Caucasians as 40.1% of the population, Black/African American as 52.3%, Hispanic/Latino as 4.6%, and Asian as 4.0% (U.S. Census Bureau, 2019). Families, students, afterschool programs, community groups, and educators often attend this event.

A sign above the brain injury association booth explained the study. Research assistants stood in front of the booth and recruited participants by explaining the purpose of the study and eligibility criteria. Participants were required to be older than 10 years, and to be able to read and complete the survey independently. Research assistants then asked potential participants whether they wanted to take a 5-min survey to test their knowledge of brain injury and concussion, and explained that a drawstring backpack was available as an incentive. The booth also contained contact information for the brain injury association and formalin sheep brains that fair attendees could view or touch.

Two hundred forty-six fair attendees consented to participate and completed the survey (an additional three were recruited but chose not to participate after reading the consent screen). Participant ages ranged from 10 to 65 years, including 157 females (64.1%) and 88 males (35.9%). This gender disparity reflects that the event overall attracts more females than males (females = 60%, Atlanta Science Festival, 2017). Although the focus of this research study was to compare knowledge in parents and students, a number of other adults attended the fair with students. Therefore, the survey tool also asked participants to describe themselves as either students, parents, grandparents, educators, or other adult. Table 1 describes demographic information by age group. Using the χ^2 test of homogeneity, there were no statistically significant differences in distributions between these groups by sex ($p = .481$), TBI or concussion history ($p = .235$), or knowing someone with a TBI or concussion ($p = .681$). As expected, students were more likely to be participating in sports, $\chi^2(4, N = 246) = 10.766$ ($p = .029$).

Procedures

All procedures were approved by a university institutional review board and all data

Table 1. Demographic characteristics of sample ($N = 246$)[a]

	Student ($n = 147$)	Parent ($n = 61$)	Grandparent ($n = 8$)	Educator ($n = 17$)	Other Adult ($n = 13$)
Demographics					
Age	14.41 (5.11)	39.40 (6.93)	57.50 (5.53)	40.64 (8.41)	33.31 (6.84)
Sex					
Female	91 (61.90%)	39 (63.93%)	6 (75.00%)	14 (82.35%)	9 (69.23%)
Male	56 (38.10%)	22 (36.07%)	2 (25.00%)	3 (17.65%)	4 (30.77%)
Sports history[b]					
None	28 (19.05%)	24 (39.34%)	3 (37.50%)	5 (29.41%)	3 (23.08%)
Yes, currently	67 (45.58%)	7 (11.48%)	1 (12.50%)	1 (5.88%)	1 (7.69%)
Yes, in the past	52 (35.37%)	30 (49.18%)	4 (50.00%)	11 (64.71%)	9 (69.23%)
Concussion or BI history					
None	124 (84.35%)	52 (85.25%)	7 (87.50%)	15 (88.24%)	8 (61.54%)
Concussion	15 (10.20%)	6 (9.84%)	0 (0.00%)	1 (5.88%)	4 (30.77%)
Brain injury	8 (5.44%)	3 (4.92%)	1 (12.50%)	1 (5.88%)	1 (7.69%)
Know someone with BI or concussion					
None	62 (42.18%)	26 (42.62%)	2 (25.00%)	5 (29.41%)	4 (30.77%)
Concussion	48 (32.65%)	13 (21.31%)	2 (25.00%)	5 (29.41%)	4 (30.77%)
Brain injury	30 (20.41%)	20 (32.79%)	4 (50.00%)	5 (29.41%)	3 (23.08%)
Both	6 (4.08%)	2 (3.28%)	0 (0.00%)	2 (11.76%)	2 (15.38%)

Note. BI = brain injury.
[a]Age is given in mean years (standard deviation). All others represent frequency (%).
[b]Students were more likely than other groups to be involved in sports. There were no group differences by either having a history of TBI or concussion, or knowing someone with a history of traumatic brain injury or concussion.

were collected at the brain injury association booth at the Science Expo. Because this was a low-risk study that did not collect identifying information, parental consent was waived. Participants completed an electronic survey using iPads supplied by research assistants. The survey was presented via Qualtrics software and included five screens: consent, demographics, knowledge and confidence questions about TBI, knowledge and confidence questions about concussion, and a thank you screen. Research assistants explained the consent screen, including the purpose, risks, benefits, that the study was voluntary, and contact information for questions. Participants could then select "No, I do not want to participate," or "Yes, I would like to participate" to advance to either a thank you screen, or the demographics page, respectively. After completing the study, participants received a drawstring backpack that contained a flyer explaining the study and the answers to the survey questions.

Survey materials

Demographics

Participants responded to questions about basic demographic information (age, demographic group, and county of residence), and experiences that could affect TBI and concussion knowledge, specifically sports history, TBI and concussion history, and knowing a person with TBI or concussion.

TBI knowledge and confidence

To assess TBI knowledge, 10 statements were drawn from the CM-TBI survey of TBI knowledge (Gouvier, et al., 1988; Hux et al., 2006; Linden et al., 2013; Schellinger et al., 2018). Statements were selected to reflect the most salient information about TBI, and were edited for clarity for the wide range of readers completing this survey. Participants rated statements dichotomously as true or false to simplify administration and for the survey to resemble materials familiar to students. For the final question at the bottom of the screen, participants rated their confidence that their responses were correct using a slider from 0 to 100, with 0 meaning no confidence and 100 meaning complete confidence. The 10 statements are provided in Table 2.

Concussion knowledge and confidence

Ten statements about concussion were selected and adapted from the RoCKAS (Rosenbaum & Arnett, 2010). As with the CM-TBI, adaptations were made to clarify terminology and to make the questions accessible to a wide range of readers. Questions similar to those in the CM-TBI were not included (e.g., "After a concussion, people can forget who they are and not recognize others but be perfect in every other way" closely resembles an item on the CM-TBI). As with the TBI subscale, participants selected true or false for each statement, and then rated the level of confidence in their responses about concussion in a final question that was identical to the TBI confidence question. Table 3 lists the concussion statements.

Analyses

Items on the TBI and Concussion Knowledge Questionnaires were scored as one for correct, and zero for incorrect. Each participant could score up to 10 on each subscale (TBI and Concussion), with a total range possible of 0 to 10 for a single subscale. Lower scores indicate poorer knowledge, and higher scores indicate greater knowledge. The total number of correct responses and the percent correct for each item was calculated, as well as a percent correct score for each participant on the subscales. For confidence, each participant rated themselves on the 0% to 100% scale once for TBI and once for the concussion subscale. Demographic groups (students, parents, grandparents, educators, and other adults) were maintained, but all other demographic factors were collapsed into dichotomous variables, measuring these characteristics as either present or absent. For example, knowing someone with a TBI, concussion, or both was all coded as present, and not knowing someone with either a TBI or concussion was coded as absent. Sports participation and history of TBI or concussion were similarly coded.

Statistical analysis overview

SPSS Statistics version 24 was used for statistical analyses. For knowledge outcomes, between-group differences were first assessed using a one-way analysis of variance (ANOVA). For significant models, post hoc testing with correction using either Tukey for equal variances or Games-Howell correction for unequal variances was applied. Next, linear regression was used to identify predictors of TBI and concussion knowledge separately. For these analyses, total correct score for each subscale was the dependent variable. Independent variables were demographic group (students, parents, grandparents, educators, other adults), sports participation (present, absent), personal history of TBI or concussion (present, absent), and knowing someone with a history of TBI or concussion (present, absent). A paired t test was used to compare overall TBI and concussion knowledge scores, followed by within-groups comparisons.

Pearson correlations were used to assess outcomes for concussion and moderate–severe TBI knowledge and confidence about knowledge. In order to determine whether any particular demographic characteristics were associated with a stronger relationship of confidence to knowledge, general linear models predicting knowledge scores from a combination of confidence, demographic characteristic, and an interaction of the two were analyzed.

To examine whether any of the questions were more difficult for the respondents than other questions, a mixed-effects logistic

Table 2. Accuracy of knowledge by question and group for moderate to severe brain injury

	Student *n* (%)	Parent *n* (%)	Grandparent *n* (%)	Educator *n* (%)	Other Adult *n* (%)
1. It is obvious that someone has brain damage because they look different from people who do not have brain damage. (F)	127 (86.39%)	51 (83.61%)	8 (100.00%)	17 (100.00%)	12 (92.31%)
2. It is possible that a person's personality will change after a brain injury. (T)	123 (83.67%)	51 (83.61%)	7 (87.50%)	15 (88.24%)	12 (92.31%)
3. People in a coma are usually not aware of what is happening around them. (T)	82 (55.78%)[a]	20 (32.79%)	3 (37.50%)	6 (35.29%)	6 (46.15%)
4. Even after several weeks in a coma, when people wake up, most recognize and speak to others right away. (F)	108 (73.47%)	40 (65.57%)	5 (62.50%)	13 (76.47%)	9 (69.23%)
5. Brain injuries may cause one to feel depressed, sad, and hopeless. (T)	117 (79.59%)	57 (93.44%)[b]	7 (87.50%)	15 (88.24%)	13 (100.00%)
6. Sometimes a second blow to the head can help a person remember things that were forgotten. (F)	80 (54.42%)	34 (55.74%)	4 (50.00%)	9 (52.94%)	8 (61.54%)
7. A person with brain injury may have trouble remembering events that happened before the injury, but usually does not have trouble learning new things. (F)	47 (31.97%)	19 (31.15%)	6 (75.00%)	7 (41.18%)	4 (30.77%)
8. People who have survived a brain injury can forget who they are and not recognize others, but be normal in every other way. (F)	36 (24.49%)[a]	6 (9.84%)	1 (12.50%)	5 (29.41%)	0 (0.00%)
9. Once a person is able to walk again, his or her brain is almost fully recovered. (F)	97 (65.99%)	52 (85.25%)[b]	7 (87.50%)	15 (88.24%)	13 (100.00%)
10. How quickly a person recovers depends mainly on how hard they work at recovering. (F)	77 (52.38%)	36 (59.02%)	5 (62.50%)	12 (70.59%)	11 (84.62%)
Total TBI knowledge	894 (60.82%)	366 (60.00%)	53 (66.25%)	114 (67.06%)	88 (67.69%)
Mean TBI confidence[c]	56.57% (26.08)	60.03% (22.70)	68.25% (21.32)	58.35% (24.36)	59.00% (21.33)

Note. TBI = traumatic brain injury.
[a]Students were more likely than parents to respond to these items correctly.
[b]Parents were more likely than students to respond to these items correctly.
[c]Data are presented as mean percent (standard deviation).

Table 3. Accuracy of knowledge by question and group for concussion

	Student *n* (%)	Parent *n* (%)	Grandparent *n* (%)	Educator *n* (%)	Other Adult *n* (%)
1. There is a possible risk of more serious injury or death if a second concussion occurs before the first one has healed. (T)	128 (87.07%)	58 (95.08%)	6 (75.00%)	16 (94.12%)	13 (100.00%)
2. In order to be diagnosed with a concussion, you have to be knocked out. (F)	130 (88.44%)	56 (91.80%)	8 (100.00%)	16 (94.12%)	13 (100.00%)
3. A concussion can only occur if there is a direct hit to the head. (F)	74 (50.34%)	39 (63.93%)	6 (75.00%)	13 (76.47%)	11 (84.62%)
4. Being knocked unconscious always causes permanent damage to the brain. (F)	113 (76.87%)	44 (72.13%)	6 (75.00%)	16 (94.12%)	10 (76.92%)
5. Symptoms of a concussion can last for several weeks. (T)	127 (86.39%)	57 (93.44%)	8 (100.00%)	17 (100.00%)	13 (100.00%)
6. After a concussion happens, brain imaging like CAT scan or MRI shows visible damage to the brain. (F)	47 (31.97%)	20 (32.79%)	4 (50.00%)	2 (11.76%)	3 (23.08%)
7. People who have had one concussion are more likely to have a second one. (T)	60 (40.82%)	40 (65.57%)[a]	4 (50.00%)	10 (58.82%)	7 (53.85%)
8. If you receive one concussion and you have never had a concussion before, you will become less intelligent. (F)	125 (85.03%)	57 (93.44%)[a]	7 (87.50%)	15 (88.24%)	12 (92.31%)
9. After 1–3 weeks, symptoms of a concussion are usually completely gone. (T)	63 (42.86%)[b]	14 (22.95%)	3 (37.50%)	5 (29.41%)	8 (61.54%)
10. There is rarely a risk to long-term health and well-being from multiple concussions. (F)	88 (59.86%)	46 (75.41%)[a]	6 (75.00%)	14 (82.35%)	10 (76.92%)
Total correct responses	955 (64.97%)	431 (70.66%)	58 (72.50%)	124 (72.94%)	100 (76.92%)
Mean concussion confidence[c]	49.93% (26.26)	60.97% (22.99)	72.00% (20.17)	59.41% (25.33)	58.46% (23.14)

[a]Parents were more likely than students to respond to these items correctly.
[b]Students were more likely than parents to respond to these items correctly.
[c]Data are presented as mean percent (standard deviation).

regression model was used. This analysis was limited to the student and parent comparison, given small participant numbers in the other demographic subgroups. The logistic regression considered whether or not a question was answered correctly, and a mixed-effect model was used to account for each participant having multiple responses (one for each question) rather than just one response in the data set. This analysis was completed to determine whether the distribution of percentage correct by question was similar or different when comparing students to parents.

RESULTS

TBI knowledge

A one-way ANOVA was conducted to determine whether TBI knowledge differed by group (see Table 2 for means). Differences between groups were not statistically significant, $F_{(4, 241)} = 1.309$, $p = .267$, such that TBI knowledge scores were consistent across students, parents, grandparents, educators, and other adults. A linear regression was then run to predict TBI knowledge from sports participation, history of TBI or concussion, and knowing someone with TBI or concussion. Given that scores did not vary across age groups, this variable was not included in the model. Nonsignificant predictors were removed from the model using backward elimination. After backward elimination, the final model, $F_{(3, 242)} = 6.114$, $p < .001$, adjusted $R^2 = 0.059$, included only knowing someone with TBI or concussion as a significant positive predictor of TBI knowledge ($\beta = .706$, $p < .001$).

Concussion knowledge

To examine between-group differences in concussion knowledge, a one-way Welch ANOVA was conducted. Concussion knowledge was statistically significantly different by group, Welch's $F_{(4, 31.722)} = 6.532$, $p < .001$. Games-Howell post hoc analysis revealed that the mean difference between student and parent knowledge scores (−0.593, 95% confidence interval, CI [−1.16, −0.03]) was statistically significant ($p = .036$), as well as the mean difference between students and other adults (−1.186, 95% CI [−1.91, −0.46], $p < .001$). Both parents and other adults had greater accuracy on the concussion knowledge subscale than students (see Table 3 for summary of means). All other comparisons were nonsignificant. Group, sports participation, history of TBI or concussion, and knowing someone with TBI or concussion were all entered into a linear model to predict concussion knowledge. After backward elimination, both group ($\beta = -.245$, $p = .002$) and knowing someone with TBI or concussion ($\beta = .548$, $p = .004$) statistically contributed to the final model, $F_{(4, 241)} = 6.091$, $p < .001$, adjusted $R^2 = 0.077$. The other two factors (i.e., sports participation and history of TBI or concussion) did not. Follow-up testing for group, knowing someone, and the interaction revealed effects remained for knowing someone ($\beta = .621$, $p < .001$), but were only significant for the group of students ($\beta = -.686$, $p < .001$). In this model, variance accounted for increased slightly, $F_{(3, 242)} = 13.964$, $p < .001$, adjusted $R^2 = 0.096$.

TBI versus concussion knowledge

To determine whether there was an overall difference in knowledge of concussion and knowledge of moderate–severe TBI, a paired *t* test was used. Mean concussion scores ($M =$ 66.80%, $SD = 14.77$) were greater than those of TBI ($M =$ 60.10%, $SD = 15.51$), $t_{(244)} = -5.405$, $p < .001$. Within groups paired *t* tests were used to compare knowledge for each group (see Figure 1; means and standard deviations are provided in Table 2 for TBI and Table 3 for concussion). There were no differences in TBI and concussion knowledge scores for educators, $t_{(16)} = -1.829$, $p = .08$, or grandparents, $t_{(7)} = -1.488$, $p = .180$. Concussion knowledge scores were greater than TBI knowledge scores for students, $t_{(147)} = -2.598$, $p = .01$, parents, $t_{(59)} = -5.094$, $p < .001$, and other adults, $t_{(12)} = -2.520$, $p = .03$.

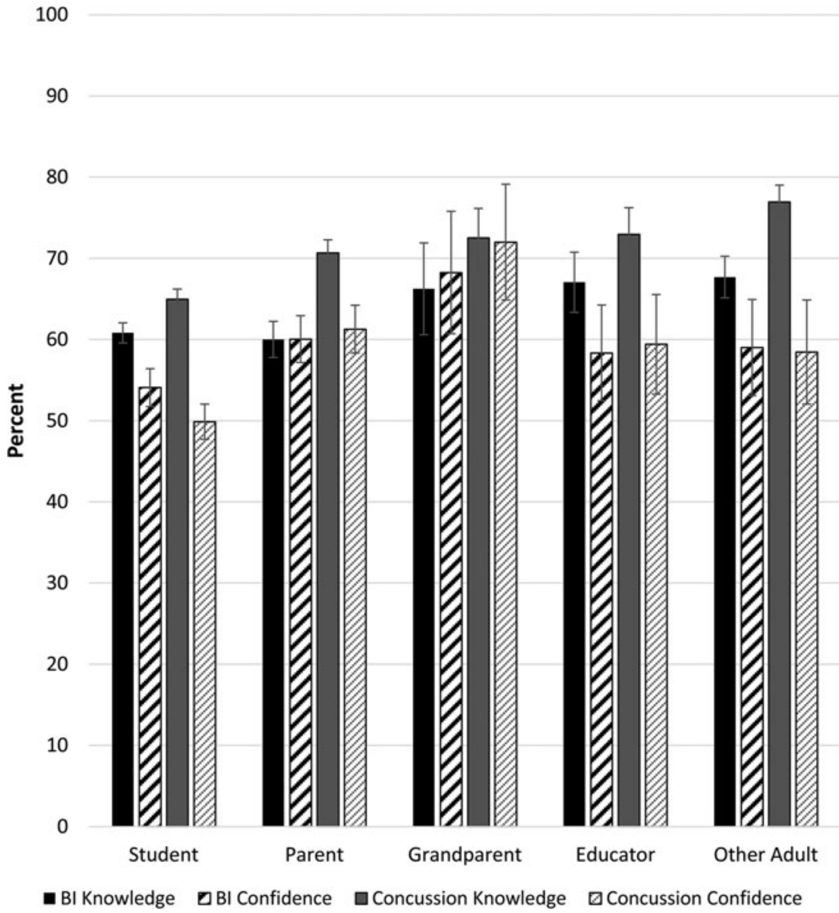

Figure 1. Mean knowledge and confidence by group for brain injury and concussion. *Note:* Error bars represent ± 1 *SD*.

Item-level responses by students and parents

Student and parent responses to each item were considered using mixed-effects logistic regression models. The other groups were removed from this analysis because of low numbers, and to focus on the relationship between student and parent knowledge. For TBI knowledge, there were no overall differences in terms of the probability of getting a question correct across the participant types ($F_{(1, 316)} = 0.18$, $p = .68$), but there were overall differences in terms of the probability of getting a question correct by question ($F_{(9, 2050)} = 31.36$, $p < .001$). There was also an interaction of participant type and question ($F_{(9, 2050)} = 3.32$, $p < .001$), indicating that the questions that participants were more likely to answer correctly varied according to the type of participant. Post hoc comparisons indicated that the likelihood that participants would respond correctly was significantly different based on participant type (student or parent) for questions 3, 5, 8, and 9. Students were more likely to answer questions 3 ($t_{(2050)} = 3.02$, $p = .003$) and 8 ($t_{(2050)} = 2.63$, $p = .009$) correctly (i.e., to agree that people in comas have low awareness of surroundings, and to reject that people may experience amnesia but appear otherwise uninjured). Parents were more likely to answer questions 5 ($t_{(2050)} = -3.52$, $p < .001$) and 9 ($t_{(2050)} = -3.39$,

$p = .001$) correctly (i.e., to agree that people may experience emotional effects following brain injury, and to reject that walking is an indicator of complete recovery). See Table 2 for item-level responses for brain injury by group.

When considering concussion knowledge, there were overall differences in terms of the probability of correctly responding to questions across the participant types ($F_{(1, 418)} = 8.42$, $p = .004$), and an overall difference in terms of the probability of getting a question correct by question ($F_{(9, 2050)} = 31.40$, $p < .001$). There was also an interaction of participant type and question ($F_{(9,2050)} = 3.06$, $p = .001$), indicating an overall difference in the probability of answering questions correctly between students and parents, but the question that participants are more likely to answer correctly varies according to the type of participant.

Post hoc comparisons indicate that the likelihood that participants would answer correctly was significantly different based on participant type (student or parent) for questions 7, 8, 9, and 10. Students were more likely to answer question 9 correctly ($t_{(2050)} = 3.22$, $p = .001$), agreeing that after 1–3 weeks, symptoms from concussion have usually resolved. Parents were more likely to answer questions 7 ($t_{(2050)} = -3.24$, $p = .001$), 8 ($t_{(2050)} = -0.43$, $p = .015$), and 10 ($t_{(2050)} = -2.44$, $p = .015$) correctly. Specifically, parents were more likely than students to correctly agree that there are risks of sustaining future concussions after a first event, reject that intelligence is affected by concussion, and reject that there are rarely risks of long-term consequences from multiple concussions. Table 3 includes item-level responses for concussion by group.

Confidence

One-way ANOVAs were used to examine group differences in ratings of TBI and concussion confidence. For TBI confidence, differences between groups were not statistically significant, $F_{(4, 241)} = 1.042$, $p = .386$. Students, parents, grandparents, educators, and other adults—all gave similar confidence ratings for TBI knowledge. For concussion confidence, differences were present between groups, $F_{(4, 241)} = 3.431$, $p = .009$. Post hoc testing with a Tukey correction revealed the mean difference between student and parent confidence scores (−11.034, 95% CI [−21.65, −0.47]) was statistically significant ($p = .036$). Students were less confident in their responses about concussion than parents. No other groups statistically differed from each other (see Figure 1).

Pearson correlations were used to assess outcomes for concussion and moderate–severe TBI knowledge and confidence about knowledge. TBI knowledge did not correlate with confidence ($r_{(246)} = .003$, $p = .959$). Concussion knowledge correlated with confidence ($r_{(246)} = .126$, $p = .048$), so that higher confidence ratings were weakly associated with higher knowledge scores.

General linear models predicting TBI knowledge scores from a combination of TBI confidence, a demographic characteristic, and an interaction of the two were considered. There was no evidence for a different relationship of confidence with knowledge according to group ($F_{(4, 235)} = 1.293$, $p = .273$), sports participation ($F_{(2, 239)} = 0.241$, $p = .786$), history of TBI or concussion, ($F_{(2, 239)} = 0.471$, $p = .625$), or knowing someone with TBI or concussion ($F_{(3, 237)} = 0.761$, $p = .761$). The same was also true of concussion for each of the four demographic predictors: group ($F_{(4, 235)} = 0.540$, $p = .707$), sports participation ($F_{(2, 239)} = 1.030$, $p = .358$), history of TBI or concussion ($F_{(2, 239)} = 1.677$, $p = .189$), or knowing someone with TBI or concussion ($F_{(3, 237)} = 1.621$, $p = .185$). In sum, none of the demographic variables predicted the relationship between confidence and knowledge.

DISCUSSION

This study aimed to describe knowledge patterns about TBI and concussion in the general public, and to consider how that knowledge was related to ratings of confidence. Participants ranged from 10 to 65 years old, and represented primarily students and parents, but also small samples of educators, grandparents, and other adults. To our knowledge, this was the first study to compare knowledge and confidence across TBI and concussion. In addition, it was also notable that we targeted the general public, regardless of current involvement in organized athletics as had been the focus of previous research. Furthermore, it was unique in comparing knowledge between children as young as 10 years and their parents, as much of the previous literature has examined knowledge about TBI and concussion only among adults. Our interest in confidence as compared with knowledge was to consider how well placed that confidence may be, as well as how receptive this audience may be to education efforts. Results provide a snapshot as to how information about TBI and concussion may be reaching and understood by the general public, and how open the public may be to educational efforts.

TBI knowledge

There were no differences across groups in TBI knowledge. Group means hovered around 60% accuracy (see Table 2), suggesting that similar information about TBI is reaching (or perhaps, not reaching) all of these groups. Only knowing someone with a history of concussion or brain injury was associated with higher scores, adding about 7% of accuracy to score totals. No other predictors were significantly associated with change in TBI knowledge scores. Some other investigations have similarly found that knowing someone with TBI is associated with higher knowledge scores, either personal (Hux et al., 2006) or professional (Schellinger et al., 2018). It is unclear whether this relationship is driven by direct observation of the effects of TBI, or whether someone who has a personal connection to the injury may be more likely to seek out resources, or to engage with resources when encountered (or perhaps some combination of these). Either way, this finding is consistent with the literature on TBI knowledge in the general public, and may be an avenue in which people are particularly open to education.

Item-by-item analysis showed that students responded with greater accuracy as compared with parents on two statements—"People in a coma are usually not aware of what is happening around them," and "People who have survived a brain injury can forget who they are and not recognize others, but be normal in every other way" (see Table 2). In both cases though, student accuracy was low (55% and 24%, respectively), thus reflecting that students may not have had *more knowledge*, but rather, *less incorrect knowledge*. In a dichotomous response variable, accuracy around 50% indicates likelihood of some guessing, and students may not have known enough about comas to know if someone was aware of their surroundings or not. In contrast, parent mean accuracy of 33% suggests that parents were somewhat more *sure* of the incorrect response. Similarly, parents as a group appeared to have the misconception that severe, isolated retrograde amnesia is a common consequence of TBI, as accuracy was very low for the parents on the forgetting others item at just 10% correct. A quarter of students correctly rejected this item. Although periods of retrograde amnesia do occur following TBI, this is typically restricted to the period just prior to the injury (Capruso & Levin, 1992). Loss of self-identity or the ability to recognize well-known friends and family is quite rare. Such severe retrograde amnesia also typically occurs in the setting of a wide range of cognitive (and possibly physical deficits), rather than a person who is "normal in every other way" (Vakil, 2005). This item has been shown to be consistently missed in the general public (Gouvier et al., 1988; see Hux et al., 2006 for discussion; Merz et al., 2016; Willer, Johnson, Rempel, & Linn, 1993; see Rosenbaum & Arnett, 2010 for similar response in high school students on an adapted concussion item), and is believed to reflect the influence of media representations of TBI, in that having a character seeking his or her identity after a blow to the head is a common narrative device. With their younger age, students may have had less exposure to this inaccuracy than parents.

Parents were more accurate than students also on two items—namely, “Brain injuries may cause one to feel depressed, sad, and hopeless,” and “Once a person is able to walk again, his or her brain is almost fully recovered.” In contrast to the previous discussion, in both of these cases, means were well above 50%, so that parents had more knowledge than students (rather than fewer incorrect perceptions about TBI as with the student-favored items). At 93% accuracy, parents were more aware of the emotional consequences of TBI. Parent accuracy aligns well with other measures of this item (e.g., also 93% correct in Schellinger et al., 2018), although student responses did indicate good awareness of this consequence, with 80% of students correctly identifying this statement as true. Emotional consequences of concussion are often the symptoms least likely to be identified (Cusimano et al., 2017; Dreer et al., 2016), but these respondents had good awareness that emotional changes may occur following a more significant injury. Students were more likely to incorrectly associate ambulation with recovery, and were just 66% accurate in their responses to this statement. Parents may have had more perspective on the complexity of the injury, and that walking was a unitary skill that may or may not be reflective of overall recovery.

Concussion knowledge

Both being a student and knowing someone with TBI were associated with performance on the concussion subscale. Being a student reduced scores, whereas knowing someone increased scores. However, this model accounted for just 9.6% of the variance in concussion scores, suggesting other information that was not accounted for by our predictors would add value to our understanding of concussion knowledge. Other studies have found associations between education, socioeconomic status, and race on measures of knowledge (Cusimano et al., 2017; Lin et al., 2015) that may have added predictive value here.

Although we found that parents and other adults have greater knowledge than students about concussion, students performed fairly well overall, and even had higher accuracy on one item as compared with parents. Differences by group on concussion knowledge may indicate that parents and other adults have greater access or awareness of concussion than students. That this difference did not appear on the TBI subscale suggests similar access (or rather, lack of access) across groups to information about TBI. Adults may be more likely to encounter media reports about concussion, or to alert to this information when considering the safety of their children or others.

Parents responded with greater accuracy than students on three items—“People who have had one concussion are more likely to have a second one,” “If you receive one concussion and you have never had a concussion before, you will become less intelligent,” and “There is rarely a risk to long-term health and well-being from multiple concussions” (see Table 3). For the increased likelihood of a second concussion, parents were 66% accurate. Student accuracy of 41% is similar to that of Rosenbaum and Arnett’s original sample of high school students, who were 46% accurate (Rosenbaum and Arnett, 2010). Given that this is an item that directly relates to prevention of future injuries within a high-risk group (those with a history of concussion), these levels of accuracy suggest a targeted need for education. Prior research also supports the need for education regarding the risk of subsequent concussion. For example, surveys of coaches and athletes who received concussion education revealed better performance on this item, with accuracy ranging from 77% to 94% (Anderson, Gittelman, Mann, Cyriac, & Pomerantz, 2016; Hildenbrand, Richards, & Wright, 2018; Kroshus, Kerr, DeFreese, & Parsons, 2017), suggesting the effectiveness of education around subsequent risks.

Both parents and students scored well on the item regarding intelligence, although students were not as likely as adults to correctly reject this item (85% accuracy vs 93%, respectively). Parents were also more accurate at recognizing risks to long-term health from multiple concussions, with 75% of parents correctly responding to this question, as compared with just 60% of students. For both groups, these numbers are lower than those reported for groups that would be expected to have encountered formal education on concussion (e.g., Chapman et al., 2018; Hildenbrand et al., 2018). The lower accuracy in the current sample may reflect the public attempting to interpret media reports about long-term effects of multiple concussions and being unclear on how that balances with recovery after concussion. Alternatively, this could also reflect differences in concussion education within this sample that were not accounted for in our demographic information, although sports participation (and perhaps greater access to education through that involvement) was not associated with concussion scores overall.

Students outscored parents on the item stating, "After 1–3 weeks, symptoms of a concussion are usually completely gone," although as with the TBI items on which students favored parents, this also appears to be a case of the students being less likely to be wrong, with 43% of students responding correctly that symptoms should have resolved within this frame, as compared with just 23% of parents. This item has had low accuracy across other studies as well, and was an item modified for this survey to reflect that recent research has challenged the 10-day timeline to recovery that was originally written into the RoCKAS (McCrory et al., 2017). Our survey reflected a more liberal window of time to recovery, yet our participants responded with similar accuracy to the previously cited investigations using the RoCKAS. Rosenbaum and Arnett (2010) found a much higher rate of accuracy at 53%, suggesting that concerns about the window of recovery may have increased over time. Although the item does not indicate in which direction parents and students may be erring, as in, do participants believe that concussions resolve more quickly versus more slowly, participants in both groups agreed with item 5, that it can take weeks to recover from a concussion. Agreeing with the longer time frame, and disagreeing with the 1- to 3-week time frame, suggests participants are overestimating typical recovery timelines.

Item 6, that imaging reveals changes in the brain after concussion, evinced poor performance from both groups, and is a consistent misperception about concussion. Because imaging is often performed in emergency departments when a person presents with a possible head injury, the public may believe this tool to an important diagnostic component. Imaging is typically used to rule out more significant injuries though, and the possible need for emergent neurosurgical intervention (McCrory et al., 2017). Such misperceptions may lead to confusion as to whether or not a concussion has occurred, particularly because neuroimaging reveals clinical findings in few concussions or mild TBIs (Jagoda et al., 2002; Lange et al., 2012). Increased understanding of diagnosis of concussion could lead to better management afterward as well.

TBI and concussion knowledge

Overall, performance was higher on the concussion subscale than on the TBI subscale. This finding should be interpreted with some caution, as questions were not necessarily balanced across the two subscales. Both reflected commonly used tools, but the questions do not necessarily mirror each other in terms of salience, and so comparison may be limited. It is of some note though, that groups did not differ on the TBI knowledge, but differences were present between students as opposed to parents and other adults on the concussion scale. This suggests a fairly even exposure to information about TBI as a whole, with the two items on which students outperformed adults, revealing some misperceptions that had not yet fully formed. On the other hand, differences between groups on the concussion scale do indicate that parents and other adults are accessing information that students are not, or not yet. Students may encounter information about concussion in the media less than adults. The fact that differences between students and grandparents or educators were not observed may be due to small sample sizes in those groups that a larger study could reveal. Figure 1 shows trends toward all adults knowing more about concussion than students.

Confidence

Participants overall had moderate levels of confidence, suggesting openness to learning more about TBI and concussion. Confidence measures showed weak associations with concussion knowledge only, and were not associated with TBI knowledge, confirming that feelings of confidence are not associated with actual knowledge. This dissociation, or very weak association, between thinking that knowledge is correct and actual measures of correct knowledge has been observed previously (Rieger et al., 2018; Weber & Edwards, 2012), but not in parents and students. Confidence is a false indicator of knowledge, and belief in confidence can reduce behaviors associated with increasing knowledge. Essentially, why seek out knowledge if you think you already have the knowledge? Perhaps encouragingly, students had the lowest levels of confidence for both TBI and concussion knowledge (see Figure 1), although only concussion was significantly different than other groups, and was only different as compared with parents (again, detection of differences between students and other groups may have been limited by the smaller sample sizes in those groups). This underconfidence in students was well placed, as students also had lower knowledge scores than parents. The fact that students were unsure about their responses indicates that students may be in a cognitive set appropriate to learning about concussion, and the lack of confidence may represent an opportunity to increase knowledge.

Implications for future research on public knowledge of TBI and concussion

Taken together, the findings of the current study suggest that although the general public demonstrates fairly good knowledge about certain aspects of brain injury, important gaps in the public's knowledge base continue to exist, including endorsement of a variety of misconceptions about injury and recovery. Although we collected data on predictors believed to be associated with TBI and concussion knowledge, these had little relation to our outcomes. Although certain demographic variables were predictive of knowledge (i.e., knowing someone with TBI or concussion and status as a parent in the case of concussion knowledge), the variance accounted for in our models was low. This suggests that other demographic variables may be important predictors of knowledge and/or that other ways of coding our demographic variables might have resulted in increased predictive power.

For example, it is possible that the nature of the relationship with someone with brain injury impacts knowledge. This study, as was the case in many previous studies, coded knowing someone with brain injury as a dichotomous variable, due to a need to keep the survey short. However, this kind of personal experience exists on a continuum. Thus, participants in this sample may have had diverse experiences, from having close contact with an immediate family member with brain injury to a single interaction with a more distant acquaintance with brain injury. It is possible that more fine-grained coding of the degree and nature of experience with someone with brain injury might have resulted in a larger effect and more nuanced results. Future research should examine this possibility, as it may inform future educational campaigns about the potential benefit of involving individuals with TBI in the provision of education.

We found relatively little impact of participant group on knowledge. Given that students could attend this expo with a variety of adults, we asked adults to categorize themselves into parents, grandparents, educators, and other adults. Parents made up the largest group, but some of our analyses of the other categories of adults were likely limited by low numbers within these groups. Future work may explore how parents compare to other stakeholders such as educators or grandparents with greater sensitivity to differences in knowledge than were achieved here.

Future research could also include a wider range of possible predictor variables. Because of the setting of this survey, we assumed many students may attend the science expo without a parent present (e.g., students may attend with after-school programs, relatives, or with a group of friends) and may not be accurate reporters of some factors previously found to be associated with knowledge scores, such as parent education level or socioeconomic status. Similarly, an additional limitation is that we did not ask participants to report their racial or ethnic background. It was not a particular goal of this study to explore the role of race or ethnicity in regard to concussion or brain injury knowledge; instead, we sought to capture a snapshot of the general public that was not associated with sports or health care settings. If we had collected this data, it may have been a strength of this study because the expo data suggest that our sample likely included a range of student and parent backgrounds in regard to this demographic descriptor. Relatively little previous research has specifically targeted ethnic and racial minorities, but there is some evidence that individuals with TBI who are non-U.S. born or speak Spanish as a primary language may have greater educational needs about TBI than the general public (Pappadis, Sander, Struchen, Leung, & Smith, 2011).

Another important variable that may impact knowledge is previous educational experiences about TBI and concussion. Concussion education is now required as part of return-to-play laws. These laws typically mandate concussion education for athletes, but the education may take many forms—pamphlets, webinars, verbal information from team representative, or a signed form—and address many different areas of concussion knowledge, from definitions to prevention and treatment (Baugh et al., 2014). Due to time constraints, our survey did not ask about education sources, if participants had participated in previous training about concussion or brain injury, or had encountered information about either through media sources. Better understanding about the impact of various forms of education on knowledge would help improve the design and format of educational initiatives.

The current study also has implications for the design of survey instruments used to examine public knowledge of TBI and concussion. To resemble materials familiar to students, we designed our survey to include only *true* and *false* as options for responses to items. Participants were therefore faced with a forced choice, and could have randomly selected a response. If we presume that guessing would result in accuracy in range of 50%, our data (see Tables 2 and 3) suggest that this was largely not the case. Given the number of respondents, a few items do suggest that participants were unsure (such as item 6 from the brain injury set, which posits that a second blow to the head can resolve problems from the first), but most items show the sample tending toward a particular response. Response accuracy on individual items also resembled other published literature, suggesting that the simplification of the item responses to a binomial forced choice resulted in valid results. However, using a 5-level disagree-to-agree scale with a neutral central item likely would have produced a more nuanced picture of what students and parents report knowing and not knowing.

We also intentionally used instruments that have been well-documented in the literature, so that comparisons could be drawn between the results of the current study and the existing literature base. As a result, however, we were unable to capture knowledge about aspects of brain injury, which are not contained on these instruments. For example, neither the RoCKAS nor the CM-TBI contains items about communication challenges after brain injury, and each only addresses a few items related to cognitive outcomes. As a result, neither our study, nor the majority of the previous work on brain injury knowledge, can speak to the public's knowledge about these challenges, including the effects of cognitive impairments on discourse production and pragmatics. Thus, future research should examine public knowledge in these domains.

Finally, future research should examine validity of the survey items, particularly those contained within the CM-TBI. To our knowledge, only a single study has formally examined the validity of the CM-TBI. Linden et al. (2013) conducted a principal components analysis to examine the factor structure of the CM-TBI. Their findings suggested removing roughly half the items from the original survey that did not load onto any of the four factors. However, their analysis was performed on a version of the CM-TBI that was modified to refer only to pediatric TBI using responses from a narrow subset of the population—namely, educators in the United Kingdom. Therefore, we selected items from the full set of questions. Various other researchers have attempted to improve the clarity of the CM-TBI items through a variety of methods, including asking multidisciplinary health care providers to review items, modifying the wording based on expert opinion, and selecting items deemed most critical for the public to know (e.g., Springer et al., 1997). We selected items that had been previously modified for clarity, but it is still possible that the public's low accuracy on some items may relate, at least in part, to ambiguity or uncertainty regarding the wording of certain items. To explore this possibility, future work could examine qualitative data about participants' rationales for their responses on specific items.

Implications for education initiatives

The findings of the current study highlight the need for continuing efforts to educate the public, regardless of their involvement in athletics. However, relatively little is known about the optimal design and long-term effects of this education. The finding that involvement in athletics (and therefore probable receipt of some form of concussion education) was not associated with increased knowledge about TBI or concussion in either students or parents is concerning, although not necessarily unexpected given the results of previous research on the topic.

A number of educational programs exist, and the effectiveness of education is the focus of much current research (e.g., Caron et al., 2017; Kurowski, Pomerantz, Schaiper, & Gittelman, 2014; Rice & Curtis, 2019). In general, research suggests that many of these programs are effective in improving knowledge (Glang et al., 2015; McAvoy, 2009). In particular, the Centers for Disease Control and Prevention maintains training and fact sheets about concussion and TBI that is designed for a variety of groups, such as students, educators, health care providers, parents, and coaches (Centers for Disease Control and Prevention, 2017), and recent evidence suggests that this source can improve concussion knowledge, particularly when tailored to the individual's baseline knowledge set (Rice & Curtis, 2019). Other knowledge interventions, such as short educational videos (Schellinger et al., 2018), have been successful in shifting public knowledge, but most educational interventions are targeted toward athletes or parents of students at risk for sports concussion (e.g., Bagley et al., 2012; Wallace, Covassin, & Beidler, 2019), and not concussion from other mechanisms, or brain injury more broadly.

There is relatively little research examining the optimal design of educational programs, although there is some evidence that active learning approaches are more effective (Wallace et al., 2019). Furthermore, most studies of the effectiveness of educational initiatives only measured immediate gains in knowledge and failed to evaluate long-term effects. In one study, Cusimano, Chipman, Donnelly, and Hutchison (2014) observed that an educational video resulted in initial gains in concussion knowledge in athletes, but that these gains were not maintained at a 2-month follow-up. Therefore, future research should also examine long-term effects of education and what design variables maximize not only initial learning, but also retention of knowledge.

CONCLUSION

The current study provides insight into what the general public knows about TBI and concussion, revealing strengths and weaknesses in which messages are accurately reaching a broad audience. Importantly, the current study examined the knowledge of students as young as 10 and recruited participants outside of an athletic context, each of which has been previously underresearched. In addition, this study expanded upon previous research by making direct comparisons between the knowledge of students and parents and examining the relationship between knowledge and confidence in that knowledge. Findings suggest that parents and adults have better concussion knowledge, but that students are aware of many important aspects of concussion. Perhaps most importantly, our confidence data show that students are less confident than adults about their concussion knowledge, and are underconfident about their knowledge. This underconfidence leaves open the door for learning, so that students are likely in a position to engage with resources when provided. Our data also may indicate that some facts about concussion are discussed in the media and other venues in which a wide range of the public participate. In contrast, public misconceptions about TBI appear to be fairly stable, with little change in scores of public knowledge across multiple studies over the last three decades (Ralph & Derbyshire, 2013). A consideration of these two kinds of knowledge about brain injury can lead to improved efforts to increase public understanding of the effects of TBI and concussion. Specifically, education should address the entire continuum of TBI severity, mechanisms and neurological effects of injury, and timelines/patterns of recovery. In addition, education on long-term effects of brain injury and its cognitive consequences is needed. Future research should continue to examine the best ways to provide this education, as there is still relatively little known about the optimal ways to design educational initiatives to maximize their impact.

REFERENCES

Ahmed, O. H., Blake, T., & Hall, E. E. (2017). Educating the masses: Suggestions for improving online concussion information via the mainstream media. *Concussion*, *2*(1), CNC27-3. doi:10.2217/cnc-2016-0026

Anderson, B. L., Gittelman, M. A., Mann, J. K., Cyriac, R. L., & Pomerantz, W. J. (2016). High school football players' knowledge and attitudes about concussions. *Clinical Journal of Sports Medicine*, *26*(3), 206–209.

Atlanta Science Festival. (2017). *Atlanta Science Festival 2017 Annual Report*. Retrieved from https://atlantasciencefestival.org/wp-content/uploads/2017/12/ASF2017report.pdf.

Aubrey, J. B., Dobbs, A. R., & Rule, B. G. (1989). Laypersons' knowledge about the sequelae of minor head injury and whiplash. *Journal of Neurology, Neurosurgery & Psychiatry*, *52*(7), 842–846.

Bagley, A. F., Daneshvar, D. H., Schanker, B. D., Zurakowski, D., d'Hemecourt, C. A., Nowinski, C. J., et al. (2012). Effectiveness of the SLICE program for youth concussion education. *Clinical Journal of Sport Medicine*, *22*(5), 385–389.

Baldwin, G. T., Breiding, M. J., & Comstock, R. D. (2018). Epidemiology of sports concussion in the United States. In *Handbook of clinical neurology* (Vol. 158, pp. 63–74). Amsterdam, the Netherlands: Elsevier.

Baugh, C. M., Kroshus, E., Bourlas, A. P., & Perry, K. I. (2014). Requiring athletes to acknowledge receipt of concussion-related information and responsibility to report symptoms: A study of the prevalence, variation, and possible improvements. *Journal of Law, Medicine & Ethics*, *42*(3), 297–313.

Berner, E. S., & Graber, M. L. (2008). Overconfidence as a cause of diagnostic error in medicine. *The American Journal of Medicine*, *121*(5), S2–S23.

Bjork, R. A. (1999). Assessing our own competence: Heuristics and illusions. In D. Gopher & A. Koriat (Eds.), *Attention and performance XVII: Cognitive regulation of performance: Interaction of theory and application* (pp. 435–459). Cambridge, MA: MIT Press.

Bloodgood, B., Inokuchi, D., Shawver, W., Olson, K., Hoffman, R., Cohen, E., et al. (2013). Exploration of awareness, knowledge, and perceptions of traumatic brain injury among American youth athletes and their parents. *Journal of Adolescent Health*, *53*(1), 34–39.

Bryan, M. A., Rowhani-Rahbar, A., Comstock, R. D., & Rivara, F. (2016). Sports- and recreation-related concussions in US youth. *Pediatrics*, *138*(1).

Capruso, D. X., & Levin, H. S. (1992). Cognitive impairment following closed head injury. *The Neurology of Trauma*, *10*(4), 879–893.

Caron, J. G., Rathwell, S., Delaney, J. S., Johnston, K. M., Ptito, A., & Bloom, G. A. (2017). Development, implementation and assessment of a concussion education programme for high school student-athletes. *Journal of Sports Sciences*, *36*(1), 48–55.

Centers for Disease Control and Prevention. (2017, July). *Heads up*. Retrieved from https://www.cdc.gov/headsup/index.html

Chapman, R. C., & Hudson, J. M. (2010). Beliefs about brain injury in Britain. *Brain Injury*, *24*(6), 797–801.

Chapman, E. B., Nasypany, A., May, J., Henry, T., Hummel, C., & Jun, H. P. (2018). Investigation of the Rosenbaum Concussion Knowledge and Attitudes Survey in collegiate athletes. *Clinical Journal of Sport Medicine*, *28*(2), 117–124.

Chrisman, S. P., Schiff, M. A., Chung, S. K., Herring, S. A., & Rivara, F. P. (2014). Implementation of concussion legislation and extent of concussion education for athletes, parents, and coaches in Washington State. *American Journal of Sports Medicine*, *42*(5), 1190–1196.

Cournoyer, J., & Tripp, B. L. (2014). Concussion knowledge in high school football players. *Journal of Athletic Training*, *49*(5), 654–658.

Cusimano, M. D., Zhang, S., Topolovec-Vranic, J., Hutchison, M. G., & Jing, R. (2017). Factors affecting the concussion knowledge of athletes, parents, coaches, and medical professionals. *SAGE Open Medicine*, *5*, 2050312117694794.

Cusimano, M. D., Chipman, M., Donnelly, P., & Hutchison, M. G. (2014). Effectiveness of an educational video on concussion knowledge in minor league hockey players: A cluster randomised controlled trial. *British Journal of Sports Medicine*, *48*(2), 141–146.

Dreer, L. E., Crowley, M. T., Cash, A., O'Neill, J. A., & Cox, M. K. (2016). Examination of teacher knowledge, dissemination preferences, and classroom management of student concussions: Implications for return-to-learn protocols. *Health Promotion Practice*, *18*(3), 428–436.

Dunning, D., Heath, C., & Suls, J. M. (2004). Flawed self-assessment: Implications for health, education, and the workplace. *Psychological Science in the Public Interest*, *5*(3), 69–106.

Ehrlinger, J., Johnson, K., Banner, M., Dunning, D., & Kruger, J. (2008). Why the unskilled are unaware: Further explorations of (absent) self-insight among the incompetent. *Organizational Behavior and Human Decision Processes*, *105*(1), 98–121.

Ernst, W. J., Trice, A. D., Gilbert, J. L., & Potts, H. (2009). Misconceptions about traumatic brain injury and recovery among nursing students. *Journal of Head Trauma Rehabilitation*, *24*, 213–220.

Glang, A. E., Koester, M. C., Chesnutt, J. C., Gioia, G. A., McAvoy, K., Marshall, S., et al. (2015). The effectiveness of a web-based resource in improving postconcussion management in high schools. *Journal of Adolescent Health*, *56*(1), 91–97. doi:10.1016/j.jadohealth.2014.08.011

Gouvier, W. D., Prestholdt, P. H., & Warner, M. S. (1988). A survey of common misconceptions about head injury and recovery. *Archives of Clinical Neuropsychology*, *3*, 331–343.

Guilmette, T. J., & Paglia, M. F. (2004). The public's misconceptions about traumatic brain injury: A follow up survey. *Archives of Clinical Neuropsychology*, *19*(2), 183–189.

Guskiewicz, K., Marshall, S., Bailes, J., McCrea, M., Cantu, R., Randolph, C., et al. (2005). Association between recurrent concussion and late-life cognitive impairment in retired professional football players. *Neurosurgery*, *57*(4), 719.

Hildenbrand, K., Richards, K. A. R., & Wright, P. M. (2018). Physical education teachers' awareness and understanding of concussions, and concussion policies and protocols. *Research Quarterly for Exercise and Sport*, *89*(3), 361–366.

Hux, K., Schram, C. D., & Goeken, T. (2006). Misconceptions about brain injury: A survey replication study. *Brain Injury*, *20*(5), 547–553.

Hux, K., Walker, M., & Sanger, D. D. (1996). Traumatic brain injury: Knowledge and self-perceptions of school speech-language pathologists. *Language, Speech, and Hearing Services in Schools*, *27*, 171–184.

Iverson, G. L., Echemendia, R. J., LaMarre, A. K., Brooks, B. L., & Gaetz, M. B. (2012). Possible lingering effects of multiple past concussions. *Rehabilitation Research and Practice*, *2012*(3), 1–7. doi:10.1155/2012/316575

Jagoda, A. S., Cantrill, S. V., Wears, R. L., Valadka, A., Gallagher, E. J., Gottesfeld, S. H., et al. (2002). Clinical policy: Neuroimaging and decision making in adult mild traumatic brain injury in the acute setting. *Annals of Emergency Medicine*, *40*(2), 231–249.

Kay, T., Harrington, D. E., Adams, R. E., Anderson, T. W., Berrol, S., Cicerone, K., et al. (1993). Definition of mild traumatic brain injury: Report from the Mild Traumatic Brain Injury Committee of the Head Injury Interdisciplinary Special Interest Group of the American Congress of Rehabilitation Medicine. *Journal of Head Trauma Rehabilitation*, *8*, 86–87.

Kelley, C. M., & Lindsay, D. S. (1993). Remembering mistaken for knowing: Ease of retrieval as a basis for confidence in answers to general knowledge questions. *Journal of Memory and Language*, *32*(1), 1–24. doi:10.1006/jmla.1993.1001

Kroshus, E., Kerr, Z. Y., DeFreese, J. D., & Parsons, J. T. (2017). Concussion knowledge and communication behaviors of collegiate wrestling coaches. *Health Communication*, *32*(8), 963–969.

Kruger, J., & Dunning, D. (1999). Unskilled and unaware of it: How difficulties in recognizing one's own incompetence lead to inflated self-assessments. *Journal of Personality and Social Psychology*, *77*, 1121–1134.

Kurowski, B., Pomerantz, W. J., Schaiper, C., & Gittelman, M. A. (2014). Factors that influence concussion knowledge and self-reported attitudes in high school athletes. *Journal of Trauma and Acute Care Surgery, 77*(3), S12–S17.

Lange, R. T., Brickell, T. A., French, L. M., Merritt, V. C., Bhagwat, A., Pancholi, S., et al. (2012). Neuropsychological outcome from uncomplicated mild, complicated mild, and moderate traumatic brain injury in US military personnel. *Archives of Clinical Neuropsychology*, *27*(5), 480–494.

Langlois, J. A., Rutland-Brown, W., & Wald, M. M. (2006). The epidemiology and impact of traumatic brain injury: A brief overview. *Journal of Head Trauma Rehabilitation, 21*(5), 375–378.

Lin, A. C., Salzman, G. A., Bachman, S. L., Burke, R. V., Zaslow, T., Piasek, C. Z., et al. (2015). Assessment of parental knowledge and attitudes toward pediatric sports-related concussions. *Sports Health*, *7*(2), 124–129.

Linden, M. A., Braiden, H. J., & Miller, S. (2013). Educational professionals' understanding of childhood traumatic brain injury. *Brain Injury*, *27*(1), 92–102.

Lumba-Brown, A., Yeates, K. O., Sarmiento, K., Breiding, M. J., Haegerich, T. M., Gioia, G. A., et al. (2018). Centers for Disease Control and Prevention guideline on the diagnosis and management of mild traumatic brain injury among children. *JAMA Pediatrics*, *172*(11), e182853.

Manasse-Cohick, N. J., & Shapley, K. L. (2014). Concussion education for high school football players: A pilot study. *Communication Disorders Quarterly*, *35*(3), 182–185.

Mannings, C., Kalynych, C., Joseph, M. M., Smotherman, C., & Kraemer, D. F. (2014). Knowledge assessment of sports-related concussion among parents of children aged 5 years to 15 years enrolled in recreational tackle football. *Journal of Trauma and Acute Care Surgery*, *77*(3), S18–S22.

McAvoy, K. (2009). *Reap the benefits of good concussion management*. Centennial, CO: Rocky Mountain Sports Medicine Institute Center for Concussion.

McCrory, P., Meeuwisse, W., Dvorak, J., Aubry, M., Bailes, J., Broglio, S., et al. (2017). Consensus statement on concussion in sport—the 5th international conference on concussion in sport held in Berlin, October 2016. *British Journal of Sports Medicine*, *51*(11), 838–847.

McKinlay, A., Bishop, A., & McLellan, T. (2011). Public knowledge of "concussion" and the different terminology used to communicate about mild traumatic brain injury (MTBI). *Brain Injury*, *25*(7–8), 761–766.

Merz, Z. C., Van Patten, R., & Lace, J. (2016). Current public knowledge pertaining to traumatic brain injury: Influence of demographic factors, social trends, and sport concussion experience on the understanding of traumatic brain injury sequelae. *Archives of Clinical Neuropsychology*, *32*(2), 155–167.

Meyer, A. N. D., Payne, V. L., Meeks, D. W., Rao, R., & Singh, H. (2013). Physicians' diagnostic accuracy, confidence, and resource requests. *JAMA Internal Medicine*, *173*(21), 1952–1958. doi:10.1001/jamainternmed.2013.10081

Mulhern, S., & McMillan, T. M. (2006). Knowledge and expectation of postconcussion symptoms in the general population. *Journal of Psychosomatic Research*, *61*(4), 439–445.

O'Jile, J. R., Ryan, L. M., Parks-Levy, J., Gouvier, W. D., Betz, B., Haptonstahl, D. E., et al. (1997). Effects of head injury experience on head injury misconceptions. *International Journal of Rehabilitation and Health*, *3*(1), 61–67.

Oyesanya, T. O., Brown, R. L., & Turkstra, L. S. (2017). Caring for patients with traumatic brain injury: A survey of nurses' perceptions. *Journal of Clinical Nursing*, *26*(11–12), 1562–1574.

Pappadis, M. R., Sander, A. M., Struchen, M. A., Leung, P., & Smith, D. W. (2011). Common misconceptions about traumatic brain injury among ethnic minorities with TBI. *Journal of Head Trauma Rehabilitation*, *26*(4), 301–311.

Patel, D. R., Fidrocki, D., & Parachuri, V. (2017). Sport-related concussions in adolescent athletes: A critical public health problem for which prevention remains an elusive goal. *Translational Pediatrics*, *6*(3), 114–120.

Ralph, A., & Derbyshire, C. (2013). Survivors of brain injury through the eyes of the public: A systematic review. *Brain Injury*, *27*(13–14), 1475–1491.

Register-Mihalik, J. K., Guskiewicz, K. M., McLeod, T. C. V., Linnan, L. A., Mueller, F. O., & Marshall, S. W. (2013). Knowledge, attitude, and concussion-reporting behaviors among high school athletes: A preliminary study. *Journal of Athletic Training, 48*(5), 645–653.

Rice, T., & Curtis, R. (2019). Parental knowledge of concussion: Evaluation of the CDC's "Heads up to parents" educational initiative. *Journal of Safety Research*, *69*, 1–9.

Rieger, B., Lewandowski, L., Potts, H., Potter, K., & Chin, L. S. (2018). Parent knowledge and perceptions of concussion related to youth football. *Cureus, 10*(3), e2268.

Rosenbaum, A. M., & Arnett, P. A. (2010). The development of a survey to examine knowledge about and attitudes toward concussion in high-school students. *Journal of Clinical and Experimental Neuropsychology*, *32*(1), 44–55.

Schellinger, S. K., Munson, B., & Kennedy, M. R. T. (2018). Public perceptions of traumatic brain injury: Predictors of knowledge and the effects of education. *Brain Injury*, *32*(11), 1377–1385. doi: 10.1080/02699052.2018.1492737

Springer, J. A., Farmer, J. E., & Bouman, D. E. (1997). Common misconceptions about traumatic brain injury among family members of rehabilitation patients. *Journal of Head Trauma Rehabilitation*, *12*(3), 41–50.

Swift, T. L., & Wilson, S. L. (2001). Misconceptions about brain injury among the general public and non-expert health professionals: An exploratory study. *Brain Injury*, *15*(2), 149–165.

Sye, G., Sullivan, S. J., & McCrory, P. (2006). High school rugby players' understanding of concussion and return to play guidelines. *British Journal of Sports Medicine, 40*(12), 1003–1005.

Taylor, C. A., Bell, J. M., Breiding, M. J., & Xu, L. (2017). Traumatic brain injury-related emergency department visits, hospitalizations, and deaths—United States, 2007 and 2013. *Morbidity and Mortality Weekly Report. Surveillance Summaries (Washington, DC: 2002)*, *66*(9), 1-16.

Thompson, L. L., Lyons, V. H., McCart, M., Herring, S. A., Rivara, F. P., & Vavilala, M. S. (2016). Variations in state laws governing school reintegration following concussion. *Pediatrics*, *138*(6), e20162151.

Torres, D. M., Galetta, K. M., Phillips, H. W., Dziemianowicz, E. M. S., Wilson, J. A., Dorman, E. S., et al. (2013). Sports-related concussion: Anonymous survey of a collegiate cohort. *Neurology. Clinical Practice*, *3*(4), 279–287.

U.S. Census Bureau. (2019). U.S. Census Bureau QuickFacts–Population estimates, Atlanta, Georgia. Retrieved from https://www.census.gov/quickfacts/fact/table/atlantacitygeorgia/PST045218

Vakil, E. (2005). The effect of moderate to severe traumatic brain injury (TBI) on different aspects of memory: A selective review. *Journal of Clinical and Experimental Neuropsychology*, *27*(8), 977–1021.

Wallace, J., Covassin, T., & Beidler, E. (2019). Concussion Bingo: Taking an active learning approach to concussion education with vulnerable populations. *Health Education Journal*, *78*(3), 315–327.

Weber, M., & Edwards, M. G. (2012). Sport concussion knowledge in the UK general public. *Archives of Clinical Neuropsychology*, *27*(3), 355–361.

Willer, B., Johnson, W. E., Rempel, R. G., & Linn, R. (1993). A note concerning misconceptions of the general public about brain injury. *Archives of Clinical Neuropsychology*, *8*(5), 461–465.

Williams, J. M., Langdon, J. L., McMillan, J. L., & Buckley, T. A. (2016). English professional football players concussion knowledge and attitude. *Journal of Sport and Health Science*, *5*(2), 197–204. doi:10.1016/j.jshs.2015.01.009