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# Demographic, Parental, and Personal Factors and Youth Athletes' Concussion-Related Knowledge and Beliefs

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***Context:*** Currently, significant attention is focused on improving care for patients with concussions through legislative mandates that include educational interventions. Few researchers have examined young athletes' concussion knowledge and the factors that may influence their knowledge.

***Objective:*** To use the socioecological model to examine demographic, parental, and personal factors associated with youth athletes' knowledge of concussion. Our ultimate goal is to inform the planning and implementation of youth sport concussion-related interventions.

***Design:*** Cross-sectional survey.

***Setting:*** Gymnasium and classroom.

***Patients or Other Participants:*** North Carolina and Arizona youth athletes (n = 225; age = 8 to 15 years) active in football, boys' or girls' soccer, boys' or girls' ice hockey, or boys' or girls' lacrosse in 2012–2013.

***Main Outcome Measure(s):*** Participants completed a validated, self-administered survey. The intention and belief measures were guided by the theory of planned behavior. Perceptions of concussion and intention to seek care were examined using descriptive statistics. Athletes' concussion knowledge was modeled using linear regressions and generalized estimating equations, with child demographic and personal factors and parental knowledge and attitudes about concussion as predictors.

***Results:*** Geography, sport, parental attitudes toward concussion, and athlete age were associated with athlete knowledge in the univariable analyses ($P < .10$). In the multivariable model, geographic location (North Carolina versus Arizona, mean difference [MD] = 2.2, 95% confidence interval [CI] = 1.1, 3.2), sport (girls' soccer versus girls' lacrosse, MD = 2.2, 95% CI = 0.7, 3.6), more favorable parental attitudes toward concussion (MD = 1.2 for a 2-standard deviation shift; 95% CI = 0.3, 2.1), and older age (>12 years, MD = 1.6; 95% CI = 0.5, 2.6) were associated with better knowledge about concussion.

***Conclusions:*** Geographic location, sport, parental attitudes about concussion, and athlete's age influenced athletes' concussion-related perceptions, indicating the need to address multiple levels of the socioecological model when targeting youth sport interventions. Parental interventions that translate to an improved culture of youth sport by improving youth athletes' perceptions and experiences are key areas for future work.

***Key Words:*** brain injury, sports, concussion education, theory of planned behavior, socioecological model

**Key Points**

- Multiple factors at various levels of the socioecological model were associated with youth athletes' concussion knowledge.
- Parental attitudes influenced youth athletes' understanding of key concepts of concussion knowledge.
- Concussion education and training interventions should target youth sport stakeholders, especially parents, and should include considerations for key demographic factors such as the state of participation, sport, and athlete's age.

Sport-related concussion is one of the most complex injuries that athletic trainers (ATs) manage in children. For athletes under the age of 15 years, little is known about factors that may influence concussion identification and management. Previous researchers[1] suggested that young athletes may respond differently to concussive injuries than older athletes. Epidemiologic data indicated that concussions accounted for a similar proportion of injuries at the youth level, at least in football, as at the high school and collegiate levels.[2] Despite these findings, few authors[3,4] have empirically and directly addressed concussion-related behavioral factors in this young age group. The lack of evidence makes it difficult for ATs and other stakeholders to implement culturally and

geographically relevant concussion-related intervention programs.

Many factors, such as geography, policy, organizational structure, parental involvement, and personal experience, may influence health-related knowledge and behaviors.[5,6] These factors may best be situated in the context of the *socioecological model*, which is a public health, systems-based model that addresses the complex interplay of policy, organizational, interpersonal, and intrapersonal levels of influence concerning a health condition and associated behaviors.[7,8] For concussion-related concerns, geography may play a role due to differences in concussion-related legislation and policy (policy level). One example is Arizona, where the law covers a wider variety of athletes, including some youth sports. This contrasts with North Carolina's law, which covers only public middle and high school athletes; some state laws do not encompass sports outside the school system.[9] Despite the similarities in these laws, this key difference (North Carolina youth sports outside the public school system not being covered) may play a role in concussion-related knowledge.

Sport-specific and team-based factors are key interpersonal-level considerations affecting concussion-related knowledge and beliefs.[5,10] Epidemiologic studies[11,12] point to higher concussion rates in collision sports, which may influence what young athletes know or believe about concussion. Athletes in sports such as football, boys' ice hockey, and boys' lacrosse may have more general awareness about concussion. However, no investigators to date have directly compared how sport type may influence what young athletes know and believe about concussion. Studies of youth sport concussion have often targeted other areas of interpersonal influence, such as coaches' and parents' concussion knowledge and attitudes.[13,14] The results of earlier coaching-centered studies suggested that youth sport coaches continued to misunderstand concussion[13] but that their knowledge base was improving.[9] More recent research also indicated a gap in parents' knowledge.[9]

In addition, we need to understand key intrapersonal-level factors in youth sports, such as the athlete's age, history of concussion, and exposure to concussion education. These factors may play roles in high school and collegiate athletes'[15–19] concussion-related knowledge and behaviors, with older athletes having better knowledge and those with a concussion history displaying no difference in knowledge. However, public health investigators[20] have observed that previous experience with other conditions influences the responses to subsequent experiences with that condition. Younger athletes may also take longer to recover from concussion, which may result in a future knowledge increase.[21] Furthermore, recent authors[17] found that high school athletes with multiple concussions had worse attitudes about the injury than those who had experienced fewer or no concussions. Also, due to increases in societal awareness, more exposure to concussion-related information for youth athletes may lead to improved basic knowledge levels.

This growing body of work illustrates the need to understand the roles that the various levels of influence in the socio-ecological model play in youth-athlete concussion perceptions and culture. Key stakeholders within the various levels of the socioecological model include parents, legal guardians, persons in authoritative positions (eg, coaches, administrators, league officials), teammates, and individual athletes. In addition, there is an overarching need for theory-driven approaches to intervention and educational program development that encompass these multiple levels of the socioecological model[10] (eg, policy, community, coaches, parents, and athlete targets). By considering the various levels of the socioecological model, we can develop more effective and comprehensive intervention programs.

Many concussion-related educational programs were not developed using a targeted approach specific to the youth athlete or parent, making knowledge transfer more difficult.[6,22] Little of this work has been situated within a public health model or theoretical framework to promote further understanding and development of effective intervention strategies. Also, few data support the types and framing of messaging, materials, and information needed specific to youth sport. Use of health behavior theory, such as the theory of planned behavior, which examines attitudes, self-efficacy, perceived social norms, and intentions to engage in specific behaviors, may allow for a line of inquiry that targets multiple levels of the socioecological model. No researchers to date have directly examined the role parents may play in their child's knowledge of concussion. To develop effective educational and training materials and continue to advance prevention efforts targeting concussion in youth sport, a more complete understanding of what these young athletes know and believe about concussion is essential.

The purpose of our study was to use a theory-guided approach in the context of the socioecological model to examine demographic, parental, and personal factors associated with youth athletes' concussion knowledge in order to inform the development and implementation of youth sport concussion-related interventions. We hypothesized that concussion knowledge would be greater among youth athletes who were from Arizona, were involved in collision sports, were older, had a personal concussion history, had previous concussion education, and had parents with more concussion-related knowledge and better attitudes toward concussion disclosure and concussion in general.

## METHODS

### Research Design

We conducted a cross-sectional survey of youth athletes participating in community sports leagues or clubs or on middle school sport teams. We obtained institutional review board approval before research began at the 2 study institutions. The survey captured data on youth athletes' knowledge, attitudes, and beliefs concerning concussion recognition and response and intentions to disclose and seek care. These constructs were guided by the theory of planned behavior. We also captured parents' knowledge and attitudes about concussion in a separate survey.

### Study Sample

A convenience sample of 225 youth football, boys' or girls' ice hockey, boys' or girls' lacrosse, and boys' or girls' soccer athletes served as the primary study participants. A total of 234 parents of athletes on these same teams also completed surveys. *Parent* was defined as the

**Table 1. Demographic Characteristics**

| Characteristic | Frequency (%) |
|---|---|
| State (n = 225) | |
| Arizona | 82 (36.4) |
| North Carolina | 143 (63.6) |
| Sex (n = 225) | |
| Male | 72 (32.0) |
| Female | 153 (68.0) |
| Sport (n = 225) | |
| Football | 37 (16.4) |
| Boys' ice hockey | 26 (11.6) |
| Boys' lacrosse | 47 (20.9) |
| Girls' lacrosse | 14 (6.2) |
| Boys' soccer | 43 (19.1) |
| Girls' soccer | 58 (25.8) |
| Previous concussion education (n = 222) | |
| Question: Has someone talked with you about concussion before? | |
| Yes | 144 (64.8) |
| No | 78 (35.2) |
| Previous concussion history (n = 201) | |
| Question (asked of parent): How many times has your child been diagnosed with a concussion? (1 or more = *yes*) | |
| Yes | 52 (25.9) |
| No | 149 (74.1) |

parent or legal guardian of a child on the recruited team. The parental sample was slightly larger than the youth sample because 9 parents completed a survey that did not correspond with a child-completed survey. These individuals were included in the analyses, given that collective parental perceptions and influence represent a key component of sport culture. This sample represented 21 youth sport teams and 3 middle schools participating in concussion-education meetings in North Carolina and Arizona. These meetings were conducted by trained study staff (research assistants and certified ATs) who administered the surveys at the beginning of the study meeting. Demographics for the athlete sample are presented in Table 1. The inclusion criterion was that individuals be listed on the sport team's roster in the recruited league or middle school. All student-athlete participants were between the ages of 8 and 15 years old (age = 11.7 ± 1.8 years). For a parent's survey to be included, his or her child must have met the inclusion criterion. There were no additional inclusion or exclusion criteria.

## Study Measures

A single athlete survey served as the primary data-collection tool for the study. A separate parental survey was completed concurrently. Demographic information for the athlete's age, sex, sport played, and concussion history was collected from the athlete's and parent's surveys. Concussion history was assessed by asking parents whether their child had ever sustained a concussion (*yes* or *no* response). For the study outcomes, athlete concussion knowledge was examined using a series of 29 questions, and concussion attitudes and beliefs were evaluated using 5 questions on concussion recognition and response. The total concussion-knowledge score was the number of correct answers to the 29 questions (a higher score represented better knowledge). The total concussion-perception score was the sum of favorable or correct responses for 5 perception questions (a higher score represented a more favorable attitude). The parents' survey was used to evaluate their concussion knowledge and attitudes. Parental knowledge was assessed using the number of correct answers to the 29 questions (a higher score represented better knowledge) and the sum of all responses to 7 attitude questions (a higher score represented a more favorable attitude) concerning concussion recognition and response. Details of the parents' survey and outcomes were presented in a previous study.[23]

The surveys were based on a previously used and validated survey guided by the theory of planned behavior[15,24] and adapted for the current study. Both the athlete's and parent's surveys were assessed for content validity by 3 content experts (3 researcher-clinicians, including 1 who was independent of the study team) and were piloted with a sample of 16 youth sport athletes and 19 youth sport parents before initiation of the current study. All questions included in each of the surveys produced >80% agreement during 2 pilot sessions. In addition, internal consistency was high for the survey constructs of athletes' or parents' concussion knowledge and attitudes (parents: Cronbach $\alpha > 0.70$). All athletes' survey constructs are shown in Table 2. Parents' constructs were reported in a previous article.[23]

## Data Collection

Approval from each league and middle school was obtained before we held meetings with athletes and parents who were part of a larger concussion study. A member of the research team explained the study, obtained informed consent (including child assent and parental consent for their child's and their own participation), distributed the surveys to the athletes and their parents in a classroom-style setting, and collected the completed surveys. Athletes and parents completed the surveys concurrently in the meeting room and were allowed to communicate about any misunderstandings but not to reveal answers. The survey took approximately 15 to 20 minutes to complete. All survey data were entered into a standardized study database, and data from the Arizona and North Carolina athletes were merged into a single dataset.

## Statistical Analyses

Descriptive statistics were used to examine the concussion-knowledge totals, individual knowledge questions, and concussion-perception questions. Our primary outcomes were total concussion knowledge (out of 29 questions) and individual responses to the 5 perception questions. Higher scores illustrate improved knowledge and more favorable attitudes and beliefs about concussion and concussion disclosure.

Simple linear regression models were used to examine the univariable association between the following variables and the outcome of youth athlete concussion knowledge: (1) geography (Arizona versus North Carolina), (2) sport (comparison of all sports included, with the referent being girls' lacrosse), (3) parents' concussion knowledge (continuous), (4) parents' concussion attitude (continuous), (5) age (8 to 12 years versus 13 to 15 years), (6) any concussion history (*no* versus *yes*), and (7) any previous concussion education (*no* versus *yes*). For the analyses of

**Table 2. Athletes' Concussion Knowledge and Belief Descriptives[a]**

| Knowledge and Belief Concepts[b] | Frequency Correct (%) |
|---|---|
| Signs and symptoms[c] | |
| Question: Check YES beside all of the things that show how a person may feel or what might happen to a person because of a concussion. Check NO if you think it would not happen. | |
| Headache (yes; n = 225) | 210 (93.3) |
| Dizziness/feeling woozy (yes; n = 224) | 205 (91.5) |
| Problem remembering things (yes; n = 224) | 202 (90.2) |
| Blacking out (yes; n = 224) | 194 (86.6) |
| Fuzzy vision (yes; n = 225) | 193 (85.8) |
| Things smell funny (no; n = 222) | 185 (83.3) |
| Trouble understanding things (yes; n = 223) | 180 (80.7) |
| Black eye (no; n = 222) | 177 (79.7) |
| Bleeding from the mouth (no; n = 222) | 173 (77.9) |
| Things taste funny (no; n = 223) | 167 (74.9) |
| Bleeding from the ear (no; n = 224) | 167 (74.6) |
| Chest pain (no; n = 223) | 165 (73.9) |
| Trouble sleeping (yes; n = 223) | 154 (69.1) |
| Tummy/stomach hurts or feels sick (yes; n = 222) | 129 (58.1) |
| Numbness/tingling in arms (yes; n = 221) | 94 (42.5) |
| Weakness in neck (no; n = 224) | 71 (31.7) |
| Additional identification knowledge[c] | |
| A concussion only occurs if you lose consciousness/black out; check: yes, no, I don't know (no; n = 225) | 165 (73.3) |
| Brain as body part injured with a concussion; check: skull, face, brain, neck, I don't know (yes; n = 224) | 176 (78.6) |
| Consequences of returning to play too soon[c] | |
| Question: Place a check mark in the box beside all of the things listed below you think can happen from someone returning to their sport too soon after a concussion. | |
| No bad things can happen (no; n = 223) | 212 (94.2) |
| You may be more likely to get another concussion (yes; n = 224) | 171 (76.0) |
| Skin rash (no; n = 224) | 218 (96.9) |
| Brain damage (yes; n = 224) | 174 (77.3) |
| I don't know what might happen (no; n = 224) | 208 (92.4) |
| Consequences of multiple concussions[c] | |
| Question: Place a check mark in the box beside all of the things listed below you think can happen because someone has more than one concussion. | |
| No bad things can ever happen (no; n = 223) | 221 (98.2) |
| You may be more likely to get another concussion (yes; n = 223) | 137 (60.9) |
| Skin rash (no; n = 223) | 215 (95.6) |
| Brain damage (yes; n = 223) | 188 (83.6) |
| Trouble remembering things (yes; n = 225) | 172 (76.4) |
| I don't know what might happen (no; n = 223) | 206 (91.6) |
| Attitudes/beliefs and intentions about concussion | |
| Do you think you should tell someone if you have a concussion? (yes; n = 222) | 216 (97.3) |
| If you think you have a concussion do you think you should keep playing in a game? (no; n = 223) | 217 (97.3) |
| If you think you have a concussion do you think you should keep playing in a practice? (no; n = 223) | 214 (96.0) |
| Would you tell someone if you thought you had a concussion? (yes; n = 223) | 216 (96.8) |
| Do you think your teammates would get upset with you if you had to come out of a game or practice because of a concussion? (no; n = 223) | 173 (77.1) |

[a] Instrument is presented in its original form.
[b] All frequencies reported as the best/correct answer.
[c] Included in the knowledge score.

parents' data, we used generalized estimating equations regression models with robust variance estimation to account for multiple athletes (ie, siblings) with the same parents. For the multivariable model, athlete concussion knowledge was modeled using linear regression with generalized estimating equations and only those variables from the univariable models that were statistically significant at the 0.10 level. These were (1) age (8 to 12 years versus 13 to 15 years), (2) geography (North Carolina versus Arizona), (3) sport (comparison of all sports included, with the referent being girls' lacrosse), and (4) parents' concussion attitude (continuous). The $\alpha$ level of .10 was used to provide a broader approach to inclusion in the multivariable model. Athletes who did not have data for all predictor and outcome variables were excluded from the analyses of those measures. All data were analyzed using SAS (version 9.4; SAS Institute Inc, Cary, NC), and the $\alpha$ level was set a priori to .05 for the multivariable model.

## RESULTS

The demographics for the study's athlete sample are outlined in Table 1. Parents were 44.0 $\pm$ 6.4 years old. There were 82 male parents and 144 female parents; 8 did not report sex. More detailed parental demographics can be found in a previous publication.[23] The overall athletes' concussion-knowledge score was moderate (22.9 $\pm$ 3.6 of 29), as were the parents' knowledge (23.3 $\pm$ 2.5 of 29) and attitude (46.3 $\pm$ 3.7 of 49) scores. For athletes, the least known concussion signs and symptoms were neck weakness (31.7% correct), numbness (42.5% correct), and nausea (58.1% correct). Headache was the most common correctly identified symptom (93.3% correct; Table 2).

Overall, concussion attitudes and disclosure beliefs were positive among the youth athletes, with 216 of 222 (97.3%) indicating they felt they should tell someone if they had a concussion and 216 of 223 (96.8%) indicating they would tell someone if they thought they had a concussion. More than 95% thought athletes should not continue playing in a game (217/223; 97.3%) or practice (214/223; 96.0%) if they thought they had a concussion. However, 51 of 223 (22.9%) felt their teammates would be "upset with them" if they had to come out of a game or a practice due to a concussion.

The results from the univariable and multivariable models, including the sample size for each analysis, are provided in Table 3. Being from North Carolina, better parental attitudes, participation in girls' lacrosse versus boys' ice hockey or football, and being older than 12 years of age were associated with better youth athlete concussion-related knowledge in the univariable analyses ($P < .10$). These factors were determined to be important inclusions in the multivariable model. In the multivariable model, being

**Table 3. Regression Estimates for Demographic, Parental, and Personal Factors Associated With Youth Athlete Concussion Knowledge**

| | Univariable | | | | Multivariable[a] (n = 172) | | |
|---|---|---|---|---|---|---|---|
| Factor | Estimate | 95% Confidence Interval | *P* Value | n | Estimate | 95% Confidence Interval | *P* Value |
| Parental knowledge (continuous)[b] | 0.3 | −0.8, 1.4 | .646 | 150 | NA | NA | NA |
| Parental attitude (continuous)[c] | 1.1 | −0.1, 2.3 | .055 | 172 | 1.2 | 0.3, 2.1 | .009 |
| State (Arizona versus North Carolina)[d] | −2.6 | −3.5, −1.6 | <.001 | 208 | −2.2 | −3.2, −1.1 | <.001 |
| Sport[e]: football versus girls' lacrosse[d] | −1.3 | −3.5, −1.6 | <.001 | 208 | 0.6 | −1.1, 2.3 | .489 |
| Sport[e]: boys' soccer versus girls' lacrosse[d] | 0.4 | −1.7, 2.6 | .684 | 208 | 1.3 | −0.4, 2.9 | .136 |
| Sport[e]: girls' soccer versus girls' lacrosse[d] | 0.8 | −1.2, 2.9 | .420 | 208 | 2.2 | 0.7, 3.6 | .004 |
| Sport[e]: boys' ice hockey versus girls' lacrosse[d] | −3.6 | −5.9, −1.4 | .002 | 208 | −1.8 | −4.1, 0.3 | .092 |
| Sport[e]: boys' lacrosse versus girls' lacrosse[d] | −0.4 | −2.4, 1.7 | .724 | 208 | 0.8 | −0.7, 2.3 | .299 |
| Age (younger versus older)[d] | −1.9 | −2.9, −0.9 | <.001 | 208 | −1.6 | −2.6, −0.5 | .002 |
| Previous concussion education? (*no* versus *yes*)[d] | −0.6 | −1.7, 0.4 | .233 | 207 | NA | NA | NA |
| Previous history of concussion? (*no* versus *yes*)[d] | −0.1 | −1.9, 1.8 | .937 | 184 | NA | NA | NA |

Abbreviation: NA, not applicable.

[a] Only includes factors significant at the 0.10 level in the univariable model.

[b] Estimate is the mean difference for a 2-standard deviation shift in parental knowledge.

[c] Estimate is the mean difference for a 2-standard deviation shift in parental attitude.

[d] Indicates mean difference between groups listed.

[e] The entire set of sport comparisons was included in the multivariable model because sport overall was significant in the univariable model.

older than 12 years of age ($P < .01$), being from North Carolina ($P < .001$), participating in girls' soccer versus girls' lacrosse ($P < .01$), and having better parental attitudes ($P < .01$) were associated with higher youth athlete concussion-related knowledge scores. Effect sizes for all univariable comparisons are shown in Table 4.

## DISCUSSION

Our findings suggest that, consistent with the socioecological model,[10] key concussion-education targets (eg, knowledge) and related factors operate at multiple levels. These factors include geography, parents' attitudes, and athletes' knowledge, which should be considered when developing and implementing concussion-education interventions and programs. Being from North Carolina, participating in girls' soccer, having better parental attitudes, and being older were associated with higher levels of youth-athlete concussion knowledge. Although the mean differences across factors were relatively small, they illustrate areas for improvement. Furthermore, the effect sizes for many of our variables of interest were moderate, indicating that the differences observed for these variables were clinically meaningful, providing further support for their consideration in intervention development and evaluation.

**Table 4. Athlete Knowledge Score: Effect Size Estimates for Variable Comparisons of Interest (Univariable Analysis)**

| Variable | Effect Size[a] |
|---|---|
| Parental knowledge (continuous) | 0.041 |
| Parental attitude (continuous) | 0.146 |
| State (Arizona versus North Carolina) | 0.755 |
| Sport[b]: football versus girls' lacrosse | 0.474 |
| Sport[b]: boys' soccer versus girls' lacrosse | 0.184 |
| Sport[b]: girls' soccer versus girls' lacrosse | 0.115 |
| Sport[b]: boys' ice hockey versus girls' lacrosse | 0.970 |
| Sport[b]: boys' lacrosse versus girls' lacrosse | 0.130 |
| Age (younger versus older) | 0.630 |
| Previous concussion education? (*no* versus *yes*) | 0.247 |
| Previous history of concussion? (*no* versus *yes*) | 0.050 |

[a] All effect sizes expressed as d except parental knowledge and parental attitude, which are expressed as r.

[b] The entire set of sport comparisons was included in the multivariable model as sport overall was significant in the univariable model.

Overall, youth athletes' concussion-related knowledge was moderate, with nearly 80% of athletes being knowledgeable about the majority of basic concussion signs and symptoms. These findings are similar to those of other studies on knowledge of concussion in youth sport[25,26] and establish a framework for future training and education at the youth sport level by providing information on key gaps in knowledge and highlighting the importance of concurrent parent and child involvement in concussion-education and -training programs.

Beliefs were positive among our youth athlete sample, given that most believed they would leave a game or practice and tell someone if they had a concussion. However, many believed their teammates would be upset with them for exiting an activity due to a concussion. These constructs reflect intrapersonal (athlete's intentions and beliefs) and interpersonal considerations (beliefs about teammates' responses) in the context of the socioecological model. Compared with older athletes in a previous study,[27] many of whom indicated they would continue to play through symptoms, a higher proportion in the study sample reported they would remove themselves from participation if they experienced a suspected concussion. However, their beliefs that teammates would be upset were similar.[28,29] Over time, the negative responses of key social referents such as coaches and teammates may begin to shape the beliefs and behaviors (eg, not reporting injuries) that have been noted among high school and collegiate athletes.[24,27,30] It is important to encourage individuals to disclose potential injuries so they can receive appropriate care. In addition, we must create an environment that encourages discussion of injuries and concussions and promotes positive, normative perceptions about concussion recognition and response so that athletes do not hide

injuries. Most vital is that these educational, training, and community-based programs should target normalization of the attitudes and behaviors among this young age group.

Our findings also suggest geographic differences in knowledge, which reflect policy and organizational levels in the socioecological model. North Carolina athletes demonstrated greater knowledge than Arizona athletes. This is surprising given that Arizona's concussion law includes mandates directed at youth sports and North Carolina's law does not extend to the youth level; however, the decision on how to comply with the law's educational mandate is left to each individual league or middle school. Both states' laws were passed within 2 months of each other (April and June 2011) and both include the basic tenets of concussion education: no return to play on the same day as a suspected concussion and medical clearance before returning. Whereas many components of the laws are similar, the enforcing agency, provisions for youth sports, and liability protection for key stakeholders such as leagues and coaches differ. The Arizona law is enforced at the school or school district level, covers youth sports participating on public lands, and provides liability protection. The state Department of Education enforces North Carolina's law, which does not cover youth or community sports and offers no liability protection. The enhanced knowledge demonstrated by our North Carolina athletes may have been influenced by the location of the convenience sample (a university community) and the abundance of medical facilities within a 20-mi (32-km) radius of the study sites. These geographic differences highlight the need to understand the larger social, political, and policy-related context in which concussion-prevention and -management interventions take place. Understanding concussion-related knowledge of a given sport community before intervention may aid ATs in determining the targets (ie, areas to address) for a specific area or group. As proposed in recent studies,[15,24,31,32] it is necessary to continue investigating the outcomes of concussion programming and interventions beyond knowledge, including attitudes, reported behaviors, and normative perceptions.

In addition, concussion-knowledge levels differed by sport in our study sample, with boys' ice hockey players having the lowest scores and girls' soccer players having the highest. These findings reflect the potential influence of interpersonal (team)- and organizational-level influences on knowledge of concussion in youth sport. One plausible explanation is the increased national attention and social awareness of concussion in youth and middle school–aged soccer athletes during the study.[33,34] In high school and collegiate cohorts, young women in sex-comparable sports (eg, girls' versus boys' soccer) were more likely to disclose symptoms compared with their male counterparts.[18,35] This may be a result of improved concussion-related knowledge and attitudes, the inherent characteristics of sports, or additional unknown factors. Our findings suggest that sport-specific educational messaging is indicated, specifically concerning symptom identification in youth ice hockey players. These sport-based expectations, the perceived injury risk in collision and contact activities, and the perceived risk of concussion inherent to specific sports (eg, attention in ice hockey to the concussion risk) may also play roles in athletes' concussion-knowledge levels. These sport-specific and culturally relevant factors should be used to drive and develop the most effective educational and training messaging.

Parental influence on the athletes' knowledge is another consideration at the interpersonal level of the socioecological model. Literature[36–38] in the health care and behavioral fields suggested that parental actions influence their children's behaviors and attitudes. Although no empirical evidence exists about the formation of concussion beliefs, individuals likely form their ideas and beliefs at a young age. Parental beliefs may also play a large role in forming their child's ideas and beliefs. We observed that parental attitude was more strongly associated with athlete knowledge than was parental knowledge, indicating that parental attitude may influence what the child knows or is willing to learn about concussion. It is possible that positive attitudes emphasize the injury's seriousness by associating disclosure and proper management of the injury with outcomes that may improve health, wellbeing, and sport participation. In addition, if parents have a more negative attitude about concussion, even with greater knowledge levels, they may not be as willing to share information with their child.

Our results also suggest that age, an intrapersonal-level factor in the socioecological model, should be considered in all concussion-education programming. Future educational methods should target younger athletes (<13 years of age) because these individuals may have less working knowledge of concussion due to having less personal experience in sport and fewer discussions about the injury. Furthermore, messaging that is appropriate for a 16-year-old would not be appropriate for these young individuals. A previous study[32] on messaging and education illustrated the need for age-appropriate and relevant messaging and content, including appropriate concussion vocabulary and images. Educational programs for children should address the steps to take after a concussion, using terminology that is appropriate for their setting and age group. Moreover, knowledge-translation strategies that improve the effectiveness of interactive educational programs, such as involving multiple stakeholders, should continue to be incorporated at all levels of sport.[32]

Interestingly, neither having sustained a previous concussion nor having previous concussion education, both intrapersonal-level factors, influenced concussion knowledge. This finding differs from the existing health care literature, which highlighted the role previous experience with a condition may play in experiences and knowledge. Typically, previous experience with a specific illness or injury influences the responses to subsequent conditions.[20] However, more recent data[17] from the high school setting suggested that experiencing a previous concussion was not associated with improved knowledge but was associated with a worse attitude about concussion. Our results indicate that other factors, such as sport-specific cultures, parents, teammates, and overall societal awareness, may also be drivers of concussion-knowledge levels. It may be that concussion education must be targeted at specific deficits to increase overall knowledge about concussion.

The current study was limited by the convenience sample, which may reduce generalizability of the results. In addition, although all individuals attending the concus-

sion sessions completed the survey, the total pool available was unknown. Furthermore, concussion-history and -education variables were self-reported and may have been limited by recall bias. Last, we studied participants from only 2 states and did not include athletes in all sports. However, these findings are important in providing a base understanding of the relationships among various levels of the socioecological model and young athletes' concussion knowledge.

## CONCLUSIONS

Athletic trainers should be mindful of the many factors that may influence concussion knowledge and beliefs and the role they can play in improving these important factors among young athletes. Our data support the use of age, geographic location, and sport to differentiate messaging and highlight the role of parental attitudes in youth athlete concussion knowledge. These findings also highlight the need for interventions targeting multiple levels of the socioecological model.[10] Such interventions may include athletes, parents, coaches, administrators, health care providers, organizational change, team culture, and societal "buy-in." Our data and recent literature[9,39,40] emphasize that the current "one-size-fits-all" approach may not be an effective mandate for concussion education. Future researchers should continue to investigate factors beyond knowledge to determine key targets for interventions aimed at improving concussion-related behaviors and outcomes in youth sports.

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