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Concussion Knowledge, Attitudes, and Self-Reporting Intentions in Youth Athletes

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Context: Although it has been suggested that developmental and sociological factors play a role in concussion reporting, the empirical evidence related to this is limited.

Objective: To examine the influences of sex, school level, school location, concussion-reporting history, and socioeconomic status on concussion-related knowledge, attitudes, and reporting intentions among middle school and high school athletes.

Design: Cross-sectional study.

Setting: Middle School and High School athletes attending pre-participation examinations (PPEs) were asked to complete paper-based surveys.

Patients or Other Participants: Overall, 541 athletes representing 18 sports returned fully completed surveys.

Main Outcome Measure(s): Outcomes were concussion-related knowledge, perceived seriousness, positive feelings about reporting, and self-reporting intentions. We examined group differences in these outcomes across levels of the explanatory variables of sex, school level (middle school versus high school), school location (urban versus rural), concussion self-reporting history (yes or no), and socioeconomic status (free or reduced-price lunch versus no free or reduced-price lunch) using Wilcoxon rank sum tests. Then we used multivariable ordinal logistic regression models to identify predictors of higher score levels for each outcome. Odds ratio (OR) estimates with 95% confidence intervals (CIs) excluding 1.00 were deemed significant.

Results: Odds of higher levels of knowledge were higher in urban versus rural school student-athletes ($OR_{Adjusted} = 1.81$; 95% CI = 1.03, 3.17), and lower in student-athletes on free or reduced-price lunch versus those not on free or reduced-price lunch ($OR_{Adjusted} = 0.52$; 95% CI = 0.36, 0.77). Similarly, odds of higher levels of seriousness were lower in male versus female student-athletes ($OR_{Adjusted} = 0.48$; 95% CI = 0.32, 0.72). Further, odds of higher levels of self-reporting intentions were lower among male versus female student-athletes ($OR_{Adjusted} = 0.53$; 95% CI = 0.37, 0.75).

Conclusions: Developmental and sociological factors were differentially associated with concussion-related knowledge, attitudes, and self-reporting intentions. These results can inform medical providers, parents, and coaches with regard to context-specific clinical assessments of concussion symptoms.

Key Words: middle school athletes, mild traumatic brain injuries, high school athletes, sport

Key Points

- The socioecological model provides a robust framework for identifying determinants of concussion-reporting behaviors in youth athletes.
- Sociological and developmental factors appear to differentially influence subconstructs associated with concussion-reporting behaviors among middle school and high school athletes.
- Factors across different levels of the socioecological continuum may be considered when examining concussion-related knowledge, attitudes, and self-reporting intentions in youth athletes in order to inform sophisticated interventions targeting concussion-reporting behaviors in this group.

An estimated 1.1 to 1.9 million sport- and recreation-related concussions are reported among youth (age <18 years) in the United States annually.[1–3] Previous researchers[2,4] have estimated sport-related concussion incidence rates of 0.75 and 2.50 per 1000 athlete-exposures in middle schools and high schools, respectively. Although epidemiologic studies have been helpful in identifying patterns related to the concussion incidence in youth sports, underreporting of symptoms has made it difficult to capture the complete scope of youth sport-related concussion incidence and to identify associated risk factors.[2,4–9] It has consequently been challenging to develop and implement targeted concussion-prevention strategies (those designed for specific subgroups of athletes) in this population because of this compromised appraisal of the problem and the resultant lack of empirical evidence that can be used to tailor specific prevention strategies. Therefore, improving concussion-reporting behaviors in this group is an essential precursor to planning and developing prevention programs.

Concussion-symptom reporting among youth athletes is a multidimensional paradigm. Reporting behaviors are

associated with concussion-related knowledge, attitudes toward self-reporting, and intentions to self-report.[10–13] Having accurate concussion-related knowledge plays a key role in identifying symptoms and self-reporting.[10] Further, the widespread use of inaccurate and seemingly innocuous terms such as *dings* or *bell ringers* to describe potentially serious concussion-related events exacerbates the problem of underreporting.[10,12] Athletes must have the requisite knowledge to feel sufficiently empowered to report concussion symptoms as they present.[14] However, higher levels of knowledge alone do not guarantee better concussion-reporting behaviors.[15–19] In fact, attitudes toward concussion reporting have been shown to be a vital factor associated with self-reporting behaviors.[10,12,17] For example, failing to comprehend the seriousness of a concussion not only may prevent youth athletes from reporting symptoms but also may keep them from seeking appropriate care when experiencing symptoms.[10–13,20] In addition, it is important to consider the role of self-reporting intentions in this paradigm and to distinguish them from attitudes toward reporting.[12] Although attitudes capture general perceptions about concussion reporting, self-reporting intentions capture the perceived likelihood of performing the behavior of interest (ie, self-reporting of concussions or potential symptoms).[12] Therefore, to capture the comprehensive scope of concussions in youth sport, it is critical to influence change not only with respect to concussion-related knowledge but also with respect to the attitudes and intentions related to self-reporting.

To influence change in concussion-related self-reporting behaviors among youth athletes, it is important to identify determinants of reporting behaviors in this context. It is reasonable to approach this problem through the lens of the socioecological model in public health and suspect that developmental and sociological factors play significant roles in influencing the subconstructs of reporting behaviors.[12,21,22] However, limited empirical evidence supports this claim.[11,23] Register-Mihalik et al[11] recently demonstrated an association between athlete age and concussion-related perceptions; further similar studies are required in different athlete samples to extend the generalizability of this relationship. Further, it has been previously suggested that socioeconomic status (SES) is directly associated with the quality of overall education and educational outcomes[24–26] and implicated with respect to access to health care.[27,28] For instance, parental income, education, and occupation have all been identified as socioeconomic predictors of educational outcomes.[24] However, the relationship between SES and concussion education has not yet been explored. Similarly, geographic location has been shown to be associated with access to health care,[29] yet evidence of a relationship between geographic development (ie, urbanicity as compared with rurality) and concussion-related education and behaviors is limited.[23]

Accordingly, the purpose of our study was to examine concussion-related knowledge, attitudes, and reporting intentions in a sample of middle school and high school athletes. We hypothesized that all of the aforementioned dimensions of reporting behaviors would be concurrently associated with both developmental and sociological factors.

METHODS

Design and Participants

We used a cross-sectional study design to collect data regarding concussion knowledge, attitudes, and self-reporting behaviors in a sample of middle school (grades 7 and 8) and high school (grades 9 through 12) student-athletes from multiple schools in the Columbia, South Carolina, region. Informed consent and assent were secured from guardians and participants, respectively. This study was approved by the institutional review board at the University of South Carolina.

A convenience-sampling scheme was used, with participants recruited at pre-participation examinations (PPEs) conducted by University of South Carolina Sports Medicine in 2016. A total of 1461 student-athletes (878 high school, 583 middle school) who attended the PPEs were targeted for recruitment at the final station. A total of 541 participants (37% of those originally recruited) from 18 sports completed surveys and were included in the study. Participants completed the surveys without assistance.

Instrument Synthesis

We used existing, previously validated concussion-related questionnaires and literature to synthesize an instrument for this study.[10,12,30] The synthesized instrument consisted of 4 sections: (1) demographics, (2) concussion knowledge, (3) concussion attitudes, and (4) concussion reporting. The demographic section collected information on participant sex, sport(s), and SES (on free or reduced-price lunch [FRL] versus not on free or reduced-price lunch [NFRL]).[31] We also used school information to identify student-athletes as being enrolled at a middle or high school and at an urban or rural school. Although variations exist across the United States in what is considered a middle school, the classifications used in this study originated from the schools themselves. Middle school student-athletes consisted of those in grades 7 and 8, whereas high school student-athletes were those in grades 9 through 12.

The concussion-knowledge section of the instrument consisted of 18 true-false items[30] related to facts about concussion and concussion-symptom presentation. Each correct answer was awarded 1 point, and scores ranged from 0 to 18 points (Table 1). Higher scores indicated better concussion knowledge.

The concussion-attitudes section of the instrument contained 10 items related to athletes' perceptions of reporting and return-to-play decisions.[10,12] Informed by the work from which these items were adapted, they were divided them into 2 sections, capturing the perceived seriousness of experiencing concussion symptoms or continuing physical activity when experiencing symptoms (measured from 3 items) following trauma to the head or body; and the degree of positive feelings such as courage, importance, self-value, etc, felt about reporting symptoms upon experiencing them (measured from the remaining 7 items).[10,12] Participants responded to each item on a 7-point scale. Scores on the seriousness subscale ranged from 3 to 21 points, with higher scores indicating greater perceived seriousness. Scores on the positive feelings subscale ranged from 7 to 49 points, with higher scores indicating more positive attitudes toward reporting symptoms (Table 1).

Table 1. Score Ranges and Ordinal Levels Used for Analysis of Each Outcome Construct of Interest

Construct	Score Range[a]	Ordinal Levels[b]
Concussion-related knowledge	0–18	1: 0–6 2: 7–12 3: 13–18
Perceived seriousness of concussions	3–21	1: 3–9 2: 10–15 3: 16–21
Positive feelings about self-reporting	7–49	1: 7–20 2: 21–34 3: 35–49
Self-reporting intentions	4–20	1: 4–9 2: 10–15 3: 16–20

[a] Potential range of scores based on responses to all items for each outcome construct of interest.
[b] Ordinal levels created for multivariable modeling of each outcome construct of interest.

The final section of the instrument consisted of 7 items related to reporting history and behaviors.[10,12] Three items were used to measure a 12-month history of medically diagnosed and suspected concussions (including dings and bell ringers), and the remaining 4 items were used to measure self-reporting intentions.[10,12] Participants responded to the final 4 items on a 5-point scale, noting the likelihood of seeking medical attention upon suspecting a concussion. Scores on the self-reporting intentions subscale ranged from 4 to 20 points (Table 1). Higher scores indicated a greater likelihood.

Statistical Analysis

For analyses, our main explanatory variables were sex, school level (middle school versus high school), school location (urban versus rural), SES (FRL versus NFRL), and 12-month concussion-reporting history. The 12-month reporting history was based on a self-report of at least 1 medically diagnosed (by an athletic trainer, nurse, physician, etc) concussion, suspected concussion (when the athlete thought a concussion was sustained though it was never medically diagnosed), or ding or bell ringer in the 12 months before the study. Student-athletes with at least 1 reported occurrence of any of these outcomes were considered to have a history of reporting. Our main outcome measures were concussion-related knowledge, attitudes (specifically, the seriousness and positive feelings subconstructs), and self-reporting intentions. Composite scores (based on the section-specific summations described earlier) were computed for knowledge, perceived seriousness, positive feelings about reporting, and self-reporting intentions.

Sample frequencies and distributions were calculated for our main explanatory measures. Because of the discrete nature of the outcomes of concern, group-stratified medians and interquartile ranges (IQRs) were then computed for composite knowledge, perceived seriousness, positive feelings about reporting, and self-reporting intentions. Group differences in scores of the outcome measures were examined across levels of the aforementioned explanatory variables using Wilcoxon rank sum tests.

Again, because of the discrete nature of the outcomes of concern, we created ordinal levels of knowledge, seriousness, positive feelings, and self-reporting intention scores for multivariable modeling. We divided the range of each score into 3 levels using approximately 33% increments in each score to determine the relative cut points. We took this approach to ensure that progression from one level to the next for each outcome had inferential value with respect to the underlying construct of interest. We fit multivariable ordinal logistic regression models to identify predictors of higher levels (ie, levels 2 and 3 versus 1 and level 3 versus levels 1 and 2) of knowledge (0–6, 7–12, or 13–18 correct responses), perceived seriousness (3–9, 10–15, or 16–21 composite score), positive feelings (7–20, 21–34, or 35–49 composite score), and self-reporting intentions (4–9, 10–15, or 16–20 composite score; Table 1). Considering the overall objective of the study, we simultaneously entered all explanatory variables into the regression models. We did not include sport in our models as the participants in this study were in the process of tryouts and not definitively engaged in their sport at the time of data collection. We explored potential interactions in models and reported only the significant findings. All statistical analyses were conducted using SAS (version 9.4; SAS Institute, Cary, NC) with an a priori α of .05.

RESULTS

Sample Characteristics

The majority of the participants were boys (62.5%), enrolled in high school (60.8%), and on FRL (64.3%), which is an indicator of low SES (Table 2). Most student-athletes came from schools located in an urban area (83.0%).

Knowledge

The median knowledge score was 11.0 (IQR = 4.0; Table 2). We noted significant group differences in the distributions of knowledge scores between middle school and high school (medians = 11.0 and 11.0, respectively; $P = .02$), urban and rural (medians = 11.0 and 10.0, respectively; $P < .001$), and FRL and NFRL (medians = 11.0 and 12.0, respectively; $P < .001$; see Supplemental Figure 1, available online at http://dx.doi.org/10.4085/1062-6050-232-19.S1) student-athletes. Approximately 70% of the sample answered fewer than 13 of the 18 knowledge items correctly (n = 12 with scores of 0–6, n = 369 with scores of 7–12, n = 160 with scores of 13–18). School location and SES emerged as significant predictors of higher levels of knowledge in our multivariable ordinal logistic regression model of knowledge (Table 2). The odds of achieving higher levels of knowledge were greater among urban-school than rural-school student-athletes (adjusted odds ratio [$OR_{Adjusted}$] = 1.81; 95% confidence interval [CI] = 1.03, 3.17). Similarly, the odds of achieving higher levels of knowledge were lower among FRL than NFRL student-athletes ($OR_{Adjusted} = 0.52$; 95% CI = 0.36, 0.77).

Attitudes

The median scores for perceived seriousness and positive feelings about reporting were 17.0 (IQR = 4.0) and 41.0 (IQR = 11.0), respectively (Table 3). We noted significant group differences in the distributions of seriousness scores between male and female (medians = 17.0 and 18.0, respectively; $P < .001$) and between middle school and

Table 2. Analysis of Concussion-Related Knowledge

Variable	Knowledge Median (Interquartile Range)[a]	*P* Value[b]	Adjusted Odds Ratio (95% Confidence Interval)[c]
Sex		.79	
Male (n = 338)	11.0 (4.0)		0.89 (0.60, 1.32)
Female (n = 203)	11.0 (4.0)		Referent
School level		.02[d]	
High school (n = 329)	11.0 (4.0)		1.33 (0.90, 1.95)
Middle school (n = 212)	11.0 (3.5)		Referent
School location		<.001[d]	
Urban (n = 449)	11.00 (3.0)		1.81 (1.03, 3.17)[d]
Rural (n = 92)	10.00 (3.0)		Referent
Socioeconomic status		<.001[d]	
Free or reduced-price lunch (n = 348)	11.0 (3.0)		0.52 (0.36, 0.77)[d]
No free or reduced-price lunch (n = 193)	12.0 (3.0)		Referent
Concussion history in past 12 mo?		.07	
Yes (n = 114)	11.0 (3.0)		1.20 (0.76, 1.89)
No (n = 427)	11.0 (4.0)		Referent
Total (N = 541)	11.0 (4.0)		

[a] Group-stratified, total sample medians and interquartile ranges of knowledge scores across levels of sex, school, school location, socioeconomic status (measured using free or reduced-price lunch participation), and 12-month concussion history.
[b] Reported *P* values refer to the results of Wilcoxon rank sum tests for group differences in knowledge scores across levels of the covariates of interest.
[c] Adjusted odds ratios and 95% confidence intervals estimated from the final multivariable ordinal logistic regression model of knowledge scores. Estimates describe the odds of higher levels of knowledge scores in the comparison group compared with the referent in each covariate of interest. The proportional odds assumption was satisfied in the final model ($P = .46$).
[d] Denotes statistically significant results at the .05 level.

high school (medians = 17.0 and 18.0, respectively; $P = .02$; Supplemental Figure 2) student-athletes. More than 66% of participants had composite perceived seriousness scores of greater than 15 (n = 27 with scores of 3–9, n = 153 with scores of 10–15, and n = 361 with scores of 16–21). Our multivariable ordinal logistic regression model identified sex as a significant predictor of higher levels of seriousness, with lower odds of higher levels of seriousness among male than female student-athletes ($OR_{Adjusted} = 0.48$; 95% CI = 0.32, 0.72).

We noted no significant group differences in the distributions of positive feelings across levels of our main explanatory variables (Supplemental Figure 3). Approximately 75% of all participants had composite positive feelings scores greater than 34 (n = 24 with scores of 7–20, n = 109 with scores of 21–34, and n = 408 with scores of 35–49). Consistent with the bivariate analyses, in the multivariable ordinal logistic regression model, we observed no significant predictors of higher levels of positive feelings toward reporting.

Self-Reporting Intentions

The median score of self-reporting intentions was 14.0 (IQR = 5.0; Table 4). We observed significant group differences in the distributions of self-reporting intentions scores between male and female student-athletes (medians = 13.0 and 15.0, respectively; $P < .001$; Supplemental Figure 4). More than 52% of participants had self-reporting intention composite scores of less than 14 (n = 78 with scores of 4–9, n = 286 with scores of 10–15, and n = 177 with scores of 16–20). The results of the bivariate analyses were mirrored in the multivariable ordinal logistic regression modeling: the odds of higher levels of self-reporting intentions were lower among male than female student-athletes ($OR_{Adjusted} = 0.53$; 95% CI = 0.37, 0.75).

DISCUSSION

This study presents results from a multifactorial approach to identifying determinants of concussion knowledge and attitudes in youth athletes. Consistent with the emerging literature in this area, we approached this paradigm from the perspective of the socioecological model.[12,22] We considered sociological and developmental factors and examined their influence on specific determinants of concussion-reporting behaviors. Our results indicate that factors such as sex, school location, and SES affect concussion-related knowledge, attitudes, and self-reporting intentions in different ways. As such, our results align with the socioecological perspective on this paradigm and illustrate that concussion-reporting behaviors in this cohort were associated with athlete-specific factors, as well as larger community-level factors. These results may be used to identify areas for potential intervention across different levels of the socioecological continuum.

Knowledge

Based on the distribution of knowledge scores in this sample, we note that a considerable proportion of the sampled student-athletes demonstrated low-to-moderate concussion-related knowledge (ie, correctly answering at most two-thirds of the items), which potentially suggests the need for broader intervention among student-athletes of this age. Although previous researchers[10,20] have shown varying levels of concussion-related knowledge among athletes in this age bracket, it is difficult to juxtapose the

Table 3. Analysis of Perceived Seriousness of Concussions and Positive Feelings About Self-Reporting

	Seriousness			Positive Feelings		
Variable	Median (Interquartile Range)[a]	*P* Value[b]	Adjusted Odds Ratio (95% Confidence Interval)[c]	Median (Interquartile Range)[a]	*P* Value[b]	Adjusted Odds Ratio (95% Confidence Interval)[c]
Sex		<.001[d]			.13	
Male (n = 338)	17.0 (5.0)		0.48 (0.32, 0.72)[d]	40.0 (13.0)		0.79 (0.51, 1.21)
Female (n = 203)	18.0 (4.0)		Referent	41.0 (10.0)		Referent
School level		.02[d]			.20	
High school (n = 329)	18.0 (5.0)		1.25 [0.86, 1.81]	41.0 (12.0)		1.00 (0.67, 1.51)
Middle school (n = 212)	17.0 (5.0)		Referent	40.5 (10.5)		Referent
School location		.07			.24	
Urban (n = 449)	17.0 (4.0)		1.60 (1.00, 2.57)	41.0 (11.0)		1.61 (0.97, 2.68)
Rural (n = 92)	17.0 (6.0)		Referent	40.0 (15.0)		Referent
Socioeconomic status		.64			.35	
Free or reduced-price lunch (n = 348)	17.0 (6.0)		0.96 [0.65, 1.41]	41.00 (13.0)		0.94 (0.61, 1.44)
No free or reduced-price lunch (n = 193)	17.0 (4.0)		Referent	40.00 (10.0)		Referent
Concussion history in past 12 mo		.11			.11	
Yes (n = 114)	17.0 (5.0)		0.80 (0.52, 1.25)	39.0 (14.0)		0.63 (0.40, 1.02)
No (n = 427)	17.0 (5.0)		Referent	41.0 (11.0)		Referent
Total (N = 541)	17.0 (4.0)			41.0 (11.0)		

[a] Group-stratified, total sample medians and interquartile ranges of seriousness and positive feelings scores across levels of sex, school, school location, socioeconomic status (measured using free or reduced-price lunch participation), and 12-month concussion history.

[b] Reported *P* values refer to the results of Wilcoxon rank sum tests for group differences in scores of seriousness and positive feelings.

[c] Adjusted odds ratios and 95% confidence intervals estimated from the final multivariable ordinal logistic regression model of higher levels of seriousness and positive feelings scores. Estimates describe the odds of higher levels of each outcome of interest in the comparison group compared with the referent in each covariate. The proportional odds assumption was satisfied in each of the final models ($P = .41$ and $P = .69$ for the seriousness and positive feelings models, respectively).

[d] Denotes statistically significant results at the .05 level.

Table 4. Analysis of Concussion Self-Reporting Intentions

Variable	Median (Interquartile Range)[a]	*P* Value[b]	Adjusted Odds Ratio (95% Confidence Interval)[c]
Sex		<.001[d]	
Male (n = 338)	13.0 (5.0)		0.53 (0.37, 0.75)[d]
Female (n = 203)	15.0 (5.0)		Referent
School level		.90	
High school (n = 329)	14.0 (5.0)		1.10 (0.78, 1.55)
Middle school (n = 212)	14.0 (5.0)		Referent
School location		.52	
Urban (n = 449)	14.0 (5.0)		1.03 (0.65, 1.61)
Rural (n = 92)	13.5 (5.5)		Referent
Socioeconomic status		.36	
Free or reduced-price lunch (n = 348)	14.0 (5.0)		1.05 (0.74, 1.49)
No free or reduced-price lunch (n = 193)	13.0 (5.0)		Referent
Concussion history in past 12 mo		.12	
Yes (n = 114)	13.0 (5.0)		0.84 (0.55, 1.26)
No (n = 427)	14.0 (5.0)		Referent
Total (N = 541)	14.0 (5.0)		

[a] Group-stratified, total sample medians and interquartile ranges of self-reporting intention scores across levels of sex, school, school location, socioeconomic status (measured using free or reduced-price lunch participation), and 12-month concussion history.
[b] Reported *P* values refer to the results of Wilcoxon rank sum tests for group differences in scores of self-reporting intentions across levels for the covariates of interest.
[c] Adjusted odds ratios and 95% confidence intervals estimated from the final multivariable ordinal logistic regression model of self-reporting intention scores. Estimates describe the odds of higher levels of self-reporting intention scores in the comparison group compared with the referent in each covariate of interest. The proportional odds assumption was satisfied in the final model ($P = .87$).
[d] Denotes statistically significant results at the .05 level.

results from different studies because of differences in the instruments used. Further, it is reasonable to suggest that increasing age is accompanied by higher levels of knowledge and general self-awareness. Although we observed school-level differences in knowledge scores in bivariate analyses, our multivariable regression model revealed that school level was not a unique predictor of concussion-related knowledge levels after adjusting for covariate effects. Moreover, the existing empirical evidence points to sex differences in concussion-related knowledge among athletes in this age group,[32] though sex also did not emerge as a significant predictor of concussion-related knowledge levels in this sample after adjustment for covariate effects. These departures from expectation may be related to sample-specific factors; however, it is important to replicate similar studies in student-athletes of comparable ages and demographic profiles to confirm or refute the observed results.

Notably, urbanicity and SES emerged as predictors of knowledge levels, with urban student-athletes and NFRL student-athletes faring better in terms of concussion-related knowledge than their respective counterparts. The relationship between school location and concussion-related knowledge seen here has been previously illustrated among high school athletes.[23] Therefore, it may be important to consider the specific exposures unique to urban student-athletes as plans are developed to balance concussion-related knowledge across geographic locations. The relationship between SES and concussion-related knowledge mirrors the existing literature surrounding the influence of SES on overall educational outcomes.[24–26] As we consider strategies to reduce socioeconomic-spectrum–related disparities in health care delivery and health outcomes, similar approaches to reduce discrepancies in concussion-related knowledge (such as efforts to increase access to reliable and accurate concussion-related information for individuals on the lower end of the socioeconomic spectrum) may also be important to consider. Ultimately, concussion-education in this cohort is a complex challenge that has been shown to require nuanced, multimodal solutions.[33] The results of our study, coupled with the existing literature in this area, can help inform the development of tailored concussion-education programs for youth athletes.

Attitudes

As in knowledge scores, we also observed heterogeneity in attitude subconstruct scores across levels of the explanatory variables of interest. However, only sex emerged as a unique predictor of attitudes toward concussion reporting after accounting for covariate effects (specifically, the perceived seriousness of concussions), suggesting that male student-athletes were more dismissive of concussions than their female counterparts. Given that the perceived risk of concussions in this group has been previously linked to a prior history of concussion,[34] our results suggest that as compared with female athletes, the perceived seriousness of concussions among male athletes may arguably be dependent on personal experience of concussion.

This result also indicates a potential avenue for exploration with respect to the development of interventions. Although sex differences in concussion-related knowledge were not apparent, based on the observed results related to attitude scores, interventions may be designed to improve the perceived seriousness of concussions among male athletes. The level of perceived

seriousness observed among female athletes was arguably a positive sign considering the greater risk of concussions observed among female athletes of this age.[35] At the same time, it is also reasonable to suggest that the higher risk of concussions observed among female athletes as compared with their male counterparts is a manifestation of reporting habits that accompany such higher perceived seriousness. Further studies are required to reconcile the directionality of these associations. Importantly, we also note that although no other explanatory variables emerged as significant predictors of the attitude subconstructs in this sample, similar studies in different samples of youth athletes are required to fully understand the associations between the aforementioned explanatory factors and attitudes toward concussion reporting.

Self-Reporting Intentions

Akin to knowledge scores and the attitude subconstruct scores, the distribution of self-reporting intention scores also revealed considerable heterogeneity in self-reporting intentions in this sample. The results of the bivariate analysis and multivariable model aligned, and we observed an association between sex and higher self-reporting intentions in this sample, even after accounting for covariate effects. Consistent with the literature[32,36,37] in this area on high school and collegiate athletes, male student-athletes generally had lower self-reporting intentions than their female counterparts. Although we identified no further predictors of self-reporting intentions in this sample, this result may yet be used to inform targeted interventions. Indeed, further attention may be directed at better understanding the causal structure predicating low self-reporting intentions among male student-athletes and aiming to improve self-reporting intentions in this group.

Limitations and Related Considerations

We acknowledge the limitations to this study. We recognize that using PPEs for data collection limits our ability to confirm whether all survey respondents participated in athletics in the season subsequent to the PPEs. Further, we note that the general nature and distribution of the observed scores for each outcome of concern may also have been affected by participants' sport histories, which we did not capture or analyze in this study. Also, the external validity of our findings is limited by the convenience-sampling scheme and the related geographic restriction of our sample to the Columbia, South Carolina, region. We were unable to account for additional individual- and school-level factors (such as age and grade level, the nature and extent of prior concussion education, school size, etc) that may function within the socioecological continuum in determining concussion-reporting behaviors. Furthermore, we also acknowledge that our results are susceptible to general biases related to survey design, administration, and data analysis. In particular, although we used previously validated instruments in this study, we note that they have not been examined specifically within middle school athletes, who formed nearly 40% of the analytical sample. Further, we collected self-reported data on 12-month concussion histories, which were thereby vulnerable to information bias regarding this important covariate. Also, we acknowledge the possibility of nonresponse bias and associated inferential limitations related to the proportion of recruited participants who returned completed surveys. We chose to include only these data in the analyses, as we did not have sufficient data with the requisite fidelity for the remainder of the recruited participants. Though we note the possibility of differences between those included and those excluded from the analysis and that our results may be vulnerable to bias arising from these differences, we are unable to discuss this further given the available data. With that said, different instrument components, modes of administration, and analytical methods may be considered in future iterations of similar studies to validate the results observed here.

These limitations notwithstanding, our results provide a platform for the development of targeted interventions as well as the design of future research. The specific factors associated with concussion-related knowledge, attitudes, and self-reporting intentions may all be addressed to affect self-reporting behaviors among youth athletes, and future research on some of the aforementioned sociological factors may be used to further understand concussion-related self-reporting behaviors in this context.

CONCLUSIONS

Our results indicate that sociological and developmental factors differentially influenced the observed concussion-reporting behaviors among middle school and high school athletes. Although school location and SES were significant determinants of concussion-related knowledge, sex appeared to be the sole determinant of both attitudes toward self-reporting and self-reporting intentions. As such, our findings suggest that multiple levels of the socioecological framework may be simultaneously involved in explaining the observed concussion-reporting behaviors in this population. These results may be used to inform nuanced (potentially group- or sex-specific) clinical assessment of concussion symptoms and sophisticated interventions targeting concussion-reporting behaviors. Specific examples include interventions motivated by improving concussion-related knowledge in rural locations and in communities of low socioeconomic standing, as well as those motivated by improving concussion-related perceived seriousness and self-reporting intentions among male athletes. Future research on exposures that are unique to the sociological factors examined here may also be used to elucidate the causal framework underlying concussion-related self-reporting behaviors in youth athletes.

SUPPLEMENTAL MATERIAL

Figures. Distribution of rank sums used in Wilcoxon rank sum tests.

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