Factors Associated With Self-Reported Concussion History in Middle School Athletes

Douglas P. Terry, PhD,*†‡§ Magdalena Wojtowicz, PhD,¶ Nathan E. Cook, PhD,*†§ Bruce A. Maxwell, PhD,‖ Ross Zafonte, DO,*†‡§ Tad Seifert, MD,**†† Noah D. Silverberg, PhD,‡‡§§ Paul D. Berkner, DO,¶¶ and Grant L. Iverson, PhD*†‡§

Abstract

Objective: Identifying personal characteristics associated with sustaining a concussion is of great interest, yet only a few have examined this in children. The purpose of this study was to examine the association between sex, neurodevelopmental disorders, health history, and lifetime history of self-reported concussion in 12- and 13-year-old athletes. **Design:** Cross-sectional study. **Setting:** Middle schools. **Participants:** Participants were 1744 twelve- and thirteen-year-old student athletes who completed preseason Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT) testing, including a self-report questionnaire about previous concussions, developmental diagnoses, and previous medical treatment. **Independent Variables:** Age, sex, attention-deficit/hyperactivity disorder (ADHD), learning disabilities (LDs), and previous treatment for migraine. **Main Outcome Measures:** Self-reported history of concussion. **Results:** A minority of athletes (13.7%) reported previous concussions (1 concussion, n = 181; 2 concussions, n = 41; and 3+ concussions, n = 17). A small proportion reported a history of ADHD (4.4%), LD (2.8%) or migraine treatment (4.0%). Higher rates of self-reported previous concussions were associated with male sex [16.9% vs 9.1%; $\chi^2(1) = 21.47$, $P < 0.001$] and previous migraine treatment [31.9% vs 13.0%; $\chi^2(1) = 20.08$, $P < 0.001$]. There were no differences in self-reported concussion history between 12- and 13-year olds ($P = 0.18$) and those with/without ADHD ($P = 0.41$) or LDs ($P = 0.06$). The overall logistic regression model was statistically significant [$\chi^2(5) = 42.01$, $P < 0.001$] but explained only 4.3% of the variance. Previous treatment for migraine [$P < 0.001$, Exp(B) = 3.30] and male sex [$P < 0.001$, Exp(B) = 2.06] were independently associated with a self-reported concussion history, whereas age, LD, and ADHD were not (P's > 0.05). **Conclusions:** Male sex and previous migraine treatment were associated with higher rates of self-reported previous concussions in both independent and multivariate models in middle school athletes, whereas age, ADHD, and LDs were not.

Key Words: head injuries, concussion, pediatric sports medicine, migraine

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INTRODUCTION

Potential risk factors for sustaining a sport-related concussion include personal characteristics, such as genetics,[1] age,[2–8] sex,[9] personality factors (eg, risk taking, aggression, and impulsivity),[10] and previous concussion history[2,11–17]; these characteristics might influence and interact with an athlete's chosen sport,[18] position, style of play,[18] and biological vulnerability to concussion. The literature on age as a risk factor for concussion is mixed—some studies have suggested higher risk in young adults[2–5] and some studies

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*From the *Department of Physical Medicine and Rehabilitation, Harvard Medical School, Boston, Massachusetts; †Spaulding Rehabilitation Hospital, Boston, Massachusetts; ‡Home Base, A Red Sox Foundation and Massachusetts General Hospital Program, Boston, Massachusetts; §MassGeneral Hospital for Children Sport Concussion Program, Boston, Massachusetts; ¶Department of Psychology, York University, Toronto, ON, Canada; ‖Department of Computer Science, Colby College, Waterville, Maine; **Departments of Neurology and Sports Health, Norton Healthcare, Louisville, Kentucky; ††Kentucky Boxing and Wrestling Commission, Frankfort, Kentucky; ‡‡Division of Physical Medicine & Rehabilitation, University of British Columbia, Vancouver, BC, Canada; §§Vancouver Coastal Health Research Institute Rehabilitation Research Program, Vancouver, BC, Canada; and ¶¶Department of Biology and Health Services, Colby College, Waterville, Maine.*

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Corresponding Author: Grant L. Iverson, PhD, Department of Physical Medicine and Rehabilitation, Center for Health and Rehabilitation Research, 79/96 Thirteen St, Charlestown Navy Yard, Charlestown, MA 02129 (giverson@mgh.harvard.edu).

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suggest greater risk in adolescents.[6–8] Mixed findings have also been reported for sex, with some studies suggesting that boys and young men are at greater risk for injury compared with girls and young women[3,19–21] while other studies suggesting increased risk for women.[4,22–27] In terms of neurodevelopmental conditions, high school and collegiate athletes with attention-deficit/hyperactivity disorder (ADHD) report a greater lifetime history of concussion,[28–30] and researchers have also reported that athletes with learning disabilities (LDs) report a greater lifetime history of concussion.[28,30] A small number of studies have suggested that individuals with migraine headaches have a greater lifetime history of concussion,[31] with some even reporting migraine as a potential independent risk factor for concussion.[32] However, prospective case-controlled studies have not yet been completed to confirm whether migraine is a risk factor for sustaining a concussion or rather a consequence of concussive injury.[31] Numerous studies indicate that athletes with previous concussions seem to be at greater risk for future injury.[2,11–16] The reasons for this are not well understood, and they could relate to style of play, personality characteristics (eg, risk taking and impulsivity), a lowered threshold for injury, or other genetic or vulnerability factors.

Most research on sport-related concussion has been conducted with high school, collegiate, and professional athletes. Very few studies have examined elementary and middle school–aged children. This incomplete knowledge of child and adolescent concussion may put the neurologic health of our youth at risk and warrants further investigation. To address this gap, the purpose of this study was to examine the association between sex, neurodevelopmental factors, health history, previous headache treatment, and lifetime history of concussion among middle school athletes aged 12 and 13 years. By modeling multiple potential predictors simultaneously, we might elucidate unique associations between these factors and concussion history. Based on past research in high school and collegiate students, we hypothesized that boys, athletes with a diagnosis of ADHD or LD, and those with a history of treatment for migraine would report a greater lifetime history of concussion.

METHODS

Participants

Participants in this cross-sectional, descriptive, cohort, survey study included 2,082 12- and 13-year-old student athletes who completed baseline preseason testing in their middle schools between 2009 and 2014. Baseline testing included the Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT) instrument. ImPACT includes a self-reported demographic and health history questionnaire [ie, number of previous concussions, problems with ADHD, diagnosis of an LD, and history of treatment for headaches, migraines, or psychiatric problems by a physician]. The only exclusion criterion was having missing data on one or more of these developmental or health history variables (n = 338). The final sample included 1744 middle school athletes (40.7% girls). Institutional review board approval for this de-identified database was obtained.

Procedure

Starting in 2009, ImPACT administration has been made available to middle schools and high schools in the state of Maine by the Maine Concussion Management Initiative (MCMI) as part of a community outreach program. In 2014, when data collection for this specific study ended, approximately 92 middle and high schools were participating in this program and a total of 43,381 student athletes aged 11 to 19 years completed baseline testing. ImPACT was administered at the individual school/team level as part of preseason testing for sports participation. Baseline testing typically occurred in small groups. Certified athletic trainers predominantly proctored the assessment, although it was occasionally administered by other trained individuals (eg, school nurse, coach, and school official). The proctor administered ImPACT using standard administration procedures. The MCMI staff at Colby College accessed all data directly through the ImPACT online portal, removed personal identifying information, and created an anonymous clinical research database. This study was approved by the Colby College Institutional Review Board.

Statistical Analyses

All analyses were performed on IBM SPSS Statistics version 21. Chi-square tests were used to examine differences in the rates of personal characteristics between athletes who did and did not report a concussion history. A logistic regression was conducted to examine the unique association between multiple correlates and lifetime history of self-reported concussion. The primary personal characteristics examined were sex (0 = girls, 1 = boys), age (12 = 0, 13 = 1), ADHD (no = 0, yes = 1), LD (no = 0, yes = 1), and previous treatment for migraine by a physician (no = 0, yes = 1). Secondary exploratory factors were previous participation in special education (no = 0, yes = 1), treatment of headaches by a physician (no = 0, yes = 1), and previous treatment for mental health problems by a physician (no = 0, yes = 1). Statistical significance was set at $P < 0.05$ for all comparisons.

RESULTS

Of the total sample, 13.7% reported one or more previous self-reported concussions. Boys were more likely to report a previous history of concussion than girls [16.9% vs 9.1%; $\chi^2(1) = 21.47$, $P < 0.001$, odds ratio (OR), 2.02; 95% confidence interval (CI), 1.50-2.74]. Twelve- and 13-year olds had similar rates of reporting a previous history of concussion (12.4% vs 14.7%; $\chi^2(1) = 1.83$, $P = 0.176$, OR, 1.21; 95% CI, 0.92-1.61). A small proportion of the total sample reported a history of ADHD (4.4%), LD (2.8%), and previous treatment for headaches (8.1%), migraines (4.0%), or a psychiatric condition (3.7%). Boys were more likely than girls to have ADHD (OR, 2.74; 95% CI, 1.57-4.79) and LDs (OR, 3.08; 95% CI, 1.48-6.39), have attended special education (OR, 2.53; 95% CI, 1.46-4.37), and repeated a grade (OR, 2.40; 95% CI, 1.28-4.49). Girls were more likely than boys to have previous treatment for a psychiatric condition (OR, 1.75; 95% CI, 1.08-2.83).

Contrary to our hypothesis, middle school athletes with ADHD were not more likely to report a history of previous concussions than those without ADHD (16.9% vs 13.6%;

$\chi^2(1) = 0.69$, $P = 0.41$, OR, 1.30; 95% CI, 0.70-2.39). Athletes with LDs were not more likely to report a history of previous concussions than athletes without LDs (22.9% vs 13.4%; $\chi^2(1) = 3.54$, $P = 0.06$, OR, 1.91; 95% CI, 0.96-3.81). Middle school athletes with previous treatment for migraines were more likely to report previous concussions (31.9% vs 13.0%; $\chi^2(1) = 20.08$, $P < 0.001$, OR, 3.15; 95% CI, 1.86-5.32), as were athletes with previous treatment for headaches (33.3% vs 13.7%; $\chi^2(1) = 49.98$, $P < 0.001$, OR, 3.67; 95% CI, 2.51-5.38). Of the 69 participants who reported a history of migraine, 49 (71%) also reported a history of treatment for headaches. Those with previous treatment for mental health problems had a similar self-reported concussion history as those with no previous mental health treatment (OR, 0.90; 95% CI, 0.42-1.90). The sample characteristics are presented in Table 1.

Logistic regression was used to determine which factors were independently associated with self-reported concussion history after controlling for other possible correlates. The predictor variables were sex, age, ADHD, LD, and history of treatment for migraine. The predictor model provided statistically significant improvement over the constant-only model ($\chi^2(5) = 42.01$, $P < 0.001$). The independent correlates of self-reported concussion history were previous treatment for migraine ($P < 0.001$, Exp(B) = 3.30) and male sex ($P < 0.001$, Exp(B) = 2.06). The Nagelkerke pseudo R^2 indicated that the model accounted for only 4.3% of the total variance, see Table 2. A second logistic regression analysis was conducted with additional variables, for exploratory purposes. The predictor variables were sex, age, ADHD, LD, participation in special education, and history of treatment for headaches, migraine, or psychiatric problems. The overall expanded model was also statistically significant ($\chi^2(8) = 69.19$, $P < 0.001$). The independent correlates of self-reported concussion history were previous treatment for headaches ($P < 0.001$, Exp(B) = 3.47) and male sex ($P = <0.001$, Exp(B) = 2.10) in this expanded model. The Nagelkerke pseudo R^2 indicated that the model accounted for only 7.1% of the total variance, see Table 3.

DISCUSSION

To our knowledge, this is the largest study to date on the correlates of self-reported concussion among middle school students. Based on previous studies with high school and college students, we hypothesized that middle school boys[3,19–21] and middle school student athletes with ADHD,[28–30] LDs,[28,30] or a personal history of migraine

TABLE 1. Concussion and Health History for the Total Sample and Stratified by Sex

	Total Sample (N = 1744)	Boys (n = 1031)	Girls (n = 713)
History of concussion (n; %)			
No of past concussions	1505; 86.3	857; 83.1	648; 90.9
1 past concussion	181; 10.4	134; 13.0	47; 6.6
2 past concussions	41; 2.4	26; 2.5	15; 2.1
3+ past concussions	17; 1.0	14; 1.4	3; 0.4
Developmental/learning problems			
ADHD (n; %)	77; 4.4	61; 5.3	16; 2.2
LD (n; %)	48; 2.8	39; 3.8	9; 1.3
Special education classes (n; %)	77; 4.4	60; 5.8	17; 2.4
Repeated one + years of school (n; %)	57; 3.3	44; 4.3	13; 1.8
Health problems			
Previous treatment for mental health problems (n; %)	64; 3.7	29; 2.8	35; 4.9
Previous treatment for substance abuse (n; %)	3; 0.2	3; 0.3	0; 0
Previous treatment for migraines (n; %)	69; 4.0	35; 3.4	34; 4.8
Previous treatment for headaches (n; %)	141; 8.1	77; 7.5	64; 9.0
Rates of previous concussions (frequency of 1 or more; %)*			
Age 12	91; 12.4	67; 15.4	24; 7.7
Age 13	148; 14.7	107; 17.6	41; 10.2
Sex	—	174; 16.9	65; 9.1
ADHD	13; 16.9	9; 14.7	4; 25.0
LD	11; 22.9	10; 25.6	1; 11.1
Special education classes	15; 19.5	11; 18.3	4; 23.5
Previous treatment for mental health problems	8, 12.5	6; 20.7	2; 5.7
Repeated one + years of school	8, 14.0	5; 11.4	3; 23.1
Treatment for migraines by a physician	22, 31.9	12; 34.3	10; 29.4
Treatment for headaches by a physician	47, 33.3	31; 40.3	16; 25.0

The rates (percentages) of middle school athletes with each developmental problems, academic issue, injury, or health condition are presented for the overall sample.
** For the final section, the rate of middle school athletes who report a history of one or more previous concussions is stratified by age group, developmental or academic problem, and health conditions. This is based on a subset of the data (eg, number of athletes who reported having ADHD and a previous concussion divided by the number of athletes who reported having ADHD).*

TABLE 2. Logistic Regression Results for Predicting Previous Concussions for the Entire Sample (N = 1744)

Variables	B	S.E.	Wald	*P*	Exp(B)	95% CI	
Age	0.13	0.15	0.85	0.357	1.14	0.86	1.52
Sex	0.72	0.16	21.24	<0.001	2.06	1.51	2.80
LD	0.37	0.36	1.05	0.307	1.45	0.71	2.97
ADHD	0.03	0.32	0.01	0.923	1.03	0.55	1.93
Treatment for migraines	1.19	0.28	18.76	<0.001	3.30	1.92	5.66
Constant	−2.47	0.16	241.54	<0.001	0.08	—	—

R^2 = 0.043.

treatment[31,32] would have a greater self-reported lifetime history of concussions. In this study, middle school boys were more likely to report a history of one or more concussions than girls (ie, 16.9% vs 9.1%)—this sex difference remained significant in multivariable analyses. This finding is consistent with many studies reporting a greater history[21] and incidence[3,19,20] of concussion in boys and young men. However, some studies have shown the opposite that girls and young women have not only a greater incidence of concussion,[4,22–27] but also report a greater number of total concussion symptoms after injury.[33] Female athletes have also reported more symptoms specific to the migraine spectrum relative to their male counterparts.[33] The discrepancy in these findings may be partially explained by sample characteristics, depending on whether the study examined players within a single sport (eg, men's vs women's soccer) or a cohort of athletes across sports (eg, all high school athletes). Given differences in concussion incidence across sports,[22,23,26] the proportion of players in each sport may have at least some influence on the study results.

In this study, middle school athletes with ADHD or LDs were not more likely to report a previous history of concussion. This result is inconsistent with past studies reporting that high school and college students with ADHD[28–30,34] or LDs[28,30] report a greater lifetime history of concussion. For comparison, in a previous study of adolescents between the ages of 13 and 18 years, 16.1% of athletes without ADHD reported one or more previous concussions, compared with 26.4% of boys with ADHD and 20.6% of girls with ADHD.[28] In the present sample of 12- to 13-year olds, 13.6% of athletes without ADHD reported one or more concussions, compared with 14.7% of boys (ie, 9/61) with ADHD and 25.0% of girls with ADHD (ie, 4/16). Given that one's cumulative history for a concussion can only increase with time, these differences may be related to continued sport exposure and the introduction of additional contact and collision opportunities (eg, tackle football). It is possible that there is an interaction between these neurodevelopmental factors and increased age/sport exposure, which is not yet evident. Youth with ADHD are also more likely to sustain bodily injuries and have emergency department visits,[35–37] so their differential cumulative history of concussion might occur separate from sport-related injuries too.

Middle school athletes with a history of migraine treatment were significantly more likely to report past concussions than athletes with no history of migraines (ie, 31.9% vs 13.0%)—this finding remained significant in the primary multivariable analysis. In an exploratory multivariable analysis, when additional developmental (eg, special education) and health history (ie, past treatment for headaches or mental health problems) variables were added, migraine history was no longer an independent predictor but headache treatment history was. This could be explained, at least in part, by sample sizes and multicollinearity because more middle school athletes reported a history of treatment for headaches (n = 141; 8.1%) than migraine (n = 69; 4.0%), and 71% of those who reported a history of migraine also reported a history of treatment for headaches.

Given that this is a cross-sectional retrospective cohort survey study, we cannot draw conclusions about causation, such as whether the association between migraine and

TABLE 3. Exploratory Logistic Regression Results for Predicting Previous Concussions for the Entire Sample (N = 1744)

Variables	B	S.E.	Wald	*P*	Exp(B)	95% CI	
Age	0.16	0.15	1.23	0.267	1.18	0.88	1.57
Sex	0.74	0.16	21.69	<0.001	2.10	1.54	2.87
LD	0.35	0.40	0.76	0.382	1.41	0.65	3.06
Attended special education	0.16	0.33	0.24	0.622	1.18	0.62	2.24
ADHD	0.02	0.33	0.01	0.946	1.02	0.54	1.94
Treatment for headaches	1.25	0.23	29.69	<0.001	3.47	2.20	5.43
Treatment for migraines	0.38	0.32	1.38	0.240	1.46	0.78	2.76
Treatment for a psychiatric condition	−0.25	0.41	0.38	0.540	0.78	0.35	1.73
Constant	−2.60	0.17	247.07	<0.001	0.07	—	—

R^2 = 0.071.

concussion is unidirectional, bidirectional, intermediary, effect modifying, and/or spurious. Future research is needed to examine this association. Theoretically, migraine history could be an effect modifier for concussion. A personal history of migraine could represent inherent vulnerabilities that (1) predispose an individual to sustaining a concussion, (2) magnify both clinical (eg, headache, nausea, and light sensitivity), and subclinical (eg, intracellular and cerebrovascular) effects of concussion, and/or (3) increase the likelihood of a refractory recovery course after injury. Those who have experienced a prolonged recovery might be more likely to remember sustaining that injury when asked about it on a future health survey. There is some published evidence to indirectly support aspects of this effect-modifying theory. First, previous research raises the possibility of a common molecular pathophysiological cause of migraines and post-traumatic headache.[38–43] Mild head trauma can activate trigeminal nociception, similar to that seen in migraine. Furthermore, upper cervical sensory nerve roots that converge on the trigeminal nucleus caudalis may also contribute to the activation process, because of flexion and extension of the cervical spine in response to inciting trauma.[44] Second, many studies have illustrated that greater acute postinjury symptom severity is associated with slower recovery in migraineurs.[26,45–52] Those with a migraine history might be more vulnerable to greater acute symptoms. Third, acute and subacute postinjury headaches of any type are a risk factor for slower recovery and persistent symptoms in some studies.[49,53–58] Individuals with pre-existing headache conditions might be at increased risk for postinjury headaches.[59] Finally, one large-scale multisite study found that a personal history of migraine was associated with increased risk for having persistent symptoms, for more than 4 weeks, in children and adolescents who experienced a mild brain injury.[49] Therefore, those with preinjury migraine might be more likely, for multiple reasons, to have worse outcome from a concussion and thus be more likely to recall sustaining that injury when asked about it in the future.

This study has 3 major limitations. First and foremost, concussion history, neurodevelopmental history, and health history were based on the child self-report. We did not have access to medical records, school records, or information from parents to verify any of the preinjury developmental or health problems. It is possible that some children of this age group may not be able to accurately differentiate between headaches and migraine headaches. Second, we were unable to determine when or how the previous injuries occurred. Third, we do not know whether the past injuries occurred before or after diagnosis of the other health conditions (eg, migraines or ADHD). It is possible that some of the athletes developed migraine after a past head trauma, but that information was not available. Finally, it is worth noting that our regression model predicted a small portion of the variance. This model was designed to examine which personal characteristics were most associated with self-report concussion history; it was not designed to be a comprehensive model that could accurately predict concussion history based on these variables. These results suggest that other factors may be related to a history of concussion; however, it is unrealistic to try to fully predict this outcome because of the diversity of these factors and because there will be some randomness associated with sustaining a concussion in sports.

CONCLUSIONS

This study is one of the first to examine the personal characteristics of middle school athletes that are associated with a greater lifetime history of self-reported concussion. Results suggest that male sex and a history of treatment for headaches/migraines are associated with concussion history. Attention-deficit/hyperactivity disorder, at this age, was not associated with a greater lifetime history of concussion. These data suggest that individual characteristics, such as sex and migraine history, are associated with self-reported concussion history from an early age. Further research elucidating the potential role of migraine as a risk factor for injury and/or modifier of recovery course is warranted.

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