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Abstract

Little is known about the rate of concussions in adolescents with attention-deficit hyperactivity disorder (ADHD). We hypothesized that high school athletes with ADHD would report a greater history of concussion than students without ADHD. 6,529 adolescent and young adult student athletes, between the ages of 13 and 19 (M=15.9, SD=1.3 years), completed a preseason health survey in 2010. Of those with ADHD, 26.1% reported a history of one or more concussions compared to 17.1% of those without ADHD ($p<.00001$; OR=1.71). Stratified by gender, 27.0% of boys with ADHD reported a history of one or more concussions compared to 20.0% of boys without ADHD ($p<.004$; OR=1.48), and 23.6% of girls with ADHD reported a history of one or more concussions compared to 13.6% of girls without ADHD ($p<.003$; OR=1.97). Of those with ADHD, 9.8% reported a history of two or more concussions compared to 5.5% of those without ADHD ($p<.0003$; OR=1.87). Stratified by gender, 10.0% of boys with ADHD reported a history of two or more concussions compared to 6.7% of boys without ADHD ($p<.033$; OR=1.54), and 9.1% of girls with ADHD reported a history of two or more concussions compared to 3.8% of girls without ADHD ($p<.006$; OR=2.51). In this large-scale, retrospective survey study, boys and girls with ADHD were significantly more likely to report a history of concussion. Additional research is needed to determine if students with ADHD are more susceptible to injury (i.e., have a lower threshold) or have different recovery trajectories.

Key Words: Attention-Deficit Hyperactivity Disorder, Concussion, Mild Traumatic Brain Injury, Surveillance, Adolescents

Introduction

Attention-deficit hyperactivity disorder (ADHD) is characterized, in part, by inattention and impulsivity which could place people at increased risk for accidental injury. Researchers in hospital emergency departments have reported that both children and adults with ADHD are at statistically increased risk for sustaining *bodily* injuries compared to those who do not have ADHD.[1-9] However, relatively little is known about sport-related concussion or mild traumatic brain injury (MTBI) in daily life in children and adolescents with ADHD.[10] In a sample of children presenting for evaluation at an outpatient traumatic brain injury clinic, 20% had a pre-injury diagnosis of ADHD[11]. In small prospective and retrospective studies[12], Max and colleagues noted that 15-21% of children who sustained MTBIs had pre-existing ADHD, and 16% of children who sustained orthopedic injuries had pre-existing ADHD. Bijur and colleagues[13] examined a longitudinal cohort of children at ages 5 and 10. Aggression at age 5 was significantly associated with risk for sustaining a head injury, fracture, and laceration between age 5 and 10. Hyperactivity at age 5 was significantly associated with future risk for lacerations, but not head injury, burns, or fractures. McKinlay and colleagues,[14] examining a longitudinal birth cohort (N=1,265), reported that adolescents with ADHD were more likely to have sustained an MTBI before the age of five than adolescents who did not have ADHD. In a chart review study of children and adolescents admitted to an inpatient psychiatry unit,[15] there was a very high rate of ADHD in the sample (over 60%) but no association between ADHD and a history of MTBI. A survey study of high school and university students in Canada revealed a significant association between ADHD and head trauma.[16] In a large case control study using a health maintenance organization database, there was no significant association between pre-existing ADHD and MTBI.[17] Some prospective studies have shown an increased likelihood of

being diagnosed with ADHD after an MTBI,[14,18] whereas other studies have not shown an increased risk for being diagnosed with ADHD after this injury.[12,19,20]

The purpose of this study was to determine whether adolescent athletes with ADHD have a greater lifetime history of concussion than those who do not have ADHD. Given that researchers have reported that people with ADHD are at increased risk for bodily injuries,[1-9] and one survey study reported an association between ADHD and head trauma in adolescents and young adults,[16] we hypothesized that high school student athletes with ADHD would report a greater lifetime history of concussion than those without ADHD.

Methods

In 2010, 6,926 student athletes from Maine completed baseline, preseason testing with ImPACT®, a computerized program measuring symptom ratings and cognitive functioning. This program is used for concussion management; athletes post-injury test scores are compared to their pre-injury scores. A demographics and history questionnaire is embedded in the ImPACT® program. The health survey asked the student whether he or she has had "problems with ADD/hyperactivity" and this question required a yes or no response. The survey also asks about the number of times the student has been diagnosed with a concussion. In addition, the survey includes information about the characteristics and dates of injury—but this additional information is often not completed (and so it was not analyzed in this study). Of the original sample, 397 (5.7%) had missing data on their number of prior concussions. Therefore, the final sample included 6,529 adolescent and young adult students between the ages of 13 and 19 (M=15.9, SD=1.3 years). There were 3,736 (57.2%) boys and 2,793 girls (42.8%). These students were from 49 schools across the state, with no school contributing more than 5% of the total sample. The students completed baseline testing prior to participating in their first sport for

that school year (some students participated in several sports during the year). For boys, the breakdown of sports played at the time of assessment was as follows: football = 30.7%, soccer = 23.1%, basketball = 12.7%, hockey = 9.4%, Lacrosse = 5.7%, track and field and cross country = 4.3%, wrestling = 3.7%, baseball = 2.9%, and other = 7.5%. For girls, the breakdown of sports played at the time of assessment was as follows: soccer = 29.0%, field hockey = 16.6%, cheerleading = 12.3%, basketball = 10.7%, lacrosse = 7.6%, track and field and cross country = 5.3%, volleyball = 3.6%, ice hockey = 3.4%, swimming = 3.3%, softball = 2.9%, and other = 5.3%.

Results

In the total sample, 17.7% reported a history of one or more concussions, 5.7% reported two or more injuries, and 2.0% reported three or more past injuries. Stratified by gender, 20.5% of males and 14.0% of females reported one or more past concussions, 7.0% of males and 4.0% of females reported two or more, and 2.8% of males and 1.1% of females reported three or more past injuries.

In the total sample, 6.3% self-reported a diagnosis of ADHD, representing 8.0% of the males and 3.9% of the females. Of those with ADHD, 26.1% reported a history of one or more concussions compared to 17.1% of those without ADHD [X^2 (1, 6,529)=21.05, p<.00001; OR=1.71, 95% CI=1.35 – 2.15]. Stratified by gender, 27.0% of males with ADHD reported a history of one or more concussions compared to 20.0% of males without ADHD [X^2 (1, 3,736)=8.37, p<.004; OR=1.48, 95% CI=1.13 – 1.94], and 23.6% of females with ADHD reported a history of one or more concussions compared to 13.6% of females without ADHD [X^2 (1, 2,793)=8.92, p<.003; OR=1.97, 95% CI =1.25 – 3.10].

Of those with ADHD, 9.8% reported a history of two or more concussions compared to 5.5% of those without ADHD [X^2 (1, 6,529)=13.14, p<.0003; OR=1.87, 95% CI=1.33-2.64]. Stratified by gender, 10.0% of males with ADHD reported a history of two or more concussions compared to 6.7% of males without ADHD [X^2 (1, 3,736)=4.56, p<.033; OR=1.54, 95% CI=1.03 – 2.30], and 9.1% of females with ADHD reported a history of two or more concussions compared to 3.8% of females without ADHD [X^2 (1, 2,793)=7.51, p<.006; OR=2.51, 95% CI=1.27 – 4.94].

Of those with ADHD, 5.1% reported a history of three or more concussions compared to 1.8% of those without ADHD [X^2 (1, 6,529)=20.86, p<.00001; OR=2.90, 95% CI=1.80-4.67]. Stratified by gender, 5.3% of males with ADHD reported a history of three or more concussions compared to 2.5% of males without ADHD [X^2 (1, 3,736)=8.08, p<.004; OR=2.17, 95% CI=1.26 – 3.75], and 4.5% of females with ADHD reported a history of three or more concussions compared to 0.9% of females without ADHD [X^2 (1, 2,793)=12.99, p<.0005; OR=5.06, 95% CI=1.90 – 13.49]. The concussion histories, stratified by ADHD status, are illustrated in Figure 1.

Insert Figure 1 About Here

Most of the participants with ADHD had missing data relating to whether or not they were taking medications of any kind (54.6%). A subgroup reported that they were taking a medication specifically for ADHD (34.6%), and 10.7% did not record an ADHD-related medication (but did record either taking other medications or taking no medications). The percentages of subjects who were taking ADHD medications who reported one or more, two or more, or three or more prior concussions (26.8%, 10.6%, and 4.9%, respectively) were similar to

these rates of prior injury in the ADHD sample who did not record taking medications (25.7%, 9.3%, and 5.2%).

Discussion

This large-scale, cross-sectional, survey study revealed a significant association between ADHD and lifetime history of concussions in both male and female adolescent student athletes. Boys with ADHD were significantly more likely to report a history of one (27.0%), two or more (10.0%), and three or more (5.3%) prior concussions compared to boys without ADHD (20.0%, 6.7%, and 2.5%, respectively). Similarly, girls with ADHD were significantly more likely to report a history of one (23.6%), two or more (9.1%), and three or more (4.5%) prior concussions than girls without ADHD (13.6%, 3.8%, and 0.9%, respectively). These results are fairly consistent with the results from a survey study of Canadian high school and university students.[16] In that study, three samples were analyzed separately (from Table 2 on page 313): a high school sample of 1,091 students, of whom 5.4% reported a history of ADHD (6.6% of boys and 4.8% of girls); a second high school sample of 196 students who attended a special vocational school for youth with learning problems, of whom 19.9% reported a history of ADHD (21.5% of boys and 16.9% of girls); and a sample of 2,259 university students, of whom 3.4% reported a history of ADHD (6.9% of men and 2.2% of women). In the high school sample, 52.5% of those with ADHD reported a history of head injury (compared to 35.5% of those without ADHD). In the vocational school sample, 48.7% of those with ADHD reported a history of head injury (compared to 32.5% of those without ADHD). In the university sample, 45.5% of those with ADHD reported a history of head injury (compared to 25.6% of those without ADHD). In other published studies, some have found an association between ADHD and MTBI[14,18] and some have not.[11,12,15,19,20] There is literature illustrating that children who sustain moderate or severe TBIs

are at statistically increased risk for being diagnosed with new-onset ADHD [21-23] and this has been termed "secondary ADHD." The same, however, cannot be said for MTBI. There is insufficient evidence to suggest that MTBI can cause ADHD de novo, or hasten the onset in a genetically-vulnerable individual.

This study has important methodological limitations. This was a cross-sectional, retrospective, survey study. The research design did not allow us to determine when the prior concussion occurred in most students, the mechanisms of injury (i.e., sports versus daily life), or when the diagnosis of ADHD was made. In addition, as a survey study we could not confirm that their self-reported histories of concussion or ADHD were accurate. These students did not undergo diagnostic interviews. Importantly, however, the subgroups of girls and boys who reported that they were currently on medications for ADHD also had higher lifetime concussion rates, increasing confidence in the overall findings in this study. Moreover, the rate of self-reported diagnosis of ADHD in the boys (8.0%) and girls (3.9%) in the present study was roughly similar to, albeit somewhat lower than, the rates reported in the US general population and in the state of Maine. The rates of diagnosed ADHD have increased over the past decade, and the estimated prevalence of ADHD in the US for children between the ages of 6 and 17 (in 2004-2006) was 11.8% for boys and 4.8% for girls.[24] According to the Center for Disease Control (CDC) website (http://www.cdc.gov/ncbddd/adhd/data.html; accessed November 24, 2013), the percentage of youth aged 4-17 in the US who have ever been diagnosed with ADHD (as of 2011) was 11.0% (and 12.9% for the state of Maine). The US rates were 13.2% for boys and 5.6% for girls (these rates were not provided by state).

We conclude that adolescent student athletes with ADHD have a greater lifetime history of concussions and multiple concussions than those without ADHD. The reasons for this are

unclear and likely multifactorial. Individuals with ADHD are at increased risk for injuries in general, perhaps due to being less attentive, more impulsive, and more prone to risk taking. Research is now needed to determine if athletes with ADHD are more susceptible to injury (i.e., have a lower threshold) or have worse or different short-, medium-, or long-term outcomes from concussion. Research is also needed to determine whether student athletes who sustain sport-related concussions should be managed differently in regards to resumption of medications and return to school and sports.

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Figure 1. History of Concussions in Adolescent and Young Adult Athletes With or Without ADHD (percentages).