

Consistency of Self-Reported Concussion History in Adolescent Athletes

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Abstract

Relying on self-reported concussion injury history is common in both clinical care and research. However, young athletes may not provide consistent medical information. To date, little is known about the reliability of self-reported concussion history in high school students. This study examined whether student athletes reported their lifetime history of concussions consistently over time. Self-reported concussion history was examined in 4792 student athletes (ages 13–18) from Maine who completed a preseason health survey on two occasions (median re-test interval = 23.7 months; standard deviation = 7.3; interquartile range = 12.4–24.5). Consistency of self-reported concussion history was determined by differences in the number of concussions reported during the second survey. Inconsistent concussion history was defined primarily by a decrease in the number of lifetime concussions reported at the second testing, compared with at the first testing. The majority of the sample (80.3%) reported no change in the number of concussions between the two baseline assessments. A minority (15.9%; $n = 763$) reported more concussions during the second assessment. Only 3.8% ($n = 181$) of student athletes provided inconsistent concussion histories, defined as fewer concussions at the second assessment. Boys provided inconsistent concussion histories a little more frequently, compared with girls (5.3% and 2.0%, respectively; $p < 0.001$). Similarly, athletes with self-reported attention-deficit hyperactivity disorder (ADHD) provided inconsistent concussion histories somewhat more frequently, compared with those without ADHD (7.8% and 3.5%, respectively; $p < 0.001$). Of the athletes with inconsistent concussion histories, greater degree of inconsistency was associated with a greater number of concussions initially reported at baseline ($r_s = 0.54$; $p < 0.001$). Only a small proportion of student athletes provided inconsistent concussion histories. Male gender, ADHD, and greater number of baseline concussions were significantly associated with inconsistency in reporting. Overall, these findings suggest that student athletes are quite consistent when reporting their concussion history when surveyed twice during high school.

Keywords: assessment tools; head trauma; pediatric brain injury

Introduction

CONCUSSION IS A COMMON INJURY among young athletes, especially those involved in contact sports such as football and hockey.^{1–3} There has been a tremendous amount of research on sport-related concussion in the past decade and this literature has been summarized in systematic reviews and meta-analyses.^{4–7} Within this literature, there is considerable interest in the effects

of multiple concussions. A history of recurrent concussion is associated with increased risk for a future concussion,⁸ greater adverse effects of a future concussion,⁹ and slower recovery.^{8,10} However, most prior studies have relied on self-report of concussion history through interview and/or questionnaires.^{11–15} This approach requires young athletes to have an accurate understanding of their medical history and to be able to provide reliable information regarding their concussion history. To date,

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little is known about the consistency of self-reported concussion history in young athletes.

Self-report of concussion history may be subject to several forms of bias, particularly in younger subjects. Current evidence suggests that the method of inquiry may affect concussion reporting in young athletes. For example, high school athletes report more symptoms during a self-administered questionnaire than during a structured interview.¹⁶ Situational factors, such as social desirability (i.e., presenting a favorable image of oneself to others), have been shown to influence self-reporting of health behaviors in young adults.¹⁷ Lack of knowledge of the signs and symptoms of concussions, as well as avoidance of perceived consequences of being diagnosed with a concussion, also may influence self-reporting of symptoms in young athletes.^{18–22} In a recent study, 21.1% of adolescent hockey players provided inconsistent information regarding concussion history on two self-reported instruments administered during the same session.²³

Taken together, these studies suggest that there is potential variability in self-reporting of concussion history in young athletes. Addressing the issues of consistency in concussion reporting is important for both concussion management and research. The present study examined consistency in self-reported concussion history in a large cohort of high school athletes. Additional factors that may contribute to reporting consistency, such as age, gender, number of concussions reported at baseline, current sport, and attention-deficit hyperactivity disorder (ADHD), also were examined.

Methods

A cohort of 5597 high school student athletes from Maine completed baseline preseason testing on two occasions between 2009–2013. Baseline computerized neurocognitive testing was performed using the Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT[®]) instrument as part of a statewide concussion initiative sponsored at the time by the Maine Concussion Management Initiative at Colby College. Students between the ages of 13 and 18 who completed a second baseline between 90 days and 3 years were included in the analyses. A total of 4992 students met this criterion. Of the sample, 200 had missing data regarding the number of concussion at either the first or second baseline (i.e., 4% of the data), resulting in a final sample of 4792. The average duration between the two baselines was 20.7 months (median = 23.9; standard deviation [SD] = 7.0; interquartile range = 12.6–24.5).

As part of ImPACT, students are asked to self-report number of prior concussions, problems with attention deficit disorder/ADHD, diagnosis of a learning disability, repeating one or more years in school, and whether they attended special education classes. The database also included information regarding whether students had completed post-injury testing between the two baselines. We examined the percentages of student athletes who reported the same, more, or fewer lifetime concussions between the two baseline assessments. We could not independently verify self-reported concussions; therefore, we defined inconsistent concussion history as a decrease in the number of lifetime concussions reported at repeat testing, compared with at baseline. We further examined consistency in concussion reporting by examining a subgroup of students who had sustained an injury and completed a post-injury assessment during the interval between their two baseline evaluations ($n = 587$). This was done to examine an increase in the number of self-reported concussions from the first to second baseline, which may be due to the athlete sustaining a new injury. The frequency of athletes with inconsistent concussion history was computed and analyzed using chi-square tests. The association between inconsistent reporting and baseline number of concussions was

examined using a Spearman correlation because of violations of assumption of normality.

Results

Sample characteristics

Participants' average age was 14.9 years (SD = 0.8; range = 13–18) and 46.6% ($n = 2327$) were girls. A total of 255 (5.3%) of the sample reported a diagnosis of ADHD. Mean number of concussions was 0.22 (range = 0–7). Sample characteristics are presented in Table 1.

Consistency of self-reported concussion history

Of the 4792 student athletes, 80.3% ($n = 3848$) reported no change in their concussion history at follow-up, compared with at baseline (i.e., they reported the same number of concussions at both time-points). Of the athletes who reported no concussions at baseline ($n = 4064$), a total of 467 (11.5%) reported one concussion at repeat testing. A minority of the total sample (15.9%, $n = 763$) reported more concussions during the second assessment. From this group, 613/763 (80.3%) reported one more concussion, 110/763 (14.4%) reported two more concussions, and 40/763 (5.2%) reported three or more concussions during the second assessment. Only 3.8% ($n = 181/4792$) of student athletes provided inconsistent concussion histories, defined as reporting fewer concussions during the second assessment. Of these 181 students, 147/181 (81.2%) reported one fewer concussion, 23/181 (12.7%) reported two fewer concussions, and 11/181 (6.1%) reported three or more fewer concussions. The vast majority (4609/4792; 96.2%) of participants consistently reported the number of prior concussions they sustained within ± 1 . Frequencies of consistent and inconsistent self-reported concussion history are presented in Table 2. We examined whether there was a difference in time between testing of consistent (i.e., same number of concussion at baseline and follow-up; M [Mean] = 1.75 year; SD = 0.58 years) and inconsistent (i.e., fewer number of concussion at follow-up; M [Mean] = 1.78 year; SD = 0.57 years) concussion reporting. We did not find a statistically significant difference between the two ($p > 0.05$), suggesting that time between testing did not contribute to inconsistency of concussion reporting.

Sex differences

Defining inconsistent as reporting fewer concussions at time 2, boys reported inconsistent concussion histories more frequently than girls (i.e., 5.3% and 2.0%, respectively; $X^2[1] = 35.85$, $p < 0.001$). This difference could not be accounted for by a difference in the number of concussions reported at baseline between the genders (i.e., boys and girls with inconsistent concussion histories did not differ on the mean number of concussions reported at baseline; $p = 0.77$).

Consistency in those with self-reported ADHD

Student athletes with self-reported ADHD reported fewer concussions at time 2 more frequently than those without ADHD (i.e., 7.8% and 3.5%, respectively; $X^2[1] = 12.25$; $p < 0.001$). This difference could not be accounted for by a difference in the number of concussions reported at baseline between athletes with ADHD and those without ADHD ($p = 0.50$). The consistency of concussion reporting also was stratified by the athletes' sport at the time of baseline testing (see Table 2).

TABLE 1. DISTRIBUTION OF CONCUSSION HISTORY AT BASELINE STRATIFIED BY SAMPLE CHARACTERISTICS (TOTAL SAMPLE, $N=4792$)

Characteristics	Total	No concussion	1 Concussion	2 Concussion	3+ Concussions
Boys (<i>n</i> , %)	2557 (51.4)	2082 (81.4)	326 (14.6)	99 (4.4)	23 (0.9)
Girls (<i>n</i> , %)	2235 (48.6)	1966 (87.9)	191 (8.5)	55 (2.5)	50 (2.2)
ADHD (<i>n</i> , %)	255 (5.3)	198 (77.7)	31 (12.2)	11 (4.3)	15 (5.9)

ADHD, attention-deficit hyperactivity disorder.

Associations with age and number of past concussions

The association between number of baseline concussions and degree of inconsistent reporting (i.e., fewer concussions at time 2) was examined using a Spearman correlation including subjects with inconsistent difference scores between 1 and 4. This was done to eliminate a small number of outliers who had difference scores of >4 ($n=2$) and could artificially inflate the correlation. There was a significant, medium-sized, positive correlation ($r_s=0.54, p<0.001$) between the number of lifetime concussions reported during the first assessment and the difference score (i.e., number of concussions reported at time 1 minus the number reported at time 2). That is, students who reported more prior concussions at baseline tended to be less consistent in their concussion history reporting over time. In addition, there was no significant association between the age of the student athlete and degree of inconsistent reporting ($r_s=0.08, p=0.26$).

Increase in number of concussions at second baseline

We further examined consistency in concussion reporting by examining a subgroup of students who had sustained an injury during

the interval between their two baseline evaluations. For students who were identified as injured and who completed post-injury testing at the school ($n=587$) between their two baseline assessments, 17.0% ($n=110$) reported no change in their concussion history at follow-up, compared with at baseline. A small minority reported a decrease in concussions during their second assessment (2.6%; $n=15$). The majority of students with post-injury testing (80.4%; $n=472$) reported an increase in concussion history during their second assessment. This represented 61.8% ($n=472/763$) of all the students who reported an increase in concussion history during their second assessment.

Consistency of self-reported developmental difficulties

The consistency of self-reporting of developmental variables including self-reported ADHD and learning disorder (LD) status also was examined as a comparator for the consistency of self-reporting concussions. Finding that developmental difficulties are inconsistently reported over time would suggest that any inconsistency in reporting prior concussions may reflect generally weak reliability in the self-report of health data (i.e., not be specific to concussions). The vast majority of students in our sample

TABLE 2. CONSISTENCY OF SELF-REPORTED CONCUSSION HISTORY

	Follow-up = baseline		Follow-up > baseline		Follow-up < baseline		Total <i>n</i>
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	
Total sample	3848	80.3	763	15.9	181	3.8	4792
Boys	1997	78.1	424	16.6	136	5.3*	2557
Girls	1851	82.8	339	15.2	45	2.0	2235
ADHD	193	75.7	42	16.5	20	7.8 [^]	255
No ADHD	3655	80.6	721	15.9	161	3.5	4537
Contact sports	3123	65.2	668	14.0	161	3.3	3951
Limited contact sports	74	86.0	8	9.3	4	4.7	86
Non-contact sports	157	82.1	24	15.3	4	2.5	157
Baseball	74	86.0	8	9.3	4	4.7	86
Basketball	490	85.2	68	11.8	17	3.0	575
Cheerleading	173	79.7	38	17.5	6	2.8	217
Field hockey	323	82.4	60	15.3	9	2.3	392
Football	534	71.3	171	22.8	44	5.9	749
Ice hockey	201	76.1	53	18.9	10	3.6	264
Lacrosse	187	82.0	34	18.5	15	4.8	228
Skiing/snowboarding (all types)	135	73.4	30	18.0	12	8.1	184
Soccer	1080	80.5	214	15.9	48	3.6	1342
Track and field and cross country	157	82.1	24	15.3	4	2.5	157

Inconsistent reporting for number of concussions was defined as reporting a fewer number of concussions on follow-up, compared with at baseline. Sports refer to current sport played as indicated by the athlete at the time of their first testing. Categorization of sport into contact, limited contact, and non-contact were based on classification from the American Academy of Pediatrics.*Difference was significantly different between boys and girls ($p<0.001$). [^]Difference was significantly different between those with ADHD and those without ADHD ($p<0.001$).

ADHD, attention-deficit hyperactivity disorder.

consistently reported their ADHD (96.1%) and LD (97.3%) status at follow-up, compared with at baseline. Of the subjects who reported different ADHD or LD status at follow-up, it was not possible to determine whether this change in status represented a true change (e.g., a new diagnosis or clarification of a past diagnosis during the re-test interval) or inconsistent reporting between the two testing sessions.

Discussion

This study examined the consistency of self-reported concussion history in large sample of high school athletes. We defined one type of inconsistent reporting as a decrease in the number of lifetime concussions reported at repeat testing, compared with at baseline. We found that a small proportion (3.8%, 181/4,792) of athletes provided inconsistent information regarding concussion history. A subgroup of students were identified as injured and underwent post-injury testing at their school during the re-test interval ($n=587$). Of those, 17% reported no change in their concussion history on repeat testing. We cannot definitively presume that these are examples of inconsistent reporting because it is possible that some of these students were not medically diagnosed as having sustained a concussion (i.e., they were given ImPACT following a suspected or possible injury). Some studies have suggested that adolescents and young adults may not be reliable (i.e., underreport or are inconsistent) in reporting concussion history.^{18,20,23} In our study, we found that the vast majority of athletes were consistent in their reporting of concussion history. These data could have important implications for research and injury surveillance efforts in young athletes. Although the gold standard for identifying concussion history may be medical documentation, these data suggest that the use of self-reported concussion on commonly used screening tools may be sufficiently reliable in adolescent athletes.

The present study documented the consistency of self-reported concussion history over time, repeating the same survey method. Of note, one prior study examined consistency in concussion reporting in adolescent hockey players using different modalities (computerized vs. paper and pencil), and administration contexts (completed the questionnaire independently vs. with parental involvement).²³ They found that there were discrepancies in self-reported concussion history in 21.1% of athletes (i.e., 9.6% reported fewer concussions and 11.4% reported more concussions). This latter study demonstrates how inquiring about concussion in a different manner can contribute to inconsistencies.

We also found that 15.9% of athletes reported an increase in the number of concussions across the two time-points. Of those individuals, a large proportion (i.e., 62%) underwent post-injury testing, suggesting that they sustained a suspected or possible injury during that time interval, which could have accounted for some of the discrepancy in reporting of concussions over time. Our study suggests that high school athletes are quite consistent when reporting their concussion history over a 3-month to 3-year interval when asked the same question in the same format.

The present study found that a small minority of high school athletes (3.8%) reported fewer concussions on follow-up, compared with baseline testing. A recent study in professional National Football League players found that only 6.6% reported fewer concussions during a second administration of a screening tool completed 9 years after the first administration.²⁴ There are several potential reasons for the difference in these two studies, including age, time between the two administrations (i.e., 3 months to 3 years

in the present study, compared with 9 years in the latter study), the long retrospective interval when considering lifetime history of concussions, and the greater number of lifetime concussions experienced by former professional athletes.

We examined characteristics associated with inconsistent concussion reporting and found that boys provided inconsistent concussion histories (i.e., fewer concussions at time 2) somewhat more frequently than girls. Gender differences have been previously noted in concussion incidence^{1,25,26} and symptom reporting.^{27,28} Adolescent boys have been found to have worse recall of injuries over time, compared with adolescent girls,²⁹ and former male collegiate athletes have been found to be less likely to disclose concussion history.²¹ Although precise dates of the concussions and duration between concussion and reporting could not be examined, our findings suggest that small gender differences also exist in the consistency of concussion history reporting. Athletes with ADHD also provided inconsistent concussion histories (i.e., fewer concussions at time 2) more frequently than those without ADHD, although the large majority of those with ADHD were consistent in their injury reporting.

The number of lifetime concussions reported at baseline was positively associated with the degree of inconsistent reporting. Hence, athletes who reported a greater number of concussions at baseline provided more inconsistent concussion history information at repeat testing. It is possible that consistent recall of concussion history is more difficult for adolescent athletes who have a greater number of concussions at baseline (e.g., it is more difficult to recall the exact number of concussions when one has a history of three or more concussions, compared with one). Similarly, McKay and colleagues²³ found greater disagreement in concussion reporting in individuals reporting one or two previous concussions, compared with those reporting no previous concussions. Self-reporting of concussion history also may be affected by the age of the reporter, with younger individuals potentially having more inconsistent reporting across measures, as observed by McKay and colleagues.²³ In the current study, there was no association between age and inconsistency of concussion reporting in adolescent athletes. This potentially suggests that age of the athlete (in particular the youth athlete) may have a larger impact on concussion reporting across modalities (e.g., using different measures) as opposed to across time (e.g., reporting concussion history on the same measure over time).

This study has some important methodological limitations. First, athletes were not provided with a definition of concussion and previous literature has suggested differing rates of prior concussion depending on how adolescents are asked about concussion.³⁰ Second, we defined inconsistent reporting primarily as a decrease in the number of concussions reported at repeat testing, compared with at baseline. We operationalized inconsistency in this manner because an increase in the number of concussions could have been due to the new incidence of concussion, inconsistent reporting, or both. Although it is likely that some inconsistency occurred in this direction as well, we believe a large number of the self-reported increased number of concussions were due to new injuries. We examined the consistency of concussion reporting in a subgroup of athletes ($n=587$) who had completed post-injury testing between the two assessments (i.e., suggesting that an injury had occurred). The majority of these students (80.4%) reported an increase in number of concussions; this suggests that they did experience a medically diagnosed concussion between the two assessments. Third, the research design did not allow us to determine when the prior concussion occurred in students, the mechanisms of injury

(i.e., sports vs. daily life), or confirm the diagnosis of concussion with medical records. Finally, some literature has suggested youth athletes may underreport concussions and this issue could not be examined further using these data.²⁰ Variability in concussion reporting may be related to changes in the youths' understanding of or ability to identify a concussion, as well as concerns about potential consequences of reporting a concussion.^{18–20}

In conclusion, these findings suggest that student athletes are quite consistent when reporting their concussion history when surveyed twice during high school. A small percentage of participants (3.8%) reported fewer concussions on repeat baseline testing, indicating clearly inconsistent reporting, and we assume that there is a small but unknown percentage of athletes who incorrectly report no change or an increase in their number of injuries. We conclude that, although solely relying on self-report to document concussion history may not be ideal, self-reported injury history may be relatively reliable in high school athletes. Future research is needed to assess the accuracy and reliability of self-reported concussion injury, compared with documented medical history of concussion.

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Author Disclosure Statement

GLI has been reimbursed by the government, professional scientific bodies, and commercial organizations for discussing or presenting research relating to mild traumatic brain injury and sport-related concussion at meetings, scientific conferences, and symposiums. He has a clinical practice in forensic neuropsychology involving individuals who have sustained mild traumatic brain injuries (including athletes). He has received honorariums for serving on research panels that provide scientific peer review of programs. He is a co-investigator, collaborator, or consultant on grants relating to mild traumatic brain injury funded by several organizations. He has received research support from test publishing companies in the past, including ImPACT[®] Applications Systems (not in the past 5 years). For the remaining authors, no competing financial interests exist.

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