Academic Dysfunction After a Concussion Among US High School and College Students

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Objectives. To determine whether concussed students experience greater academic dysfunction than students who sustain other injuries.

Methods. We conducted a prospective cohort study from September 2013 through January 2015 involving high school and college students who visited 3 emergency departments in the Rochester, New York, area. Using telephone surveys, we compared self-reported academic dysfunction between 70 students with concussions and a comparison group of 108 students with extremity injuries at 1 week and 1 month after injury.

Results. At 1 week after injury, academic dysfunction scores were approximately 16 points higher (b = 16.20; 95% confidence interval = 6.39, 26.00) on a 174-point scale in the concussed group than in the extremity injury group. Although there were no differences overall at 1-month after injury, female students in the concussion group and those with a history of 2 or more prior concussions were more likely to report academic dysfunction.

Conclusions. Our results showed academic dysfunction among concussed students, especially female students and those with multiple prior concussions, 1 week after their injury. Such effects appeared to largely resolve after 1 month. Our findings support the need for academic adjustments for concussed students. (*Am J Public Health*. 2016;106: 1247–1253. doi:10.2105/AJPH.2016.303154)

Concussions, or mild traumatic brain injuries (TBIs), place a tremendous burden on student athletes, accounting for 13% of all injuries among US high school athletes.[1] Concussed individuals experience somatic symptoms (e.g., headache, dizziness), cognitive difficulties (e.g., impaired concentration, memory loss), sleep disturbance, and altered mood, especially depression.[2] These symptoms are associated with poor academic performance among otherwise healthy individuals and can greatly impair concussed students' ability to perform at their maximum academic potential.[3–6]

Among students who suffer moderate or severe TBIs, there is a wealth of evidence revealing decreased academic performance many years after injury, supporting extra services for these students after their return to school[7–9]; however, there is sparse literature examining academic performance among students who have sustained milder forms of TBI (e.g., concussions). Concussed students typically return to school within a week after injury, while their brains are likely still recovering.[1,2,10]

Anecdotally, students with concussions report difficulties with schoolwork, including increased required effort, poorer performance, and symptom exacerbation.[11–13] Survey studies of concussed students and their parents show that anywhere from 27% to 90% of students report trouble doing schoolwork or grade declines.[14–17] Medical record reviews and surveys involving parents and school officials reveal that up to 73% of concussed students receive academic adjustments (i.e., curriculum modifications or services based on limitations) after their return to school.[15,18–21]

These studies are limited, however, in that they are mostly descriptive and lack comparison groups of students who have not suffered brain injuries, limiting researchers' ability to distinguish the academic effects specific to concussion from the effects of the pain and disruption of daily activity from sustaining any injury. In addition, most studies do not include assessments of academic effects within the typical concussion recovery window of 1 month, instead focusing on many months to years after injury.[10,22–24] Also, many are based in concussion clinics, and thus subject to referral bias,[14,15,17] and do not examine factors that may increase susceptibility to concussion effects (e.g., age, gender, concussion history).[25–30] Therefore, current guidelines related to accommodations and strategies for students when they "return to learn" after a concussion lack a solid evidence base.[11,31,32]

We sought to determine whether concussed students experience greater academic dysfunction (i.e., inability to perform at a normal academic level) than students who sustain other injuries and to what extent gender, age, and concussion history modify this association. We hypothesized that concussed students would experience more academic dysfunction than those with isolated musculoskeletal extremity injuries and that the magnitude of this difference would be greater among female students, younger students, and those with a history of previous concussions.

METHODS

In our prospective cohort study, conducted from September 2013 through January 2015, students who had sustained

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a sports-related concussion or musculoskeletal extremity injury were enrolled from 3 emergency departments (EDs), with follow-up taking place at 1 week and 1 month after injury. We chose to use ED patients with an extremity injury as a comparison group because previous research suggests that the trauma of sustaining any injury may result in sequelae similar to those associated with concussions.[33–35] Thus, we isolated academic sequelae specific to concussions from those attributable to sustaining a sports injury.

We identified participants through the University of Rochester's Emergency Department Research Associate Program and medical record reviews.[36] Students were eligible if they had sustained an isolated injury (i.e., an injury to only 1 part of the body) through sports participation, were enrolled full time in high school or college, and were English speaking. Although sports participation could have involved either organized or unorganized sports (e.g., physical education classes), approximately 80% of the students took part in organized sports.

Concussed students were required to have an ED diagnosis of concussion, to meet the American Congress of Rehabilitation Medicine clinical definition of mild TBI,[37] or to meet the following concussion definition: a blunt injury to the head or to the body with impulsive force transmitted to the head that resulted in any of the following symptoms: headache, nausea, vomiting, dizziness/balance problems, fatigue, drowsiness, blurred vision, memory difficulty, or difficulty concentrating.[16] We determined the presence of these symptoms through medical record reviews and the participant's description of the injury event during recruitment. ED patients were eligible to serve in the comparison group if they had sustained an extremity injury requiring an x-ray.

Students who visited the ED more than 24 hours after injury or were admitted to the hospital as inpatients were excluded. Concussed students were excluded if they had a positive computerized tomography scan, as indicated by the presence of an acute traumatic intracranial lesion. Individuals with an extremity injury were excluded if the only injury was a laceration or if the injury was a head, neck, thorax, chest, or abdomen injury. These inclusion and exclusion criteria were instituted to ensure comparability in terms of injury severity between the 2 injury groups. If students did not meet any of our exclusion criteria after a medical record review, they or their guardians were contacted via telephone to ask whether they wanted to take part in the study, to verify that they met the inclusion criteria, and to obtain informed consent. All of the students were told that the purpose of the study was to examine the association between sports injuries and problems in school.

Measures

We obtained data on acute injury characteristics from hospital medical records and a telephone-based screening instrument and conducted telephone interviews with participants at 1 week (5–9 days) and 1 month (25–35 days) after injury. These interviews assessed self-reported academic dysfunction, presence of concussion sequelae (i.e., postconcussive symptoms, sleep disturbance, mood disturbance, impaired cognition), demographic characteristics, and premorbid characteristics that could influence concussion sequelae (e.g., concussion history, self-reported learning disability).

There are currently no validated self-report measures of academic dysfunction. Therefore, we drew on anecdotal reports from a concussion clinic, case reports, qualitative literature, and a collaborator's clinical survey to create a new self-report dysfunction measure.[8,38–40] Previous research has shown that self-reported memory problems after a concussion correlate with poor performance on neuropsychological tests, indicating that a self-report instrument should be a good measure of true academic dysfunction.[41,42] Our resulting measure contained 29 statements. We determined, through an exploratory factor analysis, that these statements were in the broad areas of general performance (e.g., I have difficulty doing well on tests or quizzes), attention (e.g., I cannot stay on task), and symptom exacerbation (e.g., I get headaches or dizzy when I have to concentrate). The full instrument is shown in Appendix A (available as a supplement to the online version of this article at http://www.ajph.org).

For each statement, participants were asked to indicate, on a scale ranging from 0 (not true at all) to 6 (very true), the extent to which the statement was currently true for them. Therefore, potential scores ranged from 0 to 174, with higher scores indicating greater academic dysfunction. In the case of items that were worded in a way such that a higher score was better, we reversed the scoring to reflect that a higher score indicated more academic dysfunction. For any statement in which students provided more than a 0 rating, they were also asked whether the issue was new since their injury.

We pilot tested our measure with a current college student who had sustained a concussion and a recent college graduate to ensure the clarity of the instrument. In our sample, the measure showed high internal consistency (standardized Cronbach α values of 0.93 to 0.95). It also had good criterion validity: students who reported having a learning disability, attention deficit disorder (ADD) or attention deficit/hyperactivity disorder (ADHD), or a low grade point average (GPA) had higher scores. In addition to completing this instrument, students were asked about date of return to school, absenteeism, self-reported GPA, and academic adjustments received.

Statistical Analyses

We performed a cross-sectional analysis at each follow-up time point. We used multivariable linear regression (ordinary least squares) and included covariates identified in the existing literature as potential confounders or predictors of academic dysfunction (i.e., school level, gender, concussion history, race, ethnicity, type of insurance, self-reported learning disability, ADD/ADHD, preinjury GPA, participation in an organized sport). We used manual backward selection and retained only variables that were significantly associated with the outcome ($P < .05$) or appreciably changed the estimate for injury type (by more than 10%) when they were removed from the model.[43] The final model adjusted for concussion history and self-reported ADD/ADHD and preinjury GPA.

On the basis of the existing literature, we considered gender, school level (high school vs college), and concussion history potential effect measure modifiers.[25–30] If the interaction term between injury type and a covariate was significant at the .05 level at either time point, the covariate was determined to be an effect measure modifier.

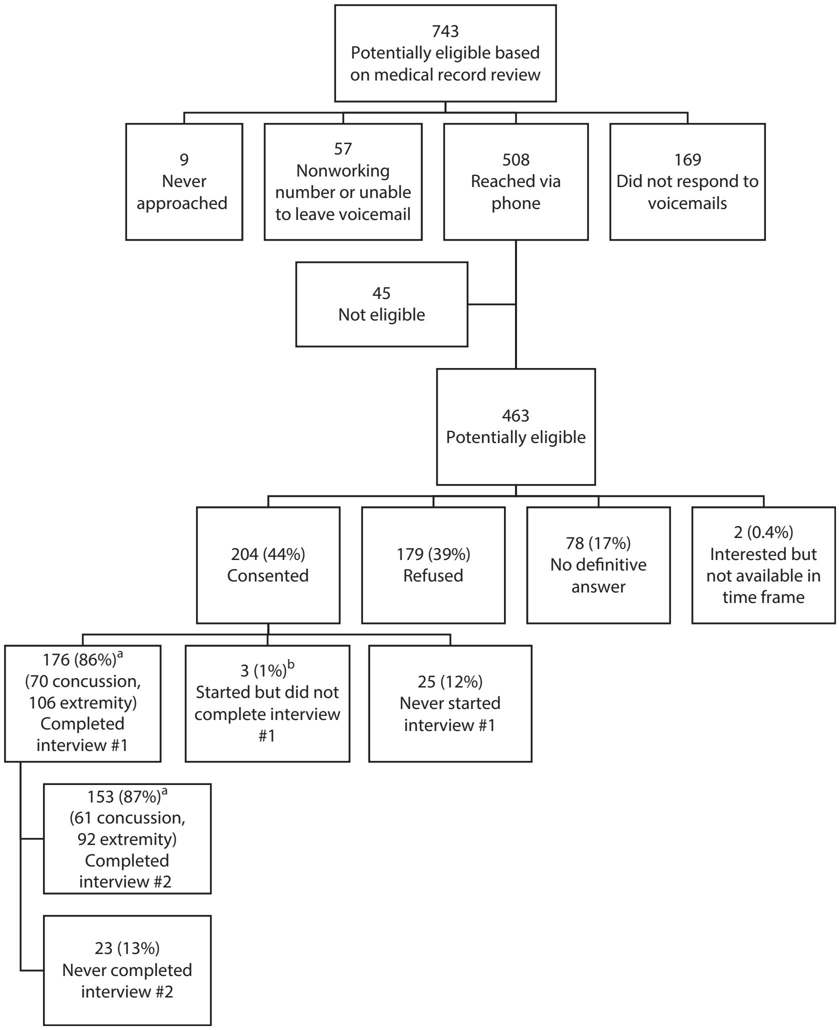
We excluded from our analyses any individual who did not have complete data on all of the covariates or had not returned to school at the time of the interview (33 students at 1 week after injury and 8 students at 1 month after injury). Students who had not returned to school at 1 week after injury were eligible to participate at 1 month. All students with data points at a given time period were included in the analyses; thus, students included in the 1-month after injury analysis were not a subset of students included in the 1-week analysis. We used SAS versions 9.3 and 9.4 (SAS Institute, Cary, NC) in conducting all of our analyses.

RESULTS

Of 743 possibly eligible students identified through our medical record review, we called 734 and reached 508 students or guardians (Figure 1). After discussions with potential participants or their guardians, 45 students (9%) were determined not to be eligible for the study. Of the 463 potentially eligible participants who remained, 204 (44%; 56% with a concussion, 39% with an extremity injury) consented to take part in the study, and 179 (39%; 25% with a concussion, 45% with an extremity injury) refused. The remaining students either could not find time to take part in the study or never indicated definitive consent or refusal.

Of the 204 consenting students, 176 (86%) completed the first interview (70 with a concussion, 106 with an extremity injury), and 153 (75%) completed both interviews (61 with a concussion, 92 with an extremity injury). Although 3 additional students with an extremity injury started but did not complete the first interview, 2 of them provided the complete data required for our analyses. Of note, 23 (13%) students had not returned to school at the time of the 1-week postinjury interview (24% of students with a concussion and 6% of students with an extremity injury) and therefore could not complete the self-reported academic dysfunction instrument.

Students' age and gender were similar in the 2 injury groups (Table 1). More students in the concussion group than in the extremity injury group were White, and a higher proportion of concussed students had private insurance, but these characteristics were not associated with academic dysfunction in our sample ($P = .63$ and $P = .64$, respectively). At 1 week after injury, a higher proportion of students with an extremity injury had returned to sports participation; at 1 month after injury, however, a slightly higher proportion of concussed students had returned to participation (Table 2).



[a]We excluded from analysis any individual who did not have complete data on all covariates or had not returned to school at the time of the interview (n = 33 at 1 week after injury, n = 8 at 1 month after injury).
[b]Two of these 3 participants provided all information required for these analyses.

FIGURE 1—Recruitment of Participants From 3 Rochester, NY, Area Emergency Departments: September 2013–January 2015

Academic Dysfunction

Students with a concussion took longer to return to school (median = 4 days; mean = 5.4; SD = 5.1) than students with an extremity injury (median = 2 days; mean = 2.8; SD = 2.6). A higher percentage of students in the concussion group than in the extremity injury group received academic adjustments (e.g., extra time on tests, tutoring) 1 week after their injury (42% vs 25%), but the distribution was more similar at 1 month (31% vs 24%).

At the 1-week postinjury interview, 83% of concussed students reported that at least 1 item on the academic dysfunction instrument was new since their injury, as compared with 60% of students with an extremity injury. At the 1-month interview, 61% of concussed students and 30% of students with an extremity injury reported that at least 1 item was new.

At 1 week after injury, concussed students had a 15-point higher average score on the self-reported academic dysfunction

TABLE 1—Characteristics of High School and College Students With a Concussion or Extremity Injury: Rochester, NY, Area, September 2013–January 2015

Characteristic	Concussion Group (n = 70), Median (IQR) or No. (%)	Extremity Injury Group (n = 108), Median (IQR) or No. (%)
Age, y	15.5 (15–17)	16.0 (15–18)
College (vs high school)	17 (24)	26 (24)
Male	45 (64)	73 (68)
Race		
White	53 (76)	75 (69)
Black	6 (9)	19 (18)
Other	11 (16)	13 (12)
Unknown	0 (0)	1 (1)
Hispanic ethnicity	2 (3)	6 (6)
Type of insurance		
Private	53 (76)	67 (62)
Public	16 (23)	41 (38)
Unknown	1 (1)	0 (0.0)
No. of previous concussions		
0	37 (53)	69 (64)
1	20 (29)	21 (19)
2	8 (11)	9 (8)
≥ 3	5 (7)	9 (8)
Preinjury grade point average[a]	3.5 (3.2–3.8)	3.5 (3.0–3.7)
Learning disability	4 (6)	9 (8)
ADD/ADHD	11 (16)	18 (17)
Plays organized sport[b]	57 (81)	85 (80)

Note. IQR = interquartile range; ADD = attention deficit disorder; ADHD = attention deficit/hyperactivity disorder.

[a]Sample size was n = 164 (63 for concussion, 101 for extremity injury).

[b]Only among those who completed the 1-week postinjury interview (n = 176: 70 for concussion, 106 for extremity injury).

instrument than students with extremity injuries (63 vs 48; b = 14.75; 95% confidence interval [CI] = 4.60, 24.90). At 1 month, there was no difference in scores between the 2 groups (42 vs 40; b = 1.77; 95% CI = –8.45, 11.98). After adjustment for preinjury GPA, self-reported history of ADD/ADHD, and prior concussions, concussed students had a 16-point higher average score on the academic dysfunction instrument than students with extremity injuries at 1 week after injury (b = 16.20; 95% CI = 6.39, 26.00; Figure 2). At 1 month after injury, there was no difference between the groups (b = 0.83; 95% CI = –8.99, 10.65; Figure 2).

Susceptible Subgroups

The association between injury type and academic dysfunction varied by gender and by concussion history, with a stronger relationship among female than male students and a progressively larger association with increasing number of previous concussions, although the association was larger among those with no prior concussions than among those with 1 prior concussion (Figure 2; at 1 week after injury, gender by injury type interaction $P = .01$, concussion history by injury type interaction $P = .01$; at 1 month after injury, $P = .08$ and $P = .07$, respectively).

Among male students, those with a concussion had higher academic dysfunction scores than those with an extremity injury at 1 week after injury, although the difference was not statistically significant (b = 7.71; 95% CI = –3.67, 19.08). The difference was much larger among female students (b = 37.80; 95% CI = 20.28, 55.32). Among students with no prior concussions, the concussion group again had higher scores than the extremity injury group (b = 17.43; 95% CI = 4.96, 29.90), but among those with a history of multiple concussions (2 or more), the concussed students' scores were much higher (b = 43.19; 95% CI = 21.51, 64.87; additional differences at the 2 time points are shown in Figure 2. (See also Table A, available as a supplement to the online version of this article at http://www.ajph.org.)

DISCUSSION

This study is one of the first to quantify academic dysfunction among concussed students in the first month after injury. At 1 week after injury, after adjustment for preinjury GPA, a self-reported history of ADD/ADHD, and prior concussions, students with concussions reported more academic dysfunction than those with extremity injuries; however, at 1 month after injury, there was no overall difference between the 2 groups. Our results also showed that female students and students with a history of 2 or more previous concussions were more susceptible to the effects of concussion.

The academic dysfunction recovery time of between 1 week and 1 month observed here is similar to what has been reported as the recovery time frame with respect to somatic symptoms and cognition after a concussion.[10,35] However, because we assessed academic dysfunction only at 1 week and 1 month after injury, we were unable to determine exactly when concussed students returned to the academic achievement level of those with extremity injuries. Interestingly, the majority of concussed students (61%) still reported at 1 month that at least 1 academic functioning component was not the same as it was before their injury. This finding should be interpreted cautiously, however, because perceptions of preinjury academic achievement may be skewed; previous studies have shown that concussed individuals underreport their preinjury symptoms by as much as 97%.[44] Further research is needed to refine the specific trajectories of recovery to elucidate whether improvements are gradual or sudden and which symptoms and areas of academic dysfunction improve more quickly.

Our finding of between-group differences in academic dysfunction at 1 week but not 1

TABLE 2—Injury Characteristics Among High School and College Students With a Concussion or Extremity Injury: Rochester, NY, Area, September 2013–January 2015

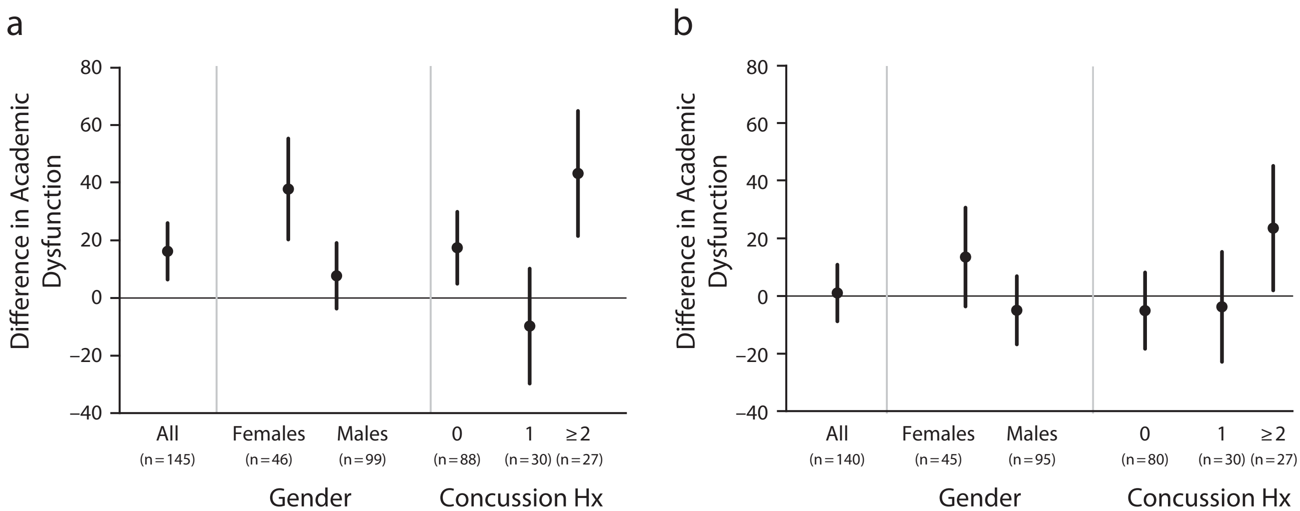
Characteristic	Concussion Group (n = 70), No. (%)	Extremity Injury Group (n = 108), No. (%)
Sport played when injury was sustained		
Soccer	14 (20)	16 (15)
Basketball	5 (7)	21 (19)
Football	9 (13)	14 (13)
Rugby	11 (16)	3 (3)
Other	31 (44)	54 (50)
Injury location		
Head	70 (100)	
Knee		26 (24)
Ankle		21 (19)
Shoulder		17 (16)
Other		44 (41)
Returned to sports participation at 1 week[a]	5 (9)	16 (19)
Returned to sports participation at 1 month[b]	33 (66)	38 (50)

[a]Only among those who played an organized sport and completed the 1-week postinjury interview (n = 142: 57 for concussion, 85 for extremity injury).
[b]Only among those who played an organized sport and completed the 1-month postinjury interview (n = 126: 50 for concussion, 76 for extremity injury).

month after injury, along with the fact that some students (e.g., female students and those with a history of previous concussions) but not others still experienced dysfunction at 30 days, supports current recommendations that students should receive services at school, through formal or informal adjustments, during the first 1 to 3 weeks after their injury.[11–13] Current recommendations for postconcussion return to school suggest specific adjustments, such as shortened school days, tutoring, reductions in academic workloads, and extended time for completion of assignments and tests.[11–13,32,38,45] An assessment of specific services provided and their relative effects on academic dysfunction was outside the scope of our study but should be examined in the future. In addition, future research should ascertain whether female students and those with multiple previous concussions would benefit from tailored interventions.

Although not statistically significant, the differences in academic dysfunction at 1 week after injury between female and male students and between individuals with and without a history of 2 or more previous concussions remained at 1 month after injury. The effects observed were likely limited by the small sample sizes within some of the strata.

The findings just described are consistent with a recent study showing that a higher percentage of female than male concussion clinic patients received academic adjustments,[18] as well as existing literature indicating that female patients and those with a history of concussions have worse symptoms and take longer to recover after a concussion.[26–30] These individuals could be identified acutely (e.g., in the ED or by an athletic trainer), and they could follow up with clinical concussion specialists and academic support specialists early in the recovery



Note. Concussion Hx = history of previous concussions. Higher number indicates worse dysfiunction. Values for b and 95% confidence intervals were adjusted for preinjury grade point average and self-reported history of attention deficit disorder or attention deficit/hyperactivity disorder and prior concussions.

FIGURE 2—Differences in Academic Dysfunction Scores Between Students With Concussions and Students With Extremity Injuries (a) 1 Week After Injury and (b) 1 Month After Injury: Rochester, NY, Area, September 2013–January 2015

process and receive more aggressive interventions rather than waiting for protracted recovery, as is often done now. Although we did identify some susceptible subgroups, our sample size did not allow us to study other characteristics (e.g., learning disabilities) potentially increasing susceptibility and the need for targeted interventions.

Strengths and Limitations

The strengths of our study included prospective enrollment near the time of injury; use of an injured comparison group; use of a novel, clinically relevant outcome; and outcome measurements assessed during the typical recovery time frame. Recruitment from an ED allowed us to enroll acutely injured participants; because of this strategy, however, we did not have preinjury measurements, and thus the number of items on our instrument rated as "new" since the injury may have been overreported. In addition, our sample may not be generalizable to the overall sport-related concussion population, although there is currently no evidence to suggest that concussed patients who visit an ED are different from those who seek medical attention elsewhere. Discharge instructions likely varied among EDs and individual providers within these departments, and we do not know how many of our concussed participants saw primary care physicians or visited a concussion clinic.

Our sample is more likely to be representative of concussion patients than samples in previous studies recruited from concussion clinics; the median of 4 days to return to school among concussed students in our study is shorter than the 12 days to return recently reported by Corwin et al. in a study involving a sample of concussion clinic patients.[15] Concussion clinic patients are more likely to experience worse concussion outcomes (73% of the Corwin et al. sample was symptomatic 4 weeks after injury).[15]

Although our response rate was low, those who agreed to take part in the study were similar in terms of age and gender to those who refused, limiting selection bias. Concussed students were more likely to agree to take part in the study than students with an extremity injury, but we have no reason to believe that there were differences in academic dysfunction between those who did and did not participate. It is possible that individuals who refused had a higher symptom burden and therefore could not participate, meaning that we did not include an important subset of students in our study.

In addition, 24% of concussed students had not returned to school at 1 week after injury and were not included in our analysis, probably limiting the effects observed. Furthermore, some of the effects observed may have been attributable to discrepancies in time taken to return to school. Our definition of concussion was broad and relied on medical record data as opposed to clinical confirmation. It is possible that some of the students who were included in our sample as concussed actually did not have a concussion; however, because of our screening criteria, it is unlikely that extremity-injured students had a concussion, and thus our results likely underestimate the association between concussion and academic dysfunction.

Finally, our self-report measure of academic dysfunction was not previously validated and underwent only limited pilot testing. It was, however, developed from existing measures, qualitative literature, and case studies, and it showed good internal consistency and criterion validity.[8,38–40] Also, although our academic dysfunction tool measured several facets of school-related postconcussion issues, our exploratory factor analysis was limited by the study's small sample size. Therefore, the domains we identified (e.g., attention, memory, symptom exacerbation) should be considered preliminary, and we could not examine them as separate outcomes. Despite these limitations, our survey instrument is the most comprehensive measure of academic dysfunction to date and adds further detail on the academic recovery of concussed student athletes. This measure can be used in other studies and should be tested in other populations.

Conclusions

Concussed students experienced significantly more academic dysfunction 1 week after their injury than those with an extremity injury, but most issues appeared to resolve at 1 month. Our results also showed that female students and those with a history of 2 or more concussions may be more susceptible to the effects of concussions. These data reinforce the need for return-to-learn guidelines and academic adjustments based on gender and concussion history. Further investigation is required into the precise timing of recovery among concussed students, including evaluations of changes in academic dysfunction over the time course of recovery via more frequent assessments than available here. Work is also needed to develop and test appropriate interventions to mitigate academic dysfunction. AJPH

CONTRIBUTORS

E. B. Wasserman conceptualized and designed the study; acquired, analyzed, and interpreted the data; and drafted the article. J. J. Bazarian, M. Mapstone, R. Block, and E. van Wijngaarden contributed to the conceptualization and design of the study and the interpretation of the data and reviewed and revised the article.

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HUMAN PARTICIPANT PROTECTION

This study was approved by the University of Rochester Research Subjects Review Board and the Rochester General Hospital institutional review board. Verbal informed consent was obtained.

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