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Characteristics of Prolonged Concussion Recovery in a Pediatric Subspecialty Referral Population

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Abstract

Objective—To identify pre-existing characteristics associated with prolonged recovery from concussion in a sample of patients referred to a pediatric sports medicine clinic.

Study design—This was a retrospective, exploratory cohort study of 247 patients age 5-18 years old with concussion referred to a tertiary pediatric hospital-affiliated sports medicine clinic from July 1, 2010, through December 31, 2011. A random sample of all eligible patient visits (3740) was chosen for further review and abstraction. Statistical comparisons between subsets of patients were conducted using exact chi-square tests, logistic regression, quantile regression, and Kaplan Meier survival curves.

Results—The median time until returning to school part-time was 12 days (interquartile range (IQR) 6-21); until returning to school full-time without accommodations was 35 days (IQR 11-105); until becoming symptom-free was 64 days (IQR 18-119); and until being fully cleared to return to sports was 75 days (IQR 30-153). 73% of all patients were symptomatic for >4 weeks, 73% were prescribed some form of school accommodation, and 61% reported a decline in grades. Characteristics associated with a prolonged recovery included a history of depression or anxiety; an initial complaint of dizziness; abnormal convergence or symptom provocation following oculomotor examination on physical examination; and history of prior concussion.

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Conclusion—Pediatric and adolescent patients with concussion may experience cognitive and emotional morbidity that can last for several months following injury. Clinicians should consider specific pre-existing characteristics and presenting symptoms that may be associated with a more complicated recovery for concussion patients.

Keywords

head injury; mild traumatic brain injury; postconcussion syndrome

Sports- and recreation-related concussions are common childhood injuries. Prior studies have estimated that nearly 150,000 children and adolescents are seen in emergency departments for concussion each year.¹ Including adults, the total number of sports-related traumatic brain injuries has been estimated to be between 1.8 and 3.8 million annually.²⁻⁵ Due to both increasing awareness and diagnosis, as well as increasing incidence of injury, the rate of concussion among children continues to rise, and has been estimated to have doubled in the past 15 years.⁶

Pediatric and adolescent patients with concussion are at risk for significant cognitive⁷⁻⁸ and emotional morbidity, including emotional lability, irritability, and depression.^{5,9} Recent studies have begun to delineate factors predisposing youth athletes to a more prolonged recovery, including a history of three or more prior concussions¹⁰⁻¹² and adolescent age.^{13,14} Certain presenting symptoms, including dizziness, headache and migrainous-like symptoms (post-traumatic migraine) have also been associated with prolonged recovery in youth athletes.^{12,15-17} Adult data have shown those with pre-existing depression have more severe acute neurocognitive deficits than those without depression.^{18,19} Less is known, however, about pre-existing patient characteristics that predispose children and adolescents to prolonged recovery from concussions.

By examining a sample of patients referred to a specialty pediatric sports medicine clinic for management of concussion, this exploratory study aimed to further characterize pre-existing patient characteristics and presenting symptoms associated with prolonged recovery. We hypothesized that those with pre-existing mood disturbances and learning disabilities, those presenting with dizziness or loss of consciousness (LOC), those with abnormal near-point convergence and symptom provocation following oculomotor examination, and those with a history of prior concussion and younger age would suffer from prolonged symptoms.

METHODS

We conducted a retrospective cohort study of patients treated for concussion in the subspecialty sports medicine clinics of a large pediatric tertiary care network. The data were collected via an electronic medical record query. A total of 3740 unique visits for patients age 5-18 years occurred in the clinics between July 1, 2010, and December 31, 2011. A convenience sample of 250 patients, chosen given estimated workload for data abstraction, was randomly selected for further evaluation. All visits for each patient were identified and charts were abstracted electronically to obtain relevant data. Eligible patients were those who had received a diagnosis of concussion (by International Classification of Diseases, Ninth Revision; ICD-9 codes 850.0, 850.1, 850.11, 850.12, 850.2, 850.3, 850.4, 850.5, or

850.9) by the referring provider. This diagnosis was confirmed by the sports medicine physician at the initial visit using the definition of concussion specified in the Consensus Statement on Concussion in Sport 4th International Conference on Concussion in Sport held in Zurich, Switzerland (mechanism of injury that results in direct or indirect forces to head resulting in symptoms including somatic, cognitive, and emotional disturbances),²⁰ a 16-point validated symptom scale,²¹ and exam findings including balance, neurocognitive deficits, vestibular/oculomotor deficits, and near-point convergence deficits (obtained as a one-time measure).^{22,23} For the majority of patients seen at the clinics, the mechanism of injury is sports-related, although some injuries are trauma-related, including motor vehicle crashes, falls, and playground injuries. Those patients seen with non-sports, trauma-related injuries in the clinic experienced whiplash-type injuries, which were considered to be a low-impact injury mechanism and therefore comparable with sports-related concussion. Patients with high-impact, traumatic injury mechanisms (including motor vehicle crashes with patient ejection, death of another passenger, or rollover; and pedestrian/bicyclist without a helmet struck by a motorized vehicle) are not typically seen in our clinic. Patients with intracranial hemorrhage or prior neurologic surgery were excluded; however, those with a pre-existing vestibular disorder, substance abuse, or psychiatric disorder were not excluded. In addition, three of the 250 charts were duplicate patients, and thusly excluded. The majority of patients seen in the sports medicine clinic are often referred for more severe or prolonged symptoms of concussion from a sports-related injury. There are patients, however, who are seen in the clinic at the time of injury regardless of severity or mechanism. Study data were collected and managed using Research Electronic Data Capture (REDCap) tools hosted at The Children's Hospital of Philadelphia.²⁴

Demographics, injury details (date, mechanism), interventions by the referring physician (including recommendation of cognitive rest), initial symptoms at the time of injury, and physical examination findings during the initial patient visit at the sports medicine clinic were all collected from the patient visit record. For school outcomes, data were examined only for patients whose initial injury occurred between September 1 and May 31 in the years 2009, 2010, and 2011. The physical examination is a standardized concussion evaluation performed by the sports medicine physicians at The Sports Medicine and Performance Center at The Children's Hospital of Philadelphia and includes assessment for dysmetria, nystagmus, smooth pursuits, fast saccades (both horizontal and vertical),²⁵ gaze stability testing, near-point convergence testing,²⁶ and gait/balance testing. The physical examination, previously published,^{22,23} is conducted in a standardized fashion by three sports-medicine trained pediatricians. The examination was administered only by these three physicians, and was documented in a standardized template in the electronic health record.

Exposures and Outcomes

Patient data were analyzed using five categories relating to different types of exposures (i.e., potential risk factors) for prolonged recovery: (1) Pre-existing conditions on initial presentation, specifically a history of depression, anxiety, attention deficit hyperactivity disorder (ADHD), and a learning disability, all of which were reported by either patients or parents; (2a) Patient- or parent-reported presenting symptoms, specifically dizziness and loss of consciousness; (2b) Physical examination at the initial clinic visit, specifically symptom

provocation following oculomotor examination (with smooth pursuits, saccades or gaze stability testing, or difficulty completing the testing), and abnormal near-point convergence (defined as convergence greater than six centimeters^{27,28}); (3) Patient age at time of injury; (4) Patient- or parent-reported prior history of concussion; and (5) Recommendation of cognitive rest by the referring provider (either an athletic trainer, primary care physician, or emergency room physician) prior to initial specialty visit, as ascertained from patient or parent report. During our visits and in our practice, we considered a patient to have a history of a certain condition or be symptomatic by either patient- or parent-report.

The sports medicine subspecialty group developed a “return to learn” protocol for cognitive rest patterned after the return to play protocol from the Consensus Statement on Concussion in Sport 3rd International Conference on Concussion in Sport held in Zurich, Switzerland.^{22,23,29} This protocol begins with no school, homework, reading, or electronics (which includes texting, computers, video games), and gradually adds light reading, followed by schoolwork at home, and then school with accommodations as symptoms improve. Patients were documented to have received cognitive rest when, per patient- or parent- report, the rest prescribed by the referring provider was aligned with this protocol. Due to the retrospective nature of this study, monitoring of such rest was not performed.

For each risk factor category, recovery outcomes examined included time until a patient was symptom-free (as assessed by the treating sports medicine clinician) and time until a patient was fully cleared to participate in sports by the sports medicine clinic. To obtain clearance, patients receive a standard post-exertion return-to-play protocol, as described in the most recent Zurich guidelines;²⁰ patients additionally must be at a full cognitive workload, and have normal vestibular and oculomotor examinations.²² School-related outcomes included the need for school accommodations prescribed by the specialty clinic (via a standardized letter to the patient’s school) at any time during recovery (including homebound education, half-days, full days with breaks, elimination of examinations, examinations with extra time and/or note-cards, and elimination of honors classes); decline in grades reported by students at any time during recovery; and time taken until a student returned to school full-time (without accommodations).

Statistical Analyses

Descriptive statistics included means, ranges, medians, and interquartile ranges (IQR). Statistical comparisons to assess the prevalence or timing of outcomes between subsets of patients were conducted with several methods. Dichotomous outcomes were analyzed using logistic regression, except for the rare instance when the exposure was categorical and one of the cells had a zero count. An exact chi-square test was conducted in those instances. Outcomes classified as times were analyzed using quantile regression given the highly skewed nature of these data and the fact that quantile regression enables valid tests of whether medians are equivalent in this context.³⁰ The presented results include prevalence values and effect estimates that indicate relative prevalence, equal to the prevalence of a given outcome in the exposed group divided by the prevalence of the outcome in the unexposed group. With both regression methods, a test for trend was conducted in instances where the relationship between the exposure and outcome potentially varied in a dose-

response fashion. Also, Kaplan Meier survival curves were used to determine the number of days until patients had returned to school full-time without accommodations, the number of days until patients were symptom-free, and the number of days until patients were fully cleared to return to all normal activities including sports participation. Survival curves were stratified by categorical risk factors of interest and tested for equivalence using the Peto test. The duration between being injured and first seen in clinic was tested using quintile regression to determine whether it should be controlled for as a potential confounder in the regression models. The analysis was conducted using Stata version 12 (College Station, TX). As our analysis contained a considerable number of bivariate comparisons, approximately 72, we calculated Bonferroni adjusted p-values and considered $p < 0.0007$ (i.e., $0.05 / 72 = 0.0007$) to be statistically significant. Such findings are denoted with an asterisk (*) for emphasis in the text below and in the tables.

RESULTS

A total of 247 patients were included in the analysis from the initial pool of 250 patient charts (3 charts were of duplicate patients). Information on demographics and outcomes are presented in Table I. For all patients, the median number of days until returning to school part-time or initiation of homebound education was 12 days (IQR 6–21); the median number of days until returning to school full-time without any academic accommodations was 35 days (IQR 11–105); the median time until becoming symptom-free was 64 days (IQR 18–119); and the median time until patients were fully cleared for all activities (including sports participation) was 76 days (IQR 30–153) (Figure).

Pre-existing conditions

Results regarding pre-existing conditions are shown in Table II. Overall, 20% of patients or parents reported at least one pre-existing condition. Patients with anxiety took more than twice as long to be fully cleared as compared with those without anxiety (168 days vs. 76 days, $p=0.001$). Patients with depression took 2.2 times longer than patients without depression to become symptom-free (142 vs. 64 days; $p=0.05$) and to be fully cleared (121 vs. 75 days; $p=0.006$). Patients with depression additionally were prescribed school accommodations more frequently (87% vs. 69%; $p=0.165$). All patients (100%) with anxiety upon initial presentation, as compared with 69% of patients without anxiety, experienced prolongation in symptoms past four weeks ($p=0.290$). None of the differences observed reached statistical significance using the Bonferroni correction. The median number of days between initial injury and time first seen in clinic did not vary significantly across these patient subgroups, and ranged from eight to 14 days.

Presenting Signs and Symptoms

Overall, 66% of patients reported experiencing dizziness immediately following injury, and 9% reported a loss of consciousness. 74% had symptom provocation following oculomotor examination on initial clinic physical examination ($n = 171$), and 62% had abnormal near-point convergence ($n = 79$, Table II). Patients reporting dizziness at the time of injury were more likely than those without dizziness to experience prolongation in symptoms past four weeks (77% vs. 61%; $p=0.028$) and to be prescribed school accommodations (77% vs. 56%;

$p=0.001$). These patients took 2.6 times longer to become symptom-free (70 vs. 27 days; $p=0.032$). Additionally, patients experiencing loss of consciousness at the time of injury took 1.8 times longer for symptoms to resolve (116 vs. 63 days; $p=0.94$), though none of these differences reached statistical significance via the Bonferroni correction.

Patients with symptom provocation following oculomotor examination on initial physical examination were more likely to be prescribed school accommodations (94% vs. 36%; $p=0.0001^*$). They additionally required more time until returning to school full-time (61 vs. 14 days; $p=0.050$), until becoming symptom-free (74 vs. 22 days; $p=0.048$), until being fully cleared (115 vs. 38 days; $p=0.003$), and were more likely to have prolongation of symptoms past four weeks (80% vs. 45%; $p=0.001$) and to report a decline in grades (65% vs. 45%, $p=0.035$). Finally, patients with abnormal near-point convergence on initial exam were more likely to be prescribed school accommodations than those with normal convergence (82% vs. 60%; $p=0.038$).

Age

In the examination of patient age (Table III), we found that children age 13-14 years took 1.8 times longer (median=40 days) than the youngest children (age 12 year or younger, median=22 days) and 15-16 year-old children (median=35 days) took 1.6 times longer to return to school full-time ($p=0.887$ comparing all age groups). We also found children in youngest age group took nearly twice as long to become symptom-free (78 days for patients less than 12, as opposed to 43 days for patients aged 17-18; $p=0.887$ comparing all age groups). Those in the youngest age group were prescribed school accommodations less frequently (57% for those less than 12 vs. >70% for all other age groups; $p=0.694$ comparing all age groups), and reported a decline in grades less frequently as well (47% for those less than 12 vs. 73% for the oldest age group; $p=0.553$ among all age groups), although none of these differences reached statistical significance by the Bonferroni correction. A patient- or parent-reported decline in grades functioned in a dose-response fashion, with a decline in grades being more common with increasing age ($p=0.0005^*$).

History of Prior Concussion

We found substantial variability regarding a history of prior concussion (Table III), with the median number of days until being fully cleared ranging from 64 days for those with zero or one prior concussion to 243 days for those with three or more prior concussions ($p=0.0006^*$). Those with two or more prior concussions took more than twice as long to become symptom-free as those with fewer than two (ranging from 45 days for those with no prior concussions to 122 days for those with three or more prior; $p=0.039$ among all groups). Those with three or more prior concussions took 3.6 times longer to return to school full-time compared with those with no prior concussions (105 days for those with three or more prior concussions vs. 29 days for those with no prior, $p=0.187$ among all groups), and the percentage of children who were prescribed school accommodations ranged from 69% for those with no prior concussions to 100% for those with three or more prior concussions ($p=0.341$ among all groups), though neither of these last two values reached statistical significance.

Recommendation of Cognitive Rest by Referring Physician

The referring provider recommended cognitive rest for approximately one-half (54%, n = 138) of all patients (Table III). These patients had a prolongation in time until returning to school (40 vs. 28 days, $p=0.540$), until becoming symptom-free (68 vs. 53 days $p = 0.569$), and until being fully cleared (100 vs. 82 days, $p=0.569$), though none of these results reached statistical significance.

DISCUSSION

This study is a comprehensive examination of a large cohort of pediatric patients presenting to a subspecialty clinic for evaluation of concussion. By studying this specific cohort, we have selected a group of patients experiencing the most severe symptoms of concussion to examine possible risk factors for prolonged recovery.

Our data show prolonged recovery times in our population compared with previous studies. Prior studies have estimated healing times after concussion ranging from 14 to 28 days among the general pediatric population,^{10,31} whereas the median time to symptom resolution in our patient sample was 64 days. The recovery times seen in our patients are likely relatively lengthy due to the spectrum bias of this subspecialty referral population with more severe concussions. Even so, our data do suggest that a subset of youth who sustain a concussion experience recovery time longer than previously suspected, even without predisposing factors.

Our data show that patients with pre-existing anxiety or depression tend to have a prolonged course compared with those without these pre-existing conditions, specifically regarding resolution of symptoms. There are recent adult data recognizing that ADHD, depression and anxiety have important implications in recovery of concussion, and that adults with underlying depression have more severe acute neurocognitive deficits than those without depression;^{18,19} additionally, recent studies have demonstrated post-traumatic stress and depression to be important mediators of the relationship between mild traumatic brain injury and health problems in military personnel returning from duty with traumatic brain injury.³² Few studies, however, have examined these preexisting conditions in children. Given the common mechanism of neuronal dysfunction underlying mood disorders and traumatic brain injury, it is possible that pre-existing dysfunction may exist and lead to a more difficult recovery; conversely, the cognition dysfunction noted may be secondary to the mood disorder itself rather than the traumatic brain injury. Although the direction of causality is still unclear,^{9,18} the association remains clinically important.

Our data show that those patients presenting with either dizziness or loss of consciousness at the time of initial injury, or found to have either symptom provocation following oculomotor examination or abnormal near-point convergence on initial physical examination at the specialty clinic, have both prolonged symptoms and poorer school outcomes. Prior studies have noted that athletes with migrainous symptoms (including photophobia, nausea, vomiting, and headache), rather than headache alone, have significantly greater neurocognitive deficits when tested.^{16,17,33} Even though post-traumatic migraine has become a significant outcome measure in the past several years, at the time of study our

group did not use post-traumatic migraine as a measure of recovery, and therefore such data were not available for this review. It should be noted that patients specifically with dizziness at the time of injury have been shown to have a higher risk for prolonged recovery,¹² and dizziness itself on initial presentation may signify more severe vestibular deficits in concussion recovery. The data on outcomes for those patients presenting with loss of consciousness are more controversial, with several studies showing that loss of consciousness, especially lasting less than 1 minute, does not predict symptom severity or duration.^{4,5,34} We were unable to stratify patients based on the time of lost consciousness, however, due to the retrospective nature of our study. Finally, although abnormalities in the oculomotor exam have been found to exist beyond the acute phase of concussion,³⁵ little data exist correlating initial oculomotor deficits or abnormal near-point convergence on physical examination with prolonged recovery or poor school performance. Initial abnormalities in these examination findings may signify more severe cognition dysfunction at the time of injury, and given their importance in completing school tasks, abnormal oculomotor examination and convergence deficits have significant implications in recovery of school performance.

Multiple previous studies comparing high school athletes with college-aged and adult athletes have shown that adolescents are predisposed to prolonged recovery times.^{13,14} Previous studies have suggested that patients younger than high school age have prolonged symptoms compared with older teenagers,³⁶ however there have been few formal investigations evaluating recovery time in children younger than age 14. Younger patients, especially those age 12 and younger, had a trend (though not statistically significant) toward prolonged recovery compared with older adolescents in our study, though they did not fare worse on school-related outcomes, possibly due to less rigorous academic demands of children of this age. Although the mechanism of prolonged recovery in the immature brain remains unknown, it has been hypothesized previously that increased susceptibility to neurotransmitter-mediated excitotoxic brain injury is involved.³⁷ Regardless, further, prospective studies involving stratification of patients by age are needed to delineate these recovery outcomes.

Our patients generally showed a dose-response effect for prolonged recovery and poorer school outcomes with any prior history of concussion. A history of three or more previous concussions has been widely reported as a risk factor for prolonged recovery time.^{11,38,39} Even though previous studies have shown fewer than three prior concussions to not predispose patients to prolonged symptoms,⁴⁰ recent data have begun to indicate poorer performance on neurocognitive testing in patients with only one prior injury.⁴¹ Our data show patients with at least two prior concussions may be predisposed to poorer outcomes.

Studies have demonstrated greater impairment on neurocognitive testing with early physical and mental activity,^{42,43} making cognitive rest a mainstay in the clinical treatment of concussion.^{44,45} However, empiric data supporting the use of cognitive rest in concussion is conflicting. One study showed no association between recommendation of cognitive rest and length of symptoms,⁴⁶ and another showed improved performance on cognitive testing and decreased symptom reporting with any cognitive rest.⁴⁷ We found that the recommendation of cognitive rest did not influence outcomes, though we have difficulty drawing conclusions

from our data, as the cognitive rest experienced by our patients was neither homogenous nor prescribed in a standardized fashion. As cognitive rest is topic of great interest, it was included in this descriptive, exploratory study. Based on prior studies showing that peak symptomatology from concussion to occur at 7 days,^{26,48} as well as our own clinical experience, we hypothesize that the timing of cognitive rest may be important; early rest in concussion may be beneficial, whereas prolonged cognitive rest may not. This hypothesis must be tested with prospective data collection in a sample more representative of all youth concussion patients.

Our findings cannot be generalized to concussion in all populations, as our focus was on a subspecialty referral population in a sports medicine clinic. Presumably, those with less severe injuries would be initially seen, treated, and recover without necessitating specialist referral. Additionally, our findings cannot be extrapolated to those patients with high-impact injury mechanisms, as such patients are not typically evaluated in the sports medicine clinics. As this was a referral population, a gap existed (median 12 days) between the patient's injury and initial specialty visit, which led to variability in the physical exam findings observed at the initial visit. The duration between being injured and first seen in clinic was found to not vary across categories of the variables treated as exposures (Tables II and III), thus obviating the need to control for this duration as a potential confounder in the regression models.⁴⁹ The fact that we only examined data in a single care network also limits the generalizability of our study as other networks may have different patterns of care.

As our study was a retrospective chart review, there were limitations on our ability to standardize outcomes, specifically those that relied on patient- or parent-report (cognitive rest, pre-existing conditions, prior concussion history, and symptomatology), provider assessments (physical exam findings), and accommodations used by schools, thereby introducing the influence of recency effect and recall bias into our data. We did not collect baseline physical examination findings for our patients, and theoretically any physical examination abnormalities, specifically vestibular deficits in patients with pre-existing neurologic or psychological disorders, may have been a pre-existing finding unrelated to acute injury. Additionally, for our physical examination, we only obtained near-point convergence as a one-time measure; other clinics have taken the approach of averaging three separate measures.⁵⁰

There was variability in the number of patients contributing to any given analysis, due to a combination of unavailable data secondary to documentation, patients lost to follow-up, and patients who continued to receive treatment and had unresolved symptoms. As such, and given the sample size of 247 patients in total, the power to detect differences across patient subgroups was often low. We observed multiple instances where recovery outcomes differed notably between subsets of patients to an extent that might be clinically meaningful but was not significant statistically via either standard measures or by the Bonferroni correction. Had studies previously reported characteristics of similar patient populations, we could have used those findings to estimate the sample size we would require to expect adequate power to test our hypothesis. Given that no such reports exist, we enrolled a convenience sample of a size that was feasible and reasonable for calculating the prevalence estimates that we have reported here. Thus one additional contribution of our study is providing prevalence

estimates that can be used to plan sample size and power issues for future studies. As in any study with tests of significance, our results should be interpreted with consideration of whether the magnitude of differences that was observed reaches levels that are clinically meaningful.

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Abbreviations

ADHD	attention deficit hyperactivity disorder
LOC	loss of consciousness
IQR	interquartile range
REDCap	Research Electronic Data Capture

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Figure.

Survival curves for days until returning to school full-time (without accommodations), time until symptom-free, and time until fully cleared as a function of days from injury

Table 1

Demographics of complete dataset

Characteristic	n=
All Patients	247
Injured September 1-May 31	207
Age, years (range)	14 (7-18)
Male, %	58
Sports-related injury, n (%)	190 (77%)
Days post-injury at first visit, median (range)	12 (1-730)
Seen for follow-up visits, n (%)	228 (92%)
Fully cleared at initial visit, n (%)	8 (3%)
Currently following up, n (%)	8 (3%)
Days until return to school part-time/initiation of homebound instruction, median (IQR) ^{*,^}	12 (6-21)
Days until return to school full-time, median (IQR) ^{*,^}	35 (11-105)
Days until symptom-free, median (IQR) [*]	64 (18-119)
Days until fully cleared, median (IQR) [*]	76 (30-153)
% Symptomatic for >4 weeks, n (%)	211 (73%)
% Requiring school accommodations, n (%) ^{*,^}	207 (73%)
% Reporting decline in grades, n (%) ^{*,^}	162 (61%)

* Data only included for patients with follow-up visits

[^] Data only included for patients injured between September 1 and May 31

IQR = interquartile range

Table II

Distribution of outcomes by patient pre-existing conditions and presenting signs/symptoms

Pre-existing Condition/ Presenting Sign or Symptom	All N (%)	Sep-May N (%)	Median Days From Injury to Initial Clinic Visit	Relative Prevalence in Exposed vs. Unexposed Group	P Val	Median Days Until Return to School Full-Time (IQR) ^	Relative Prevalence in Exposed vs. Unexposed Group	P-Val	Median Days Until Symptom-Free (IQR)	Relative Prevalence in Exposed vs. Unexposed Group	P-Val	% Symptomatic for >4 weeks	Relative Prevalence in Exposed vs. Unexposed Group	P-Val	% Requiring School Accommodations ^	Relative Prevalence in Exposed vs. Unexposed Group	P-Val	% Reporting Decline in Grades ^	Relative Prevalence in Exposed vs. Unexposed Group	P-Val			
Any Condition	49 (20%)	35 (17%)	10	0.77	0.207	31 (10,105)	0.97	0.962	81 (17,132)	1.27	0.920	75 (29,205)	0.99	0.735	78%	1.08	0.565	73%	1.06	0.559	71%	1.16	0.339
No Condition	198 (80%)	172 (83%)	13	-ref-		32 (12,113)	-ref-		64 (19,116)	-ref-		76 (30,150)	-ref-		69%	-ref-		61%	-ref-		61%	-ref-	
ADHD	22 (9%)	16 (8%)	10	0.83	0.580	24 (12,94)	0.75	0.809	61 (14,200)	0.92	0.852	51 (25,174)	0.65	0.482	74%	1.01	0.915	77%	1.12	0.440	67%	1.10	0.730
No ADHD	225 (91%)	191 (92%)	12	-ref-		32 (11,106)	-ref-		66 (19,117)	-ref-		78 (30,152)	-ref-		69%	-ref-		61%	-ref-		61%	-ref-	
Learn Disab	26 (11%)	18 (9%)	10	0.77	0.547	37 (10,100)	1.19	0.830	50 (17,90)	0.76	0.565	79 (29,159)	1.04	0.585	67%	0.92	0.519	65%	0.92	0.584	85%	1.42	0.100
No Learn Disab	221 (89%)	189 (91%)	13	-ref-		31 (12,106)	-ref-		66 (19,123)	-ref-		76 (30,152)	-ref-		71%	-ref-		60%	-ref-		60%	-ref-	
Depression	15 (6%)	10 (5%)	8	0.62	0.135	31 (28,79)	0.97	0.981	142 (31,274)	2.22	0.050	121 (57,325)	1.61	0.006	87%	1.23	0.222	87%	1.26	0.165	71%	1.15	0.602
No Depression	232 (94%)	197 (95%)	13	-ref-		32 (11,106)	-ref-		64 (17,116)	-ref-		75 (30,152)	-ref-		69%	-ref-		62%	-ref-		62%	-ref-	
Anxiety	9 (4%)	7 (3%)	10	0.83	0.681	68 (50,87)	2.13	0.987	149 (122,185)	2.33	0.066	168 (71,304)	2.21	0.010	100%	1.41	0.290	100%	1.45	0.290	100%	1.64	0.391
No Anxiety	238 (96%)	200 (97%)	12	-ref-		32 (10,106)	-ref-		64 (18,117)	-ref-		76 (30,152)	-ref-		69%	-ref-		61%	-ref-		61%	-ref-	
Dizziness	161 (66%)	136 (66%)	13	1.08	0.643	39 (14,105)	1.95	0.292	70 (21,122)	2.59	0.032	76 (30,142)	1.06	0.961	77%	1.26	0.028	77%	1.38	0.001	59%	0.89	0.421
No Dizziness	84 (34%)	71 (34%)	12	-ref-		20 (7,79)	-ref-		27 (14,112)	-ref-		72 (28,182)	-ref-		56%	-ref-		66%	-ref-		66%	-ref-	
LOC	21 (9%)	19 (9%)	8	0.67	0.223	40 (37,122)	1.38	0.650	116 (32,153)	1.84	0.094	102 (70,137)	1.46	0.230	88%	1.24	0.285	71%	1.01	0.888	41%	0.65	0.152
No LOC	223 (91%)	186 (91%)	12	-ref-		29 (10,101)	-ref-		63 (18,106)	-ref-		70 (29,151)	-ref-		70%	-ref-		63%	-ref-		63%	-ref-	
Oculo Abn	126 (74%)	108 (75%)	14	1.08	0.725	61 (24,130)	4.36	0.050	74 (25,134)	3.36	0.048	115 (43,212)	3.03	0.003	80%	1.78	0.001	90% *	3.00	0.0001	65%	1.44	0.035
No Oculo Abn	45 (26%)	36 (25%)	13	-ref-		14 (14,59)	-ref-		22 (10,49)	-ref-		38 (23,101)	-ref-		45%	-ref-		45%	-ref-		45%	-ref-	
Abnormal Converg	49 (62%)	36 (56%)	10	0.77	0.262	47 (23,118)	1.27	0.552	54 (18,120)	1.64	0.178	53 (28,140)	1.13	0.761	71%	1.13	0.927	82%	1.37	0.038	71%	0.90	0.490
Normal Converg	30 (38%)	28 (44%)	13	-ref-		37 (8,89)	-ref-		33 (22,68)	-ref-		47 (30,116)	-ref-		60%	-ref-		79%	-ref-		79%	-ref-	

* P-value significant via Bonferroni correction for regression testing, ie, <0.0007 (denoted with bold text)

[^] Data only included for patients injured between September 1 and May 31

P-val = p-value; IQR = interquartile range; ADHD = attention deficit hyperactivity disorder; Learn disab = learning disability; LOC = loss of consciousness; Oculo abn = symptom provocation following oculomotor examination; Converg = convergence; -ref- = reference category

Table III

Distribution of outcomes by age, history of prior concussion, and recommendation of cognitive rest

	Median Days From Injury to Initial Clinic Visit	All N (%)	Stop-May N (%)	Relative Prevalence in Exposed vs. Unexposed Group	P-Val	Median Days Until Return to School Full-Time (IQR) ^	Relative Prevalence in Exposed vs. Unexposed Group	P-Val	Median Days Until Symptom-Free (IQR)	Relative Prevalence in Exposed vs. Unexposed Group	P-Val	Median Days Until Fully Cleared (IQR)	Relative Prevalence in Exposed vs. Unexposed Group	P-Val	% Symptomatic for >4 weeks	Relative Prevalence in Exposed vs. Unexposed Group	P-Val	% Requiring School Accommodations ^	Relative Prevalence in Exposed vs. Unexposed Group	P-Val	% Reporting Decline in Grades ^	Relative Prevalence in Exposed vs. Unexposed Group	P-Val	
Age																								
Prior Concussions	17-18	28 (11%)	25 (12%)	9	0.64	0.709	19 (10,66)	0.86	0.887	43 (28,148)	0.55	0.887	85 (14,86)	1.04	0.863	74%	0.95	1.26	0.759	72%	0.694	73% **	1.55	0.553
	15-16	87 (35%)	73 (35%)	12	0.86		35 (11,101)	1.59		67 (17,116)	0.86		66 (29,150)	0.84	75%	0.96	1.32		75%	1.32	65%	1.38	0.0005	
	13-14	94 (38%)	81 (39%)	13	0.93		40 (12,124)	1.82		64 (18,126)	0.82		79 (31,156)	0.96	69%	0.88	1.35		77%	1.35	58%	1.23		
	<12	38 (15%)	28 (14%)	14	-ref-		22 (10,47)	-ref-		78 (26,123)	-ref-		82 (33,195)	-ref-	78%	-ref-	57%	-ref-		57%	-ref-	47%	-ref-	
Cognitive Rest by Referring? ^	3	13 (5%)	10 (5%)	19	1.58	0.482	105 (85,291)	3.62	0.187	122 (90,145)	2.71	0.039	243 (116,385) *	3.80	0.0006	100%	1.45	0.532	100%	0.341	80%	1.36	0.5974	
	2	22 (9%)	18 (9%)	11	0.92		33 (6,62)	1.14		99 (55,141)	2.20		158 (103,243)	2.47	82%	1.19	0.97		67%	0.97	64%	1.08		
	1	55 (22%)	47 (23%)	12	1.00		34 (15,123)	1.17		53 (20,122)	1.18		64 (28,143)	1.00	72%	1.04	1.20		83%	1.20	63%	1.07		
	0	157 (64%)	132 (64%)	12	-ref-		29 (8,100)	-ref-		45 (17,101)	-ref-		64 (29,140)	-ref-	69%	-ref-	69%	-ref-		69%	-ref-	59%	-ref-	
Yes		74 (54%)		12	0.75	0.187	40 (20,133)	1.43	0.540	68 (18,126)	1.28	0.569	100 (38,174)	1.22	0.393	73%	0.94	1.19	0.309	86%	0.137	67%	1.24	0.297
	No	64 (46%)		16	-ref-		28 (7,62)	-ref-		53 (21,120)	-ref-		82 (45,144)	-ref-	78%	-ref-	72%	-ref-		72%	-ref-	54%	-ref-	

P-values reported were derived using regression to compare categorically across groups

P-values reported in italics were derived using regression test for trend, reported only in instances of p<0.0007

* P-value significant via Bonferroni for regression testing, i.e., <0.0007 (denoted with bold text)

** P-value significant via Bonferroni for trend test, i.e., <0.0007 (denoted with bold text)

[^] Data only included for patients injured between September 1 and May 31

P-Val = p-value; IQR = interquartile range; -ref- = reference category