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Initial symptom burden predicts duration of symptoms after concussion★

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Abstract

Objectives—To determine which variables predict prolonged (>28 days) duration of symptoms after a concussion.

Design—We conducted a prospective cohort study of adult (>18yo) patients cared for in a specialty concussion clinic.

Methods—Symptoms were assessed using the Post-Concussion Symptom Scale (PCSS) developed at the 3rd International Conference on Concussion in Sports. Possible predictors including age, sex, loss of consciousness, amnesia, history of prior concussion, prior treatment for headaches, history of migraines, and family history of concussions, were measured by self-report. We recorded a PCSS score at each clinical visit and defined time to symptom resolution as the number of days between the date of injury and date of last symptoms.

Results—Of 64 adult patients included in the study, 53.3% were male; 20.3% reported experiencing a loss of consciousness at the time of injury while 23.4% reported amnesia. Patients ranged in age from 18 to 27 years (mean 21 ± 2 years). Most concussions (92.2%) occurred during sports. The mean initial PCSS score for those suffering symptoms for longer than 28 days was significantly higher than those who symptoms resolved within 28 days (42.5 vs. 19.2, $p < 0.01$). Of all potential predictor variables, only the initial PCSS score was independently associated with the odds of symptoms lasting longer than 28 days (aOR 1.037; 95% CI 1.011, 1.063).

Conclusions—Among adult patients with concussions, those with a higher symptom burden after injury have an increased odds of suffering from prolonged symptoms. Other potential predictor variables are not associated with the risk of prolonged recovery.

Keywords

Mild traumatic brain injury; Sports; Head trauma; Sports injury

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1. Introduction

While most concussions, especially those sustained during sports, resolve over the course of a few weeks, some patients suffer prolonged symptoms.[1–3] Previous studies have attempted to identify potential predictors of prolonged recovery after concussion such as age at time of injury, amnesia or loss of consciousness at the time of injury, sex, history of previous concussions, measures of cognitive function, individual symptoms such as headaches and dizziness, and collective symptom burden.[4–6] In a study by Chrisman et al, athletes who reported 4 or more symptoms after sustaining a sport-related concussion were twice as likely to have symptoms for greater than one week. Furthermore, history of prior concussions, amnesia at the time of injury, dizziness, nausea, and difficulties with concentration were all associated with symptom duration of greater than 7 days.[4] In a similar study by McCrea et al., loss of consciousness, amnesia, and higher symptom severity levels all appeared associated with 7 days or more of symptoms.[7] Other investigators have found that individual symptoms, such as subjective fogginess, dizziness at the time of injury, as well as amnesia and neurocognitive test scores, were also associated with symptom duration.[7–9]

The ability to predict which patients are likely to suffer prolonged symptoms would allow clinicians to better provide anticipatory guidance and prepare for the possibility of offering various therapies. In addition, the ability to predict a prolonged recovery would allow patients to make better informed decisions about various therapies offered by their treating clinicians, put occupational or academic accommodations in place, and alert coworkers of the possibility of a prolonged recovery.

Previously, we assessed a largely pediatric population and showed that score on symptom inventory at the time of initial clinic visit was independently associated with the odds of suffering the symptoms of a concussion for more than 28 days. It is possible, however, that the recovery of pediatric patients differs from that of adults and that the predictors of prolonged recovery, also differ between children and adults. Age itself has been proposed as a risk factor for worse outcomes after a concussion, including prolonged duration of symptoms, with some analyses suggesting that younger athletes take longer to recover, although not all studies support this idea.[10–12] Furthermore, there are likely differences between pediatric and adult athletes regarding the biomechanics of concussive injuries, the pathophysiological response to concussion, and the effect of concussion on neurobehavioral outcomes.[11,13,14]

In this study, we sought to determine if symptom burden at the time of the initial clinic visit was also a predictor of prolonged symptoms for adult patients suffering from concussions. To this end, we analyzed clinical data from 64 adult patients suffering from concussions to identify independent predictors of prolonged (>28 days) symptoms.

2. Methods

We conducted a prospective cohort study of adult (>18yo) patients cared for in a specialty concussion clinic at an academic medical center between October 1, 2009 and July 31, 2011. At the initial clinic visit, patients completed an intake form, providing information about

their mechanism of injury and past medical history as well as the Post-Concussion Symptom Scale (PCSS). We used the definition of concussion endorsed by the international consensus on concussion in sport.[15] Therefore, patients with a history of a trauma followed by the onset of signs or symptoms of concussion or decreases in neurocognitive function as determined by medical history and physical examination were diagnosed as a concussion. The study was approved by the institutional review board of Boston Children's Hospital.

We monitored symptoms using the PCSS developed by the international consensus on concussion in sports, which patients completed at each visit. The PCSS is a symptom inventory containing a total of 22 symptoms that patients rank on a scale from 0, when not experiencing a given symptom, to 6, when the symptom is "severe." The PCSS is part of the Sport Concussion Assessment Tool 2 (SCAT 2), which was proposed by the 3rd international consensus on concussion in sport.[15] The total score on the PCSS is the sum of the severity score (0–6) for each of the 22 symptoms. Thus, the maximum possible score on the PCSS is 132 (6 × 22). The symptoms included on the PCSS are not specific to concussion, but can be caused by many other etiologies.[16,17] Therefore, as with other studies, patients were instructed to rate only those symptoms that started at the time of their concussion and that they were still experiencing within the 24 h prior to their clinic visit.[18,19] Symptom-free was defined as a post-concussion symptom score of 0. The initial PCSS score used for our analyses was obtained at their first clinic visit.

When assessing potential predictors of symptom duration, we included only those patients seen in clinic within 21 days of injury. We chose to exclude those who presented later than 21 days after injury as (1) we expect that most patients who sustain a concussion will be able to obtain an initial clinic appointment within that time frame and (2) we felt we needed at least one week of time between presentation to clinic and our outcome of interest, symptom duration for 28 days, in order for potential predictor variables to have an association. We included all sport-related concussions as well as patients who sustained injuries by comparable mechanisms and forces similar to those observed in sports, such as falling from a standing position or fist-fighting. We excluded patients with more severe injury mechanisms and forces, such as motor vehicle collisions and falls from higher than ground level. Simple descriptive statistics were used to describe our population and the sports played at the time of injury. As in previous studies, we identified potential predictor variables from the available medical literature, including age, scores on symptom inventory (PCSS) at initial visit, total number of symptom reported at time of initial visit, sex, loss of consciousness or amnesia at the time of injury, history of prior concussion, prior medical treatments for headaches, history of migraines, and family history of concussion.[19] Migraine headaches were analyzed as a separate category, in addition to headaches not otherwise specified, as some previous literature has suggested headaches with migrainous characteristics may be associated with outcomes after concussion.[6,20,21] Although computerized neurocognitive data have been suggested as possibly predictive of recovery from concussion, pre- and post-injury tests are not routinely available for adult patients outside of those in the military or those who participate in organized sports. Furthermore, in our sample, only 17 of the 64 patients eligible for analysis of predictors of symptom duration had computerized neurocognitive data performed at their initial visit. Therefore, neurocognitive scores were not included in our analyses.

Since previous studies have shown that the majority of athletes will recover within 4 weeks of injury,[3,22] we sought to identify risk factors for having symptoms that last longer than 4 weeks. Univariate comparisons were made between the 2 groups: those whose symptoms resolved within 28 days and those whose symptoms persisted beyond 28 days, using Student's *t*-test for continuous variables and the Fischer's exact test for dichotomous variables. Any potential predictor variable that appeared different between the 2 groups with a statistical probability of $p < 0.2$ was entered into a logistic regression model in order to generate adjusted odds ratios. This allowed us to assess the independent effect of symptom burden on duration of symptoms after adjusting for other potential confounding variables. As is common when building a logistic regression model, we used a less stringent threshold for significance when deciding which variables to enter into the multivariate model, since the true size and significance of the effect of certain variables may be masked by potential confounding variables, and revealed after adjusting for those variables in the model.[23] No inferences are drawn from these univariate analyses; they are simply a screening to determine which independent variables are included in the model. Any variable with an adjusted odds ratio with a 95% confidence interval that did not cross 1 in the multivariate model was considered statistically significant.

3. Results

There were 131 adult patients cared for in clinic during the study period. The initial visit for 60 patients occurred more than 21 days after injury. For an additional 7, it could not be definitively established whether or not their symptoms resolved within 28 days of injury. Therefore, 64 patients, none of whom were lost to follow up, were included in the study.

The majority (53.3%) were male. More than 1 in 5 (20.3%) patients reported experiencing a loss of consciousness at the time of injury while 23.4% reported amnesia; 6.3% experienced both amnesia and a loss of consciousness. Most concussions (92.2%) occurred during sports. The most common sports played at the time of injury were soccer and ice hockey (Table 1). Nearly half (46.9%) had been diagnosed with a prior sport-related concussion. Patients ranged in age from 18 to 27 years (mean 21 ± 2 years). The mean score on the PCSS at the initial appointment in clinic was 27.9 ± 26.5. The most commonly reported symptoms were headaches, fatigue or low energy, pressure in the head, "don't feel right, and difficulty concentrating. The least commonly reported symptoms were sadness, nausea or vomiting, and blurred vision (Table 2). For those who had a precise date of injury and a precise date of last symptoms recorded ($n = 42$), the mean duration of symptoms was 32 ± 48days. The mean time between injury and initial clinic appointment was 11.2 ± 5.2 days, and was not significantly different between those whose symptoms resolved within 28 days and those whose symptoms lasted longer (11.6 vs. 11.0 days; $p = 0.62$).

Those suffering symptoms for longer than 28 days had both a higher mean PCSS score at the time of the initial clinic visit (42.5 vs. 19.2, $p < 0.01$) and a higher total number of symptoms (13.9 vs. 8.9, $p = 0.008$) than those who symptoms resolved within 28 days, thus meeting criteria for inclusion in the regression model. Mean age was similar between those whose symptoms lasted greater than 28 days and those whose symptoms resolved within 28 days (20.5 vs. 20.0 years; $p = 0.41$). Of the dichotomous variables, only the presence of

amnesia at the time of injury met criteria for inclusion in the model (Table 3). Therefore, symptom burden at initial visit, total number of symptoms reported, and the presence of amnesia at the time of injury were included in the multivariate model.

In the multivariate model, only the initial PCSS was independently associated with the odds of symptoms lasting longer than 28 days (aOR 1.037; 95% CI 1.011, 1.063). Neither the presence of amnesia at the time of injury (aOR 2.152; 95% CI 0.561, 8.257) nor the total number of symptoms reported (aOR 0.927; 95%CI 0.790, 1.102) were independently associated with prolonged recovery. Interestingly, PCSS score at the time of initial visit had significantly ($p = 0.02$) less of an association with symptom duration in those who experienced amnesia when compared to those without amnesia.

4. Discussion

Our analyses suggest that, among adults who sustain concussions, those with higher scores on the PCSS at the time of their initial clinic visit have a higher odds of suffering symptoms for more than 28 days. While the increase in odds may seem low (aOR 1.037), this represents the adjusted odds for a one point increase in PCSS score. No other potential predictors of prolonged recovery were independently associated with the odds of suffering prolonged symptoms in our study.

Our findings are consistent with prior work involving predominately pediatric patients. In a prior analysis of 182 patients, only symptom burden at the time of initial clinic visit was independently associated with symptoms lasting longer than 28 days. As with the current study, no other potential predictor variables were independently associated with prolonged symptoms.[19]

Other recent studies have investigated individual symptoms that may predict recovery outcomes in concussed athletes. In a case-control study of high school football players, Lau et al. showed that migraine headache symptoms, in addition to neurocognitive test scores, are predictive of longer recovery.[24] In a follow up study by some of the same investigators, dizziness at the time of injury was associated with a 6 to1 odds of suffering a prolonged recovery, defined as >20 days.[25] We did not assess individual symptoms in this study. There are 22 symptoms listed in the PCSS. As the number of variables entered into a logistic regression model increases, the stability of the model decreases. Therefore, a much larger number of patients would have been required in order to assess the independent association between individual symptoms and symptom duration.

Our findings must be considered in light of several limitations. Our sample size was relatively small. We used self-reported data for medical history. As only 17 of these underwent computerized neurocognitive assessment at their initial visit, we could not reliably assess the association between neurocognitive scores and symptom duration. Since the majority of adult patients do not have baseline neurocognitive tests, however, symptoms scores, despite their subjective nature, may be one of the few tools clinicians have to track recovery. In addition, patients referred to an academic medical center likely differ from the patient population that is treated in a typical primary care office. Our sample had a relatively

longer duration of symptoms, a relatively high proportion of subjects who reported loss of consciousness, and a relatively high proportion of patients who had amnesia when compared to studies conducted using a more general population of athletes. Prior studies in outpatient settings and emergency departments, however, have similarly suggested that initial symptoms burden predicts prolonged recovery after concussion.

5. Conclusion

In conclusion, those patients with a higher symptom burden after sustaining a concussion have an increased odds of suffering from prolonged symptoms. Clinicians should consider anticipatory guidance and earlier interventions for those patients with higher symptom burdens at their initial appointment.

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6. Practical implications

- Symptom burden at initial clinic visit is the only independent predictor of duration of concussion symptoms lasting longer than 28 days.
- Age, amnesia, loss of consciousness, and other commonly discussed variables are not independently associated with the risk of prolonged concussion symptoms.
- Clinicians caring for athletes with high symptom scores at their initial visit after a concussion should prepare the athlete for the possibility of a prolonged recovery.

Table 1

Sports participated in at the time of concussion[a].

Sport	Number of Participants *N* (%)	Female	Male
Soccer	22 (34%)	9	13
Ice hockey	20 (31%)	4	16
Football	14 (22%)	2	12
Lacrosse	11 (17%)	2	9
Basketball	10 (16%)	6	4
Rugby	9 (14%)	6	3
Wrestling	4 (6%)	0	4
Skiing/snowboarding	4 (6%)	2	2
Bicycling	3 (5%)	1	1
Baseball/softball	2 (3%)	1	1
Other	9 (14%)	4	5

Table 2

Proportion of patients reporting concussion symptoms included on the PCSS[a].

Symptom	Number (%) of patients reporting
Headache	50 (78.1)
“Pressure in head”	39 (60.9)
Neck Pain	22 (34.4)
Nausea or vomiting	14 (21.9)
Dizziness	32 (50.0)
Blurred vision	19 (29.7)
Balance problems	15 (23.4)
Sensitivity to light	30 (46.9)
Sensitivity to noise	26 (40.6)
Feeling like “in a fog”	27 (42.2)
“Don’t feel right”	39 (60.9)
Difficulty concentrating	39 (60.9)
Difficulty remembering	32 (50.0)
Fatigue or low energy	44 (68.8)
Confusion	25 (39.1)
Drowsiness	36 (56.3)
Trouble falling asleep	22 (34.4)
More emotional	22 (34.4)
Irritability	25 (39.1)
Sadness	19 (29.7)
Nervous or anxious	21 (32.8)

[a]PCSS, Post-Concussion Symptom Scale.

Table 3

Proportion of patients with each predictor variable.

Potential predictor variable	Participants with symptoms ≤28 days *n*/*N* (%)	Participants with symptoms >28 days *n*/*N* (%)	*p*-Value
Male	21/40	13/24	1.00
Prior sport-related concussion	18/39	9/23	0.61
Prior concussion (non-sport-related)	5/36	5/23	0.49
Prior undiagnosed concussion	8/33	7/21	0.54
Prior treatment for headaches	5/39	5/23	0.48
Family history of concussions	7/38	7/21	0.22
Prior diagnosis of migraines headaches	2/39	2/22	0.62
LOC[a] at time of injury	7/35	6/22	0.54
Amnesia at time of injury	6/37	9/23	0.07

[a]LOC, loss of consciousness.