Specific Factors Influence Postconcussion Symptom Duration among Youth Referred to a Sports Concussion Clinic

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Objective To identify the clinical factors that influence the duration of postconcussion symptoms among youth referred to a sports concussion clinic.

Study design A retrospective cohort study was conducted to evaluate several potential predictors of symptom duration via a Cox proportional hazards analyses. The individual postconcussion symptom scores were highly correlated, so these symptoms were analyzed in the statistical model as coefficients derived from principal component analyses.

Results Among 1953 youth with concussion, 1755 (89.9%) had dates of reported symptom resolution. The remainder (10.1%) were lost to follow-up and censored. The median time to recovery was 18 days (range 1-353 days). By 30 days, 72.6% had recovered; by 60 days, 91.4% had recovered; and by 90 days, 96.8% had recovered. Several variables in a multivariate Cox model predicted postconcussion symptom duration: female sex ($P < .001$, hazard ratio [HR] = 1.28), continued activity participation ($P = .02$, HR = 1.13), loss of consciousness ($P = .03$, HR = 1.18), anterograde amnesia ($P = .04$, HR = 1.15), premorbid headaches ($P = .03$, HR = 1.15), symptom components from the day of concussion (emotion, $P = .03$, HR = 1.08), and the day of clinic evaluation (cognitive-fatigue, $P < .001$, HR = 1.22; cephalalgic, $P < .001$, HR = 1.27; emotional, $P = .05$, HR = 1.08; arousal-stimulation, $P = .003$, HR = 1.1). In univariate analyses, greater symptom scores generally predicted longer symptom durations. Worsening of symptoms from the day of concussion to the day of clinic evaluation also predicted longer recovery ($P < .001$, HR = 1.59).

Conclusions Several factors help to predict protracted postconcussion symptom durations among youth referred to a sports concussion clinic. *(J Pediatr 2016;174:33-8)*.

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Concussions are common among children, resulting in approximately 144 000 or more visits to the emergency department annually in the US.[1] Many more youth with concussion are treated solely by primary care providers, outpatient specialists, or athletic trainers, or they do not seek medical care.[2,3] Recovery after concussion is poorly understood. Studies in adults suggest that most patients recover within 7-10 days,[4-6] but children may be more vulnerable to the concussion effects and may have longer durations of postconcussion symptoms.[7] For example, high school athletes generally recover more slowly than collegiate and professional athletes.[8,9] When a variety of study designs are considered, an estimated 2.8%-43% of youth continue to report postconcussion symptoms at 3 months.[10-17] Inconsistent, and at times contradictory, evidence exists linking clinical factors with protracted postconcussion symptoms in these patients.[18] Potential predictors include overall symptom burden,[11,13,14,19-22] specific symptoms,[12,23-28] previous concussions,[14,17,29,30] loss of consciousness (LOC),[13,22,31] absence of LOC,[14] post-traumatic amnesia,[11,13,22] age,[12,14,15] female sex,[15,32] premorbid symptoms,[17,30,32-34] and hospital admission.[12,31]

We sought to identify factors that influence the duration of postconcussion symptoms among youth referred to a sports concussion clinic. We expand on current knowledge by evaluating previous and novel predictors from a large representative sample and determining their relative importance in an inclusive multivariate survival model. Understanding which factors lead to prolonged recovery can improve overall concussion management by informing early subspecialty referral decisions, optimizing resource utilization, and helping clinicians to provide anticipatory guidance.

HR	Hazard ratio
LOC	Loss of consciousness
PCA	Principal component analysis

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Methods

We conducted a retrospective cohort study of pediatric patients presenting to a sports concussion clinic at a large Midwestern children's hospital between June 2012 and September 2014. The study was approved by the Institutional Review Board at Nationwide Children's Hospital.

Electronic medical records and clinic charting were analyzed. Concussion diagnoses were determined clinically for each patient, at the discretion of the managing physician, on the basis of the injury mechanism(s), history, and examination, and generally followed the operational definition of concussion set forth in the Consensus Statement on Concussion in Sport.[35] Study inclusion criteria were age from 10 to 19 years and a concussion injury occurring within 30 days of clinic evaluation. The age range represents the referral limits of the clinic. The interval of 1-30 days between injury and evaluation was chosen arbitrarily to allow a balanced analysis within a representative clinic sample while minimizing the numbers of individuals with distant injuries and potentially excessive recall biases. Exclusion criteria were the absence of traumatic brain injury, clinical features consistent with moderate or severe traumatic brain injury, and inability or refusal to complete the postconcussion symptom questionnaire. When patients sustained more than 1 concussion during the 28-month study period, only the data that corresponded with the first documented injury were analyzed. None of the patients in this study had an acute concussion that overlapped with recovery of a previous concussion.

As a standard component of the concussion clinic evaluation, all patients completed a written symptom questionnaire on arrival to the clinic but before their medical evaluations. The questionnaire addressed the presence and severity of 23 common postconcussion symptoms (**Table I**; available at www.jpeds.com), rated on a scale of 0 (not present) to 6 (severe). Separate scales were completed for current symptoms on the day of clinic evaluation and recalled symptoms from the day of concussion. Our questionnaire has not been validated. It was adapted from previously published symptom assessments.[36-38] In addition, patients and their parents answered basic questions related to the concussion, including the date of injury, mechanism of injury, the presence of LOC, the presence of anterograde and retrograde amnesia, whether the patient continued participating in the activity immediately after injury, the number of previous concussions, and the presence of premorbid headaches. Families self-reported race and ethnicity. Managing physician, insurance status, and clinic follow-up appointment dates were extracted from the electronic clinical records. As a standard component of our charting template, patients were asked at each consecutive clinic visit whether postconcussion symptoms had resolved and, if so, when. Resolution of symptoms in this study was defined as patient report of absent symptoms, return to premorbid symptom status, or symptom improvement allowing return to play and without planned follow-up. When resolution occurred within 24 hours of injury, such was designated as day 1 (rather than day 0). Dates of symptom resolution and cancelled/missed appointments were also extracted from the clinical record.

Statistical Analyses

Descriptive statistics were calculated for demographic and concussion data. The χ^2 test was used to compare categorical variables, and the Student *t* test or the Mann-Whitney *U* test was used to compare continuous variables that were related to the assessment of clinical predictors.

A multivariate Cox proportional hazards analysis was used to explore which factors influence the duration of postconcussion symptoms. The dependent variable was time to symptom resolution. When clinic follow-up appointments were missed or cancelled, and the date of symptom resolution was not available, the subject was censored on the date of the earliest missed appointment. All patients who completed follow-up had dates of symptom resolution. To address multicollinearity among postconcussion symptoms that are highly correlated, the 23 symptom scores from each time period (day of concussion and day of clinic evaluation) were reduced to 6 symptom components via a principal component analysis (PCA) with oblique rotation (Promax, kappa = 4).[39] The PCA-derived principal components (symptom clusters) are listed in **Table I**; each cluster was labeled by us according to the symptoms it comprised. As expected, some differences existed between symptoms reported on the day of concussion and the day of clinic evaluation, but the resulting clusters represent logical patterns of symptom groupings for both analyses. The Bartlett method was used to estimate PCA score coefficients for the Cox analysis. Given the inconsistent results from previous studies, we entered predictor variables in hierarchical stages to explore the relative effects of covariates: (1) demographic information and clinic information; (2) concussion characteristics and premorbid headaches; (3) and then the principal component data (symptom clusters) on the day of concussion and the day of clinic evaluation. Interaction terms were not analyzed. The corresponding hazard ratios (HRs) were inverted to reflect the risk of continued postconcussion symptoms (rather than symptom resolution).

In addition, univariate Cox proportional hazards analyses were used to determine whether total symptom scores at the time of concussion or the time of clinic evaluation influenced postconcussion symptom duration. The sums of the 23 symptom scores were divided by quartile (**Table II**), and pairs of consecutive quartiles were compared. We also calculated the differences between scores at clinic evaluation and at concussion (symptom score on clinic day minus symptom score on concussion day) and compared symptom durations among patients with positive and negative differences. A positive difference means that symptoms worsened from the day of concussion to the day