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Original Article

## The Incidence of Postconcussion Syndrome Remains Stable Following Mild Traumatic Brain Injury in Children



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## ABSTRACT

**BACKGROUND:** Improving our knowledge about the natural history and persistence of symptoms following mild traumatic brain injury is a vital step in improving the provision of health care to children with postconcussion syndrome. The purposes of this study were to (1) determine the incidence and persistence of symptoms after mild traumatic brain injury and (2) ascertain whether Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV), symptom criteria for postconcussion syndrome in adults are appropriate for use in children. **METHODS:** A tertiary care pediatric emergency department was the setting for this study. This was a prospective observational follow-up cohort study of children (ages 2 to 18 years) with mild traumatic brain injury. Data were collected in person during the acute presentation, and subsequent follow-up was performed by telephone at 7–10 days and 1, 2, and 3 months postinjury. Postconcussion Symptom Inventory for parents and children was used. The DSM-IV diagnostic criteria for postconcussion syndrome were explored using receiver operating characteristic curve analysis. **RESULTS:** A total of 467 children (62.5% boys, median age 12.04, range 2.34–18.0) with mild traumatic brain injury participated. The median time until symptom resolution was 29.0 days (95% confidence intervals: 26.09–31.91). Three months after injury, 11.8% of children with mild traumatic brain injury remained symptomatic. Receiver operating curve characteristic analysis of the postconcussion syndrome criteria successfully classified symptomatic participants at three months postinjury; the adolescent receiver operating characteristic curve was excellent with the area under the curve being 0.928 ( $P < 0.001$ , standard error 0.019). **CONCLUSIONS:** Consistent with our previous study, 11.8% of children presenting to the emergency room with a mild traumatic brain injury remain symptomatic at 3 months postinjury. This is the first study to demonstrate stable incidence rates of postconcussion syndrome in children and that modified DSM-IV criteria can be used to successfully classify postconcussion syndrome in children. Although most children report a decay in symptoms over time, 10% of children develop symptoms even though they initially had a good outcome. Caution should be used when using only parent report as a surrogate for childhood outcomes following a concussion.

**Keywords:** mild traumatic brain injury, concussion, postconcussion syndrome, incidence, diagnostic criteria

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Conflicts of interest: None.

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### Introduction

Improving health care in children with postconcussion syndrome (PCS) is a major public concern.<sup>1–4</sup> One in five children will sustain a traumatic brain injury (TBI) by 16 years of age, and emergency departments in the United States triage more than 473,000 children each year with a TBI, the vast majority of which are mild.<sup>5,6</sup> Although several risk factors have been identified including age, injury severity, and baseline symptoms, the prediction of

prolonged symptoms at the time of presentation proves difficult due to the influence of noninjury factors.<sup>2,7-11</sup>

The prevalence of PCS following mild TBI depends on the population studied as well as which diagnostic criteria are used.<sup>3,7,12-14</sup> Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV), has very specific diagnostic criteria including: (1) a history of traumatic brain injury; (2) evidence from neurobehavioral testing of cognitive deficits in attention and/or memory; (3) three or more of the following symptoms that appear after injury and persist for 3 months or more: fatigue, headaches, dizziness, sleep disturbance, irritability, apathy or affective disturbance, or personality changes. The symptom onset must be contiguous with TBI, distinguishable from preexisting conditions, and be of a minimum 3-month duration. In practice, the DSM-IV is usually modified as most physicians do not have access to neurobehavioral testing.<sup>12,15</sup> To date, these criteria for PCS have not been formally evaluated in children.

Prevalence rates of PCS at 3 months postinjury in children vary between 11% and 29.3%.<sup>2,7,16</sup> Improving our knowledge about the natural history and survival of symptoms following mild TBI is a vital step in the health care provision of children with PCS. The purposes of this study were to (1) determine whether the incidence of PCS symptoms after mild TBI in children was consistent with a previous report from our center<sup>7</sup> and (2) to ascertain whether DSM-IV symptom criteria for PCS in adults can be applied to children.<sup>1,12,17</sup>

## Methods

This was a prospective observational follow-up study of a cohort of children who presented to the emergency department of the Alberta Children's Hospital, Calgary, Alberta, Canada, with mild TBI between July 2011 and January 2013. This study was approved by the University of Calgary Conjoint Health Research Ethics Board (24030).

Inclusion criteria were children 2-18 years of age, presenting with a mild TBI between 8 am and midnight. Mild TBI was defined as an impact to the head or body resulting in at least one of the following: (1) an observed loss of consciousness (less than 30 minutes), (2) a Glasgow Coma Score of 13-15, or (3) at least two acute symptoms suggesting neurological dysfunction attributable to the injury (e.g., headache, confusion, vomiting, amnesia, balance problems) and documented by emergency department medical personnel.<sup>18-21</sup> Concussion is considered to be part of the spectrum of mild TBI.<sup>22</sup> Exclusion criteria included drug/alcohol use at the time of the injury/assessment, Glasgow Coma Score <13, an inability to give consent, inability to complete the questionnaires (e.g., English as a second language), and suspected child abuse. An abnormal computed tomography scan did not exclude mild TBI as long as these clinical parameters were met.

## Measures

### Postconcussion Symptom Inventory (parent and child versions)

These are age-appropriate standardized questionnaires that consist of 13-26 symptoms and also provide an overall rating of symptoms. The parent and adolescent versions have four factor-derived domains—physical, cognitive, emotional, and fatigue—and has a high level of internal consistency,  $\alpha = 0.94$  for parent- and adolescent-reported Postconcussion Symptom Inventory (PCSI) total scores and has been used in mild TBI.<sup>7,23,24</sup>

**Parent version.** Individual scores for each symptom (0-4), a total symptom score (0-104), and a “degree of difference from preinjury”

score (0-4) were obtained from parents. A change of 2 or more points in any symptom was considered clinically significant. The adolescent PCSI version is similar except individual symptoms are rated from 0 to 6 with a total score of 156.

**Older child version.** Children ages 8-12 years are asked to rate 23 individual symptoms from zero (“never”) to 3 (“almost always”) with a total possible score of 69, and “have you felt more different” is rated “no” to “a lot” (0-2).

**Young child version (ages 5-7 years).** Individual scores for 13 symptoms are rated from “never” to “a lot” (0-2) with a total score of 26, and “do you feel different than usual” (0-2). Children younger than 5 years of age did not complete questionnaires. PCSI scores were obtained in parents and children around 7-10 days and 1, 2, and 3 months postinjury.

### Symptomatic status

Children were considered to be “symptomatic” if they or their parents reported a difference (scores between 1 and 4) for the following statements: “Have you felt more different than usual” (child) and “In general, to what degree is your child acting differently than before the injury (not acting like him/herself)” (parent).<sup>7</sup> Symptom resolution was defined as the point at which parents reported no change from before the injury and their ratings for individual symptoms were back to or below pre-injury levels. Time to symptom resolution was calculated as the number of days between the injury and the day of the last telephone contact at which the child was symptomatic.

PCS was defined as the presence (or increase) of at least three of 10 symptoms from four domains (physical, cognitive, emotional, and behavioral) occurring for 3 months or longer after TBI. Neuropsychological testing was not performed and was not included in our definition. The following PCSI symptoms (modified from the DSM-IV PCS diagnostic criteria) were used: headache, dizziness, fatigue, irritability, insomnia (sleeping less than usual), difficulty concentrating, memory problems, emotional lability (being “more emotional”), and mood disturbance (depressed mood and/or anxiety). Details about emotional lability and insomnia are not reported in the PCSI (5-7 years) version, and emotional lability is not reported in the PCSI (8-12 years) version.

### Procedures

Consent and assent was obtained from the parent and child, respectively. A research assistant enrolled participants in the emergency department and collected demographic, medical, preinjury, and acute injury details from the parent, child, and medical personnel using a standard questionnaire. The emergency room physician checked and verified the data collected. Parents were asked to give preinjury symptom ratings using the PCSI. Follow-up of the parent and child was performed by telephone at 7-10 days, and 1, 2, and 3 months postinjury.

### Statistical analysis

All analyses were performed using SPSS 22.0 (IBM Corp). The Kolmogorov-Smirnov test was used to test for normal distribution of the data. Where data were not normally distributed, nonparametric tests (Mann-Whitney *U* test) were used to conduct group comparisons. Binary logistic regression was performed to assess the influence of age, gender, presence of other injury, time of presentation, and pre-injury PCSI total score on the persistence of symptoms. Symptom-free survival was calculated by using Kaplan-Meier analysis using Gehan-Breslow-Wilcoxon method to weight to becoming asymptomatic at early time points with a 95% confidence interval (CI). Participants were censored if they were lost to follow-up, withdrew from the study, or had another injury. To correlate the PCSI parent and child total scores, the total PCSI scores were expressed as a percentage of the total possible score. Correlations were performed using Spearman's Rho test. Receiver operating characteristic (ROC) curve analysis was performed using our modified

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