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Psychological factors associated with delayed symptom resolution in children with concussion

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Abstract

Objective—To characterize the psychological factors associated with persistent symptoms following pediatric concussion.

Study design—Longitudinal cohort study of 179 concussed children 8–18 years old evaluated in a pediatric emergency department. Participants were followed for one month for delayed symptom resolution defined as ≥ 3 symptoms that were new/worse than pre-injury symptoms measured using graded symptom inventory. Pre-injury psychological traits were measured by parental report on subscales of the Personality Inventory for Children-2 (maladjustment, cognitive abilities, somatization). Child report of post-injury anxiety and injury perception were measured using State-Trait Anxiety Inventory for Children (STAIC) and Children's Illness Perception Questionnaire. Psychological instrument scores were compared between those with and without DSR using a Kruskal-Wallis test. Associations between psychological traits and DSR were investigated using logistic regression.

Results—DSR occurred in 21% of participants. Score distributions were significantly worse on the STAIC [38 (IQR 33–40) vs 35 (IQR 31–39); $p=0.04$] and somatization subscale [1 (IQR 0–3) vs 1 (IQR 0–1); $p=0.01$] among children with DSR compared with children with early symptom resolution (ESR). Somatization was associated with DSR [adjusted odds ratio (OR) 1.35, 95% CI: 1.08– 1.69]. The proportion of children with abnormal somatization scores was significantly higher in the DSR group (34.2%) than the ESR group (12.8%; $p<0.01$). Other psychological measures were not different between groups.

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Conclusion—Somatization is associated with delayed symptom resolution in this cohort of concussed children. Post-concussive symptoms lasting at least one month may warrant referral to a neuropsychologist familiar with post-concussion care.

Although post-concussive symptoms for most children resolve in 1–2 weeks, up to 15–30% of children who sustain a concussion experience symptoms lasting at least 3 months.(1, 2) Post-concussive symptoms garner considerable attention in the clinical management of pediatric concussions. Widely accepted guidelines recommend that the return to play process should not begin until the athlete is asymptomatic.(3) Experts also recommend that accommodations be made for persistent symptoms as children return to the classroom. (4–6) Underlying these recommendations is the assumption that ongoing symptoms represent an incomplete resolution of the pathophysiologic changes that occur following a concussion.(7, 8)

Although injury factors such as the severity of injury likely contribute to symptom persistence(9), non-injury psychological components clearly influence symptomatology after concussion.(10) For example, pre-existing anxiety and depression are risk factors for developing persistent post-concussive symptoms.(11–14) Even among non-head-injured patients, individuals may report symptoms consistent with post-concussive syndrome.(15–17) Additionally, poorer patient perceptions of the impact of concussion have been shown to be associated with persistent symptoms.(18, 19) Even though mounting evidence suggests a significant role for non-injury psychological factors in adults experiencing delayed symptom resolution (DSR), this phenomenon remains relatively unexplored in children.

For practicing pediatric providers, knowing whether psychological factors contribute to DSR in children with concussion, similar to patterns seen in adults, is important for management. If psychological factors contribute significantly to DSR, referral to specialists who can address these factors may be indicated. Our objective was to characterize better the psychological factors associated with persistent symptoms in children following a concussion. To achieve this objective, we explored the contributions of specific psychological characteristics to the development of DSR among children presenting to an emergency department with an acute concussion. We hypothesized that pre-injury difficulties with psychological adjustment and post-injury anxiety and negative injury perception are associated with DSR in children.

Methods

We conducted a prospective cohort study from October 1, 2010, to March 31, 2013, at a tertiary care pediatric trauma center emergency department (ED). We enrolled a convenience sample of children ages 8–18 years who sustained concussions <6 hours before ED arrival. Participants were considered to have a concussion if they had a Glasgow Coma Scale (GCS) score of 13 or 14 (assigned by a faculty physician or resident) or at least 2 of the following signs/symptoms occurring after a direct blow to or rapid acceleration/deceleration of the head: bystander-witnessed loss of consciousness; post-traumatic amnesia; disorientation to person, place, or time; subjective feelings of slowed thinking; perseveration; vomiting/nausea; headache; diplopia/blurry vision; dizziness; or somnolence. Children were excluded

for the following: open head injuries; intoxication with alcohol or controlled substances, receipt of narcotics, injuries resulting from child abuse, multisystem injuries, or underlying central nervous system abnormalities such as malignancy, structural abnormalities, prior surgery or instrumentation, developmental delays, or seizure disorders. Participants were enrolled in the ED from 7:00 am to 11:00 pm by trained research assistants. A research assistant then telephoned participant families three and thirty days after the ED visit to complete data collection using scripted interviews. Participants not contacted after three attempts were considered lost to follow-up. The study was approved by the Colorado Multiple Institutional Review Board.

Demographic information, injury characteristics, and mechanism of injury were collected by research assistants at the ED enrollment visit. Baseline symptom inventory scores were obtained using the Concussion Symptom Inventory (CSI) (20). The CSI was modified to include two additional symptoms (sadness and irritability) and the wording was adjusted for the age of our population. The possible score range was 0–28. Delayed symptom resolution (DSR), our primary outcome, was defined as the presence of three or more symptoms thirty days after injury that were absent or less severe in the week before injury. This definition was derived from findings of new post-concussive symptoms in a similar cohort. (21) Additionally, the *International Statistical Classification of Diseases and Related Health Problems, 10th revision* definition requires at least 3 post-concussive symptoms to meet criteria consistent with persistent post-concussive syndrome. (22) Children who did not meet the criteria for this outcome were considered to have early symptom resolution (ESR).

Psychological characteristics were assessed using three different instruments. The Personality Inventory for Children, 2nd Edition (PIC-2) is a parent-report instrument that assesses behavioral and emotional adjustment in children and correlates well with other measures of child behavior. (23) PIC-2 subscale responses were collected from parents at the time of injury and reflect pre-injury psychological traits of the child. For this study we used three validated subscales. The Cognitive Impairment – Inadequate Abilities (COG1) subscale quantifies cognitive competence and correlates with cognitive and academic achievement. The Psychological Discomfort Short subscale (DIS-S) assesses general maladaptive psychological tendencies and correlates with measures of depression and anxiety. The Somatic Concern Short subscale (SOM) measures the tendency to internalize problems and express them through physical symptoms. Raw scores on the DIS-S, SOM, and COG1 subscales 5, 3 and 5 correspond to a T-score 60 respectively in both boys and girls; T-scores 60 indicate abnormally high levels of dysfunction in each domain relative to the general population. Raw scores were used for statistical analysis.

The second instrument used was the State-Trait Anxiety Inventory for children (STAIC). (24) We used only the child's response to the *state* portion (anxiety as a response to a specific event) of the STAIC as we were primarily concerned with the relationship between acute post-injury anxiety in response to a concussion and DSR. The instrument includes 20 items with a score range of 20–60 where higher scores indicate greater anxiety. Response to this item was recorded during the ED visit.

The Children's Illness Perception Questionnaire (CIPQ) measures five specific attributes of how a child conceptualizes illness: identity, consequences, causes, timeline, and curability. (25) We modified the CIPQ for concussion as the condition of interest. (18) Possible scores range from 0–18 with higher scores indicating increasingly negative perception of the concussion. There is no normative data for the CIPQ. We administered the CIPQ during a 3-day follow-up call to allow time for the participants to develop a perception of the impact of their concussion. Table I summarizes each of the instruments used and timing of collection.

All analyses were completed using SAS Software, v9.4. Bivariate statistics comparing demographics, injury characteristics, and psychological characteristics between concussed children with and without persistent symptoms were calculated using independent samples t-tests, Kruskal-Wallis tests, or χ^2 tests, depending on the distribution of the predictor. Subscales of the PIC-2 examined in this study (COG1, DIS-S, SOM) were examined both as continuous variables and binary variables, using cutoffs of scores greater than or equal to 5 on the DIS-S and COG1 and greater than or equal to 3 on the SOM. (23) The STAIC and CIPQ were treated as continuous variables.

Crude and adjusted odds ratios testing the association between the psychological predictors of interest and DSR were calculated using logistic regression. Age, sex, and injury mechanism (sport vs. other mechanism) were selected *a priori* for inclusion in adjusted models due to potential differences in psychological characteristics based on these variables. Associations were considered statistically significant at $\alpha < 0.05$.

Results

Research assistants screened 1253 patients for participation; 273 met inclusion criteria and 234 patients consented to participate. Of those enrolled, 179 subjects (76%) completed the 30-day follow-up call and comprised the study cohort (Figure; available at www.jpeds.com). Nine (8 with ESR and 1 with DSR) participants did not complete the 3-day call and were not included in the analysis for the CIPQ. Participants not completing follow-up were not significantly different from those who completed the study in age, sex, initial GCS, mechanism of injury, history of previous concussion, and scores on each of the psychological inventories used.

Thirty-eight children met the study definition for DSR (21%). Children in the ESR and DSR groups did not differ significantly in demographics, history of prior concussion, or injury characteristics (Table II). Forty participants received a head computed tomography (CT) scan; all five participants with abnormal results belonged to the ESR group.

Table III displays the univariate comparisons for each of the five psychological instruments. Participants with DSR had significantly higher scores for the Somatization subscale of the PIC-2 and the state portion of the STAIC compared with the ESR group.

Crude and adjusted odds ratios for each psychological characteristic are also displayed in Table III. Somatization was significantly associated with an increased odds of experiencing DSR. There was a strong trend toward increased odds of DSR with increasing state anxiety (STAIC) and this closely approached statistical significance ($p=0.06$). We also adjusted for

mechanism – sport vs. non-sport – as there may be different motivational factors for reporting symptoms. However, this did not provide substantially different ORs than the crude or age and sex adjusted ORs (data not shown).

We compared the proportion of children with abnormal PIC-2 subscale scores in the ESR and DSR groups. A significantly higher proportion of children in the DSR group had abnormal SOM scores compared with the ESR group (34.2% vs 12.8% respectively; $p<0.01$). The proportion of children with abnormal DIS-S scores was also higher in the DSR group and neared significance (29.0% vs 15.6%; $p=0.06$). There was no difference in the proportion of children with abnormal COG1 scores between the DSR and ESR groups (13.2% vs 8.5%; $p=0.39$).

Discussion

Our data indicate that non-injury psychological traits present before the injury or shortly after injury are associated with persistent post-concussive symptoms in children following a concussion. Univariate analysis demonstrated that children with symptoms lasting at least one month after a concussion (DSR) reported significantly higher scores on measures of post-injury anxiety and pre-injury somaticizing tendencies than their counterparts in the ESR group. Additionally, there was a significant association between the tendency to somaticize and developing DSR. Correspondingly, the proportion of children with an abnormal SOM-S score was nearly 3-fold higher among the DSR group than the ESR group. In the context of recovery supervision, ongoing concussion symptoms may signal the need for specialized evaluation to determine if these symptoms have a psychological basis requiring management beyond rest or activity restriction.

Symptom resolution holds a prominent place in medical decision making for concussion management. This focus reflects a hypothesis that symptoms, especially those reported in the first few weeks following a concussion, are indicative of pathophysiologic changes.(26) Although beyond the scope of this discussion, Shrey et al provide a detailed review of research supporting this hypothesis.(27) The hypothesis and supporting evidence have led to the assumption that symptom persistence indicates incomplete recovery from a concussion. It is often assumed further that activities that worsen symptoms impair recovery following a concussion. To avoid exacerbating concussion symptoms rest is commonly recommended. However, methodologically rigorous studies exploring the relationship between symptoms and activity have not supported these assumptions. Among high school and college athletes a symptom-free rest period was not associated with decreased symptom duration.(28) An observational study and randomized trial also demonstrated longer symptom duration among participants for whom rest was prescribed.(29, 30). Such studies suggest that symptom resolution depends on additional factors that are unrelated to the concussion.

Symptom reporting is inherently subjective. In the last five to ten years, pediatric studies have begun to reveal that pre-existing non-injury characteristics influence post-concussive symptom report. McNally et al showed that retrospective ratings of pre-injury symptoms explained most of the variance seen in post-concussive symptom measures.(31) In the same report, premorbid behavioral maladjustment correlated with increased post-concussive

symptoms. By contrast, in our cohort, general psychological maladjustment (DIS-S) did not show an association with DSR (although the difference in proportions of children with abnormal DIS-S scores in the ESR and DSR groups approached significance). However, a tendency to somaticize was associated with DSR among our participants. Although, the pre-injury symptom ratings seen in McNally's study were not necessarily indicative of somaticizing tendencies, taken together with our findings, clinical providers should consider that the etiology of reported symptoms is not solely attributable to incomplete recovery and might be indicative of pre-existing psychological characteristics of the child.

We also explored how innate cognitive ability may influence DSR using the COG1 subscale. Participants with poorer cognitive abilities did not have a greater likelihood of developing DSR. This contrasts with the findings of Fay et al who demonstrated increased post-concussive symptoms among children with lower cognitive reserve capacity.(32) In that study, the authors used several measures of cognitive function and combined the measures into a single composite value and measured the effect of cognitive function on symptoms at 3 months rather than one month post-injury. Thus, it is possible that we did not see a difference in our group as we used only a single measure of cognitive function measured at one month.

Several adult studies have demonstrated a strong association between DSR and anxiety.(13, 14,33, 34). This association has been less thoroughly explored in children. In one study, children who reported of a history of anxiety took more than twice as long to experience symptom resolution compared with those without such a history, though the results were not significant.(35) More convincingly, Peterson et al studied a cohort of concussed children referred to a concussion program for persistent symptoms lasting at least 4 weeks. They found that the proportion of participants displaying anxiety problems was significantly higher than the general population.(36) We found an association between increased state anxiety (anxiety at a specific point in time) immediately after a concussion and DSR in our pediatric cohort in univariate analysis. Although the association did not hold in multivariate analysis, our results neared significance. Our results contrast with the findings of Wood et al who found that trait (a general disposition toward being anxious), but not state, anxiety was significantly associated with elevated post-concussion symptoms among concussed adults. (12) That study measured state anxiety an average of 2.38 weeks after injury using the STAI, whereas we measured it within hours, which may partially explain the discrepancy. Nonetheless, our data suggest that anxiety may contribute to DSR and may be a target for early intervention in future studies. Managing anxiety that could contribute to DSR following a concussion may require skills that are not generally the purview of pediatric primary care providers.

Interpretation of our results is restricted by the following limitations. One quarter of the participants did not complete the 30-day study follow-up. These participants did not differ on any injury characteristics or psychological variables measured at the time of ED enrollment so it is unlikely that their inclusion would have led to significantly different results. We did not include a comparison group with extra-cranial injuries but no concussion. Many studies exploring DSR include such comparison groups to determine if associations between psychological factors and DSR are related to head injury specifically or injury in

general. However, pediatric ED studies comparing head-injured and orthopedically injured participants show that symptoms captured using concussion symptom inventories tend to be much higher among head-injured participants both initially and during recovery.(21, 37) Additionally, our objective was to compare the influence of psychological factors on symptom resolution among a cohort of children with concussion rather than explore the subjective nature of concussion symptoms in general. Lastly, we did not exclude subjects with abnormal findings on CT and we did include subjects with a GCS of 13–14 without documenting a return to a GCS of 15 within 24 hours of injury. Thus, we may have included children who did not meet more strict criteria for mild traumatic brain injury (TBI).(38) However, all of the participants with abnormal CTs belonged to the early symptom resolution group suggesting that intracranial injury, though considered more severe TBI, may not be an independent risk factor for DSR. Additionally, only 12 participants (11 in the ESR group) had a GCS <15 which is unlikely to have affected our findings significantly. No participant was readmitted due to a missed intracranial hemorrhage. Although this study was conducted in a pediatric trauma center ED, the findings are applicable to similar children evaluated in a general ED or office setting as the psychological factors studied are not likely to be unique to an ED population.

A substantial number of concussed children experience delayed symptom resolution. Symptom resolution plays a central role for health care providers when managing return to the athletic field and classroom because persistent symptoms are assumed to represent ongoing pathophysiology. Our data indicate that non-injury factors, especially the tendency to somaticize and, to a lesser degree, anxiety contribute significantly to DSR. As the psychological assessments used in this study are likely to be unfamiliar to primary care pediatric providers, we do not suggest attempting to incorporate them into a busy office practice. Rather, primary care providers managing the recovery of concussed children with persistent symptoms should consider referring patients to providers with particular expertise in behavioral health such as pediatric psychologists or neuropsychologists.(39) Further study is needed to determine whether collecting information regarding a child's pre-injury psychological tendencies soon after injury can identify children in need of earlier referral to such specialists.

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Abbreviations

CIPQ	Children's Illness Perception Questionnaire
COG1	Cognitive Impairment – Inadequate Abilities
CSI	Concussion Symptom Inventory
DSR	Delayed symptom resolution
ESR	Early symptom resolution

ED	Emergency Department
GCS	Glasgow Coma Scale
PIC-2	Personality Inventory for Children, 2 nd Edition
DIS-S	Psychological Discomfort Short
SOM	Somatic Concern Short
STAIC	State-Trait Anxiety Inventory for Children

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Figure.

Study Flow Diagram. ESR = Early Symptom Resolution, DSR = Delayed Symptom Resolution

Table 1

Summary of Study Measures

Instrument	Designed to Measure	Completed by	Collected during	Score Range	Score Interpretation
Concussion Symptom Inventory	Graded severity of concussion symptoms	Child	ED Visit & 30-day follow-up	0–28	Higher scores indicate more frequent and/or severe concussion symptoms
Cognitive Impairment (COG1)	Cognitive ability to achieve academic success	Parent	ED Visit *	0–13	Raw scores 5 indicate poorer cognitive abilities
Psychological Discomfort (DIS-S)	Maladaptive psychological tendencies	Parent	ED Visit *	0–12	Raw scores 5 indicate more maladaptive tendencies
Somatic Concern (SOM)	Tendency to internalize problems and display physical symptoms	Parent	ED Visit *	0–12	Raw scores 3 indicate increased tendency to somaticize
State-Trait Anxiety Inventory (STAIC)	Levels of anxiety in response to an event	Child	ED Visit	20–60	Higher scores indicate more anxiety related to an event
Children's Illness Perception Questionnaire (CIPQ)	Conceptualization of the impact of injury on child	Child	3-Day Follow-up	0–18	Higher scores indicate increasingly negative perception of the impact of injury

* These measures ask parents to reflect on their child's personality *prior to the injury*.

Table 2

Demographic, injury, and symptom inventory scores for Early Symptom Resolution (ESR) and Delayed Symptom Resolution (DSR) groups

Demographics	ESR (n=141)	DSR (n=38)	p-value
Mean age, years (SD)	12.6 (2.5)	13.4 (2.2)	0.79
Male, %	70	66	0.69
History of previous concussion, %	24	29	0.53
Injury Characteristics			
Mechanism, %			0.79
Sport	48	53	
Fall	43	34	
Assault	3	5	
Motor vehicle collision	1	3	
Other	5	3	
Loss of consciousness, %	26	29	0.68
Post-traumatic amnesia, %	26	34	0.42
Initial Glasgow Coma Scale (GCS) Score [*]	15	15	0.99
Proportion of participants with GCS <15, % [†]	8	3	0.47
Initial ED Concussion Symptom Inventory score, median (IQR)	9 (6–13)	10.5 (7–15)	0.14
30-day Concussion Symptom Inventory score, median (IQR)	0 (0–1)	4 (3–7)	<0.01

SD = standard deviation, IQR = interquartile range,

^{*} IQR for both the ESR and DSR groups was 15-15.

[†] 12 participants had a GCS of 13 or 14 (11 in the ESR and 1 in the DSR groups).

Table 3

Comparisons of psychological characteristics for Early (ESR) and Delayed (DSR) Symptom Resolution groups

	Univariate * Comparison			Logistic Regression Analysis		
Psychological Characteristics	ESR median (IQR)	DSR median (IQR)	p	Crude OR (95% CI)	Adjusted OR [†] (95% CI)	p [‡]
PIC-2 Raw Scores Psychological Discomfort-Short (DIS-S)	2 (1–3)	2 (1–5)	0.46	1.10 (0.96, 1.27)	1.09 (0.95, 1.26)	0.23
Somatic Concern-Short (SOM)	1 (0–1)	1 (0–3)	0.01	1.39 (1.11, 1.73)	1.35 (1.08, 1.69)	<0.01
Inadequate Abilities (COG1)	2 (0–3)	1 (1–3)	0.55	1.08 (0.90, 1.29)	1.10 (0.91, 1.31)	0.33
STAIC	35 (31–39)	38 (33–40)	0.04	1.06 (1.00, 1.13)	1.06 (1.00, 1.14)	0.06
CIPQ-Child	5 (3–7)	5 (3–7)	0.97	1.05 (0.91, 1.20)	1.09 (0.94, 1.26)	0.28

OR = odds ratio for developing DSR for each psychological characteristic; IQR = interquartile range; CI = confidence interval

* Kruskal-Wallis test, $\alpha=0.05$;[†] adjusted for age and sex, Wald χ^2 ;[‡] p-value for adjusted OR