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History of Somatization is Associated with Prolonged Recovery from Concussion

Jeremy M Root, MD^a, Noel S. Zuckerbraun, MD^b, Li Wang, MS^c, Dan Winger, MS^c, David Brent, MD^d, Anthony Kontos, PhD^e, and Robert Hickey, MD^b

^aEmergency Medicine and Trauma Services, Children's National Medical Center, Washington, DC

^bDivision of Pediatric Emergency Medicine, Children's Hospital of Pittsburgh, Pittsburgh, PA

^cOffice of Clinical Research, Heath Sciences, University of Pittsburgh, Pittsburgh, PA

^dDepartment of Psychiatry, University of Pittsburgh School of Medicine, Pittsburgh, PA

^eDepartment of Orthopaedic Surgery, University of Pittsburgh, Pittsburgh, PA

Abstract

Objective—To determine the association between a history of somatization and prolonged concussion symptoms, including sex differences in recovery.

Study design—A prospective cohort study of 10–18 year olds with an acute concussion was conducted from July 2014 to April 2015 at a tertiary care pediatric emergency department. 120 subjects completed the validated Children's Somatization Inventory (CSI) for pre-injury somatization assessment and Post-Concussion Symptoms Score (PCSS) at diagnosis. PCSS was re-assessed by phone at 2- and 4-weeks. CSI was assessed in quartiles with a generalized estimating equation model to determine relationship of CSI to PCSS over time.

Results—The median age of our study participants was 13.8 years (interquartile range: 11.5, 15.8), 60% male, with analyses carried out separately for each sex. Our model showed a positive interaction between total CSI score, PCSS and time from concussion for females $p < 0.01$, and a statistical trend for males, $p = 0.058$. Females in the highest quartile of somatization had higher PCSS than the other three CSI quartiles at each time point (B -26.7 to -41.1 , p -values < 0.015).

Conclusions—Patients with higher pre-injury somatization had higher concussion symptom scores over time. Females in the highest somatization quartile had prolonged concussion recovery with persistently high symptom scores at 4 weeks. Somatization may contribute to sex differences in recovery, and assessment at the time of concussion may help guide management and target therapy.

Address correspondence to: Jeremy Root, Division of Emergency Medicine, Children's National Medical Center, 111 Michigan Ave, NW, Washington, DC 20010, jroot@childrensnational.org, 202-476-4177.

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The PCSS is a 22-item scale designed to measure the severity of concussion symptoms. It is part of the sports concussion assessment, which was proposed by an international concussion conference. Items such as headaches, nausea, difficulty concentrating, and sensitivity to light or noise are scored on a 6-point scale (0 = “none,” 1–2 = “mild,” 3–4 = “moderate,” 5–6 = “severe”). The total score is the sum of the individual symptom severity scores; thus, the maximum score is 132 (6 × 22). The scale has been shown to be internally consistent and reliable in concussed adolescents.

The CSI is a 24-item scale used to characterize the breadth and severity of somatic symptoms in pediatric patients. Subjects were asked to recall symptoms associated with somatization such as back pain, constipation, feeling faint/dizzy, and hot or cold spells, scored on a 4-point scale (0 = “not at all,” 1 = “a little,” 2 = “some,” 3 = “a lot,” 4 = “a whole lot”) over the two weeks prior to injury (Table I; available at www.jpeds.com). This scale has been shown to be a valid assessment of somatization in children and adolescents.”

As sleep has been shown to affect concussion recovery, history of insomnia could be a confounder and was assessed with the ISI. The validated ISI is a seven-item scale used to assess clinical insomnia. Subjects were asked to rate symptoms of insomnia for the two weeks prior to concussion on a 4-point scale (0 = “none,” 1 = “mild,” 2 = “moderate,” 3 = “severe” 4 = “very severe”).

Descriptive statistics including age, sex, mechanism of injury, history of migraines, and history of previous concussions were reported as median with interquartile range (IQR) for continuous variables and frequency with percentage for categorical variables.

Our main outcome was the association between somatization and prolonged concussion recovery. From the outset, we estimated the prevalence of prolonged concussion symptoms between 25–40% and anticipated a 10–20% rate of high somatization. As this is a novel research question, relevant effect size estimates were not available in existing literature. Thus, we sought to recruit around 100 patients, which would give us a reasonable number of subjects across the spectrum of somatization, including 10–20 subjects with high somatization. By conventional statistical rules of thumb, this would also give us the ability to stratify and or adjust for a few key variables if necessary.

Statistical Analyses

For all analyses, we used a generalized estimating equations (GEE) model with an unstructured working correlation matrix, which allowed us to examine PCSS changes over time while accounting for the correlated nature of the data within each subject. P-values < 0.05 were considered statistically significant. Statistical analysis was carried out with SPSS version 22 (IBM Corp., Armonk NY).

Previous studies on somatization have shown that somatization and specifically, the CSI scale, was higher in girls compared with boys.” Symptoms on the PCSS have also been reported to be higher in females compared with males. We therefore suspected the PCSS change over time may be different for males and females due to different levels of somatization. We first tested a GEE model with main effects of sex, total CSI score, time,

and the interaction effect of sex and total CSI score. The primary focus of this model was to determine whether the interaction between sex and total CSI score was significant; a significant interaction would indicate that the two sexes experience different relationships between total CSI score and PCSS changes over time. The GEE model showed that there was a significant interaction between sex and total CSI score ($p=0.003$), so we stratified all subsequent analyses by sex.

Using the GEE model stratified by sex, we performed a univariate analysis for each predictor variable (age, loss of consciousness, retrograde or post-traumatic amnesia, history of prior concussion, history of migraines, total ISI score, total CSI score and CSI quartiles). For each of these predictors, there are two GEE models for the univariate analysis: the first model contains the interaction term of time and the predictor along with the main effects of time and the predictor. If the interaction term was not significant, we opted for the simpler model without the interaction term in order to obtain a better estimate of the coefficient. After conducting the univariate analysis within each sex, we used multivariable analysis in order to examine associations by using any variables that were significant in univariate analysis.

RESULTS

Table II shows the demographics, injury mechanisms and characteristics, and history of concussions and migraines of the 120 subjects enrolled in the study; 60% of our patient population was male and ~60% of our patient population had sport or recreation related injuries.

PCSS scores were collected at enrollment and at 2-week and 4-week follow-up phone calls (Table III; available at www.jpeds.com). According to normative data for ImPACT version 2.0, total PCSS scores 6 for boys and 8 for girls are in the normal classification range. The frequency and percentage of ISI scores that were consistent with a sleep disorder (ISI 8) for male and female subjects was not significant ($p = 0.60$) (Table IV; available at www.jpeds.com).

Females

Among females, our univariate model showed a significant interaction between total CSI score and time on PCSS score, $p < 0.001$. After exploring the relationship graphically, we were concerned that there might be a nonlinear relationship between raw CSI and PCSS scores. Because there were no guidelines for how to categorize CSI, CSI was divided into four quartiles to explore further the association between CSI scores and PCSS change over time (Table V; available at www.jpeds.com).

CSI quartiles, time, and the interaction between CSI quartiles and time from concussion, all had significant associations with PCSS in the model ($p < 0.001$, $p < 0.001$ and $p = 0.038$, respectively). The changes in PCSS over time by CSI quartiles are shown in Figure 1.

Because there was a significant interaction effect between CSI quartiles and time, we further stratified the female data by CSI quartiles and time. This allowed us to run two distinct,

stratified univariate analyses. In the first stratified univariate analysis, we analyzed time as a predictor of PCSS separately within each of the four CSI quartiles. PCSS decreased significantly from week 0 to week 2 within all four CSI quartiles and also decreased significantly from week 2 to week 4 in both the second (total CSI scores: 3–5) and the highest CSI quartile (total CSI scores: 13+). In the second stratified univariate analysis, we analyzed CSI quartiles as a predictor of PCSS separately within each time point. PCSS scores for females with CSI scores 13+ were significantly higher than scores for females in each of the other 3 CSI quartiles at each time point (Table VI).

The other predictors evaluated, including loss of consciousness, retrograde or post traumatic amnesia, history of prior concussions, history of migraines, age, and total ISI score, did not show a significant association with PCSS over time in females, and thus precluded the need for multivariable analysis beyond our exploration of CSI quartiles and time.

Males

In the male model univariate analysis, in addition to total CSI score, a history of retrograde or post traumatic amnesia and the total ISI score had significant relationships with total PCSS score over time, with p-values of 0.012, 0.050 and 0.003, respectively. None of these variables showed a significant interaction with time. In the multivariable analysis, a non-significant trend indicating that total CSI score was associated with PCSS score over time was supported, $B = 0.41$ (95% CI: -0.14 – 0.84) per unit of CSI, $p = 0.058$. Other predictors in the model remained significantly associated with PCSS over time. For the time effect, PCSS decreased significantly from week 0 to week 4, overall $p < 0.001$. The adjusted effects were as follows: from week 0 to week 2, $B = -14.8$ (95% confidence interval [CI]: -19.39 , -10.20), from week 0 to week 4, $B = -18.2$ (95% CI: -22.19 , -14.25), from week 2 to week 4, $B = -3.4$ (95% CI: -0.38 , -6.48), with $p < 0.001$, $p < 0.001$ and $p = 0.028$, respectively. Patients who had a history of retrograde or post-traumatic amnesia ($B = 7.7$, 95% CI: 1.34 , 14.07 , $p = 0.018$), as well as patients with higher total ISI score ($B = 0.9$, 95% CI: 0.15 , 1.68 , $p = 0.019$), exhibited increased PCSS over time.

Individual male CSI quartiles were also assessed and did not show a significant association with PCSS score over time (Figure 2).

DISCUSSION

Overall, our sample was consistent with previous studies on prolonged concussion symptoms: 39% of our subjects met criteria for a concussion by symptoms at 2 weeks and 27% met criteria at 4 weeks, with a higher percentage of females showing concussion symptoms at the 4-week interval compared with males.

As we hypothesized, our GEE model indicated that the somatization estimate (CSI score), had a significant positive relationship with total concussion symptoms score (PCSS) and time for females and statistical trend for males. Notably there appeared to be a high-risk cohort of females with high somatization scores who behaved differently from the rest of the cohort. While females with CSI scores less than 13 had PCSS scores within the normal range at 4 weeks, and those with CSI scores 13 and above had persistent concussion

symptoms at both 2 and 4 weeks. In a population cohort of non-concussed individuals, Janssens et al reported that females were more likely than males to report persistent functional somatic symptoms with the Youth Self-Report and Child Behavior Checklist. That observation is consistent with our findings in a selected cohort of females with concussion. Our study links somatization as a possible explanation for the higher concussion symptom scores and longer recovery times reported for females in the literature.²⁹ Patients, in particular female patients with a history of high somatization, may benefit from early screening post-concussion and targeted therapy to reduce school absenteeism and social problems, which may contribute to prolonged recovery.

In the univariate analysis of our male cohort, we found that CSI had a significant positive relationship with total PCSS and a trend towards significance in our multivariable analysis. It is possible that in a larger study our multivariable data trend may become significant. Interestingly, we did not find the same relationship within the individual male quartiles of CSI and PCSS and time as we did in the female cohort. Most males had PCSS scores within the normal range at 4 weeks regardless of their initial level of somatization. The effect of somatization following concussion in males may be muted; when interpreting somatization scores, clinicians should consider sex differences as they may influence the effect of somatization on concussion recovery. Indeed, research in adult populations has shown that women report more frequent bodily symptoms than men and that sex differences in symptom reporting and pain sensitivity may start in childhood.³⁰

Previous authors have suggested that psychological factors contribute more to post concussive symptoms over time than physiologic factors.³¹ It is possible that somatization may be related to mood disorders, and delays in recovery may be associated with overlap of subjective somatization symptoms and feelings of depression. Additionally, noxious experiences are known to precondition an individual to experience subsequent noxious stimuli with heightened sensitivity.³² Consequently, patients who report a history of somatization may be more in touch with their sensory input and more highly aware of their subjective symptoms.

Historically, acute concussions have been managed with rest due to concerns for reinjury. Recent research, however, has shown recommendations of rest after initial concussion diagnosis may increase symptom reporting. Assessing somatization at initial diagnosis may be critical to guide aggressive management in this population at high risk for prolonged recovery and a debilitating course.

We found that a history of insomnia (assessed by ISI) and a retrograde or post-traumatic amnesia was related to PCSS over time in males, but not in females. In adults, higher global disability has been associated with increasing insomnia post-traumatic brain injury. Sleep disorders in children after traumatic brain injury have been associated with poor functional outcomes.³³ Recent research has found athletes with pre-injury sleep difficulties are more symptomatic at baseline³⁴ and during the post-concussive period. Our data support the relationship of pre-injury sleep disorder and prolonged post-concussive symptoms in a sport and non-sport concussed population.

Our study has limitations. We recruited a sample of 120 patients; seven patients (5.8%) were lost to follow up at two weeks and 16 patients (13.3%) were lost to follow up at 4 weeks. The limited sample size up may not have allowed us to detect associations between other factors, such as history of concussions and concussion severity, with prolonged concussion symptoms. While we had a higher percentage of males in the study, concussions are known to be more prevalent in the male sex and our study population included 48 females, 40% of our subjects.

Division of our CSI quartiles was data-driven; however, to our knowledge there is no previous literature on thresholds and cut-offs for the CSI inventory, which necessitated an arbitrary cutoff to examine whether the relationship between PCSS and CSI was nonlinear. Furthermore, dividing CSI scores into categories is more practical and clinically relevant than a continuous score. It is possible, however, that CSI quartile cut-off points may be different in a larger sample size.

In our study, subjects rated their somatization symptoms over the previous two weeks after a recent concussion diagnosis. It is possible that assessment of somatization symptoms may not be accurate during an acute concussion. To mitigate, we excluded patients with GCS scores < 14, so patients did not have a significant alteration of mental status at time of somatization assessment.

No baseline concussive symptom score was available and thus, normative data were used to determine post-concussion symptom scoring in both the normal and recovered classification. Additionally, although clinical recommendations for concussion management are made in the emergency department, compliance cannot be known with certainty. However, patients were given standardized and current concussion instructions to help mitigate this limitation. Lastly, we did not specifically track how many patients declined to participate in the study. By looking through patient medical history we were able to screen out patients who met or did not meet our inclusion and exclusion criteria, so most patients approached agreed to participate. For future studies it will necessary to track patients who opted not to participate to confirm we did not have a selection bias for our subject population.

Multiple psychological and physiological factors have been shown to contribute to a prolonged concussion syndrome. There may be a specific female cohort with very high somatization at high risk for prolonged recovery from concussion symptoms. A history of somatization may be an important symptom to assess during concussion diagnosis to help guide management and encourage focused therapy in patient populations at high risk for prolonged recovery. In addition, future research on concussions should consider somatization as an important confounding variable, particularly in regard to explaining reported sex differences in concussion symptoms and recovery. Additional research, including neurocognitive testing, may assist in determining if patients with high levels of somatization demonstrate a measured delay in recovery from neuronal injury, or if their prolonged recovery is a reflection of symptom perception and reporting.

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Abbreviations

PCSS	Post-Concussion Symptoms Scale
CSI	Children's Somatization Inventory
ISI	Insomnia Severity Index

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Figure 1. Female PCSS Scores Over 4 Weeks by CSI Quartiles

Females with CSI scores at 13 and above started with high PCSS scores and remained with persistently high scores – consistent with a prolonged concussion—at both 2 and 4 week follow up. (Abnormal PCSS: > 8 for females)

Figure 2. Male PCSS Scores Over 4 Weeks by CSI Quartiles

At four week follow up, most of the males from all four CSI quartiles had PCSS scores within the normal range. (Abnormal PCSS: > 6 for males)

Table 1**Children's Somatization Inventory (CSI) 24**

Headaches
Feeling faint or dizzy
Pain in your heart or chest
Feeling low in energy/slowed down
Pains in your lower back
Sore muscles
Trouble getting your breath (when you're not exercising)
Hot or cold spells
Numbness or tingling in parts of your body
Feeling weak in parts of your body
Heavy feelings in arms or legs (feeling like your arms or legs weigh a lot)
Nausea (feeling like you might throw up or having an upset stomach)
Constipation (when it's hard to have a BM or go poop)
Loose/runny bowel movements or diarrhea
Pain in your stomach or abdomen (tummy aches)
Your heart beating too fast (even when you're not exercising)
Difficulty swallowing
Losing your voice
Blurry vision
Vomiting or throwing up
Feeling bloated or gassy
Food making you sick
Pain in your knees, elbows or other joints
Pain in your arms or legs

rated symptoms of the CSI-24

Table 2

Demographic Data

Participants, N	Total, 120	Male Count (% within Sex)*	Female Count (% within Sex)*
Age, in years (IQR)	13.6 (11.5, 15.8)		
Male, <i>n</i> (%)	72 (60.0)		
Mechanism of Injury, <i>n</i> (%)			
Sports Related	68 (56.7)		
Fall	32 (26.7)		
Other	14 (11.7)		
MVA, occupant	3 (2.5)		
Biker, fall	2 (1.7)		
Assault	1 (0.8)		
MVA, pedestrian			
Biker, vs car			
Loss of consciousness, <i>n</i> (%)	36 (30)	24 (33.3)	12 (25.0)
Retrograde or Post-Traumatic Amnesia, <i>n</i> (%)	34 (28.3)	21 (29.2)	13 (27.1)
History of Prior Concussions, <i>n</i> (%)	34 (28.3)	24 (33.3)	10 (20.8)
History of migraines, chronic headaches, <i>n</i> (%)	24 (20)	2 (2.8)	2 (4.2)

* % within sex: 24 of 72 males (33.3%) had LOC compared to 12 of 48 females (25.0%)

IQR, interquartile range, MVA, motor vehicle accident

Table 3

PCSS Scores at Diagnosis, 2-Week, and 4-Week Follow Up

At Diagnosis	Male N (%)	Female N (%)	Total N (%)
Normal (PCSS ≤6 for males, ≤8 for females)	10 (13.9)	5 (10.4)	15 (12.5)
Abnormal (PCSS > 6 for males, > 8 for females)	62 (86.1)	43 (89.6)	105 (87.5)
2-Week Follow Up			
Normal (PCSS ≤6 for males, ≤8 for females)	39 (59.1)	27 (57.4)	66 (58.4)
Abnormal (PCSS > 6 for males, > 8 for females)	27 (40.9)	20 (42.6)	47 (41.6)
<i>Lost to Follow Up</i>	<i>6 (8.3)</i>	<i>1 (2.1)</i>	<i>7 (5.8)</i>
4-Week Follow Up			
Normal (PCSS ≤6 for males, ≤8 for females)	48 (73.8)	24 (61.5)	72 (69.2)
Abnormal (PCSS > 6 for males, > 8 for females)	17 (26.2)	15 (38.5)	32 (30.8)
<i>Lost to Follow Up</i>	<i>7 (9.7)</i>	<i>9 (18.8)</i>	<i>16 (13.3)</i>

PCSS, post-concussion symptoms scale

Table 4

ISI Scores at Diagnosis

	Male N (%)	Female N (%)	Total N (%)
Normal (ISI 0-7)	54 (75.0)	38 (79.2)	92 (76.7)
Sleep Disorder (ISI 8+)	18 (25.0)	10 (20.8)	28 (23.3)

ISI, insomnia severity index;

Table 5

CSI Frequency by Quartiles and Sex

Females		
CSI Score	Frequency	Percent
<=2	14	29.2
3–5	10	20.8
6–12	10	20.8
13+	14	29.2
Total	48	100

Males		
CSI Score	Frequency	Percent
<=2	24	33.3
3–5	19	26.4
6–12	13	18.1
13+	16	22.2
Total	72	100

CSI, Children's Somatization Inventory

Table 6

Female CSI quartiles as a Predictor of PCSS Within Each Time Point

	CSI Quartiles	B	95% CI of B	P value (compared to CSI 13+)
week 0	CSI <=2	-32.786	-47.32, -18.25	<0.001
	CSI 3-5	-29.343	-46.55, -12.14	<0.001
	CSI 6-12	-32.843	-47.08, -18.60	<0.001
	CSI 13+	-	-	-
week 2	CSI <=2	-41.071	-57.96, -24.19	<0.001
	CSI 3-5	-26.651	-48.14, -5.17	0.015
	CSI 6-12	-36.029	-53.02, -19.04	<0.001
	CSI 13+	-	-	-
week 4	CSI <=2	-32.889	-47.50, -18.27	<0.001
	CSI 3-5	-30.167	-46.30, -14.03	<0.001
	CSI 6-12	-32.567	-46.90, -18.23	<0.001
	CSI 13+	-	-	-

CSI, Children's Somatization Inventory