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Initial somatic symptoms are associated with prolonged symptom duration following concussion in adolescents

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Abstract

Aim—To determine which initial postinjury symptom domains are independently associated with symptoms lasting >28 days in youth athletes who sustained sport-related concussions.

Methods—Patients who presented for care at a sport concussion clinic completed the postconcussion symptom scale. They were classified into two groups: those who reported symptom resolution within 28 days of injury and those who did not. Logistic regression models were constructed for children and adolescents to determine the independent association between symptom recovery and potential predictor variables: initial symptom scores in 5 postconcussion symptom scale domains (somatic, vestibular–ocular, cognitive, sleep and emotional), sex, loss of consciousness or amnesia at the time of injury, history of prior concussion, prior treatment for headaches or migraines, or family history of concussion.

Results—Sixty-eight child (8–12 years of age) and 250 adolescent (13–18 years of age) athletes were included. For adolescents, initial somatic symptom severity was independently associated with prolonged symptom duration (adjusted odds ratio = 1.162; 95% CI: 1.060, 1.275) and no

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Dr. Meehan receives royalties from ABC-CLIO publishing for the sale of his book, *Kids, Sports, and Concussion: A guide for coaches and parents*, and royalties from Wolters Kluwer for working as an author for *UpToDate*. He is under contract with ABC-CLIO publishing for a future book entitled, *Concussions*, and with Springer International publishing for a future book entitled, *Head and Neck Injuries in Young Athletes*. His research is funded, in part, by a grant from the National Football League Players Association and by philanthropic support from the National Hockey League Alumni Association through the Corey C. Griffin Pro-Am Tournament. Dr. O'Brien receives royalties from Wolters Kluwer for working as an author for *UpToDate*. He is under contract with Springer International publishing for a book entitled, *Head and Neck Injuries in Young Athletes*.

CONFLICT OF INTERESTS STATEMENT

Drs. Howell, Beasley and Mannix have no conflict of interests to report.

other predictor variables were. No potential predictor variables were independently associated with prolonged symptom duration for children.

Conclusion—Among adolescent athletes, a high initial somatic symptom burden (e.g. headache, nausea, vomiting, etc.) is associated with increased odds of symptoms beyond 28 days postinjury.

Keywords

Brain injury; Sports; Symptom questionnaire; Symptoms and traumatic brain injury

INTRODUCTION

Concussions account for 8.9% of injuries sustained by high school athletes and 5.8% of all injuries sustained by collegiate athletes in the United States (1), thus comprising a large number of total injuries during sports. While most athletes will no longer report concussion-related symptoms after 4 weeks postinjury, a small percentage will continue to report symptoms beyond this time (2). The factors contributing to the risk of developing prolonged and persistent symptoms after concussion remain poorly understood, making effective treatment and management strategies challenging for healthcare providers.

The ability to identify factors associated with longer symptom duration soon after injury can help to guide clinicians making decisions about initiating therapy, assist with anticipatory guidance, and help patients prepare for difficulties at work and school caused by their symptoms (3). Factors such as loss of consciousness at the time of injury (4), amnesia at the time of injury (4), post-traumatic migraine (5), anthropometric characteristics (6) or previous concussion history (7) have been identified as risk factors for developing persistent postconcussion symptoms in prior studies. Symptom burden upon initial clinical examination is a predictor of prolonged symptom duration (8), but it is unknown whether this risk is due to the overall sum of all symptoms or due to specific symptoms evaluated within a symptom inventory. Although symptom rating scales comprised of a 22 symptom inventory are commonly employed (9), the presence of certain symptoms acutely postinjury may be associated with the risk of prolonged recovery. Pardini and colleagues were among the first to identify, via an exploratory factor analysis, four distinct domains in a group of athletes with concussion: cognitive, sleep, emotional and somatic (10). Subsequently, others have used other versions of symptom domains to identify whether specific symptoms following concussion are associated with prolonged recovery (11).

One highly feasible method to document injury severity and track subsequent recovery is through symptom inventories such as the Post-Concussion Symptom Scale (PCSS), a reliable scale for adolescents and young adults (12). Dividing the PCSS into specific domains can help determine whether certain symptom domains are more strongly associated with prolonged symptom duration than others. Such information might be used for refining symptom inventories, focusing clinical histories or guiding management decisions. Thus, the objective of this study was to examine the association between symptom severity upon initial examination in 5 distinct domains and prolonged symptom resolution among children between the ages of 8–12 years and adolescents between the ages of 13–18 years who sustained sport-related concussions. In order to complete this objective, we conducted a

subanalysis of previously prospectively collected data (8) to determine the association between each symptom domain and prolonged symptom duration.

PATIENTS AND METHODS

Participants and design

The participants in this study were comprised of patients who presented to the sport concussion clinic of a tertiary care regional children's hospital between 1 October 2009 and 31 July 2011. Following their injury, patients could self-present to the clinic or were referred from an emergency department or their regular healthcare provider. Those who sustained a concussion during sports or by a mechanism involving forces similar to sports, such as falling from ground level or being injured during recreational activities, were included in the study. Patients with more severe injury mechanisms, such as falling from a height or sustaining motor vehicle collisions, were excluded. Furthermore, patients were excluded if they did not have complete medical records, did not report any concussion symptoms during the initial examination, were being considered for an alternate diagnosis at the time of assessment, did not have a reliable date of symptom resolution, had an abnormal acute trauma-related computed tomography result or were not examined within the first 21 days after injury.

All patients included in the study were diagnosed with a concussion by a sports medicine physician during their first postinjury clinical examination, which occurred 1–21 days after the concussion. We defined concussion according to the definition provided by the International Consensus on Concussion in Sports: a brain injury caused by a direct blow to the head, face, neck or elsewhere on the body, resulting in the rapid onset of impairment of neurological function (9). Therefore, those patients who experienced trauma to the head resulting in the onset of signs and symptoms included in PCSS were diagnosed with concussion. This study was approved by the institutional review board. All participants and parents/guardians (if under the age of 18 years) provided written informed consent to participate in the study.

During the initial examination, standardised forms were completed, documenting demographic information and clinical information. Symptoms were assessed for all patients using the PCSS, a standardised 22-symptom inventory adapted from the Standardized Concussion Assessment Tool, version 2 (9). This scale asks patients to rate each symptom on a scale which ranges from 0 (asymptomatic) to 6 (maximum severity). As some patients without a concussion may endorse symptoms included on the PCSS, participants were instructed to only rate those symptoms that started at the time of injury and that they had experienced within the prior 24 hours of the clinical examination. Patients then completed the PCSS at each subsequent clinical visit. Symptom-free was defined as a PCSS score of 0. If patients no longer endorsed any symptom, they documented the last day they experienced any concussion-related symptoms. The length of time between the date of concussion and the last date they experienced symptoms was then calculated to determine symptom duration time. If necessary, parents were available to assist with concussion symptom ratings or other survey questions for younger patients.

The sum of symptom severity scores was calculated from 5 separate domains (Table 1). Among adolescent athletes, concussion recovery perception is largely based on somatic symptoms such as headache, nausea or photosensitivity (13). Although previous studies have used four symptom domains (13–16), we chose to analyse 5 separate domains in order to include vestibular–ocular symptoms as a separate entity. Recent evidence has supported the notion that vestibular–ocular abnormalities may be associated with worse outcomes or prolonged recovery following concussion (17,18). Thus, we hypothesised that self-reported vestibular–ocular symptoms would have an independent association with the risk of prolonged symptom duration.

Participants were divided into two groups: those who reported symptom resolution within 28 days postconcussion and those whose symptoms persisted for longer than 28 days. This cut-off date was chosen as the majority of athletes who sustain a sport-related concussion will report symptom resolution within 28 days of injury (2), and because if symptoms persist beyond this timeframe, management strategy changes may occur.

To investigate the association between initial symptom burden domains and prolonged symptom duration in different age groups, we constructed two separate logistic regression models: (i) for children between the ages of 8 and 12 years and (ii) for adolescents between the ages of 13 and 18 years. We chose to use two separate logistic regression models based on age group due to current guidelines which suggest the use of alternate concussion assessment tools for children 12 years of age and younger (9,19). Possible predictive variables were the total symptom score on each of the five identified symptom domains (Table 1) obtained at the initial clinical examination and the following variables, which have been previously associated with prolonged recovery from concussion: age, sex, number of prior diagnosed concussions, loss of consciousness at the time of injury, amnesia at the time of injury, prior treatment for headaches, prior treatment for migraines or family history of concussion (4,16,20–24).

Statistical analysis

Continuous variables are presented as means $\pm$ SD and compared using Student's t-test for normally distributed data, while non-normally distributed data are presented as medians, interquartile range (IQR) and compared using Mann–Whitney U-tests. Categorical variables are presented as percentages and were assessed using Fisher's exact test. Potential predictor variables were compared between those who reported symptoms for longer than 28 days and those who did not. Variables that appeared different between the two groups with a statistical probability of $p < 0.20$ were identified as potential predictors and placed into logistic regression models.

Prior to performing logistic regression analyses, collinearity was assessed using condition indices and corresponding variance inflation factors. A condition index >30 was determined to require individual collinearity assessments, which were performed using variance inflation factors. Collinearity between two variables was detected with a variance inflation factor >2.5 (25,26). Statistical significance was defined as a p-value of <0.05 or, for binary logistic regression analyses, an adjusted odds ratio (aOR) with a 95% confidence interval

(CI) that did not contain one. Statistical analyses were performed with Statistical Package for the Social Sciences (SPSS version 23, IBM Inc., Armonk, NY, USA).

RESULTS

A total of 1,050 individuals received care in the sports concussion clinic during the study period and completed questionnaires. Of those, 732 were excluded: 468 because they did not report to the clinic within 21 days of injury, 64 because they were older than 18 years, and 200 because the date of symptom resolution was not obtained. Thus, a total of 318 individuals were included in the current study. Among these, 68 were children (range = 8–12 years) and 250 were adolescents (range = 13–18 years). The PCSS score obtained during the first clinical examination was higher among those who did not have a symptom resolution date (median = 28.5, IQR = 9.3, 44.0) than patients included in the study with a reliable symptom resolution date (median = 13.0, IQR = 3.0, 32.0; $p < 0.001$). No other demographic or clinical characteristics were identified between these two groups.

For the cohort of participants, the median age was 14.7 (IQR = 12.9, 16.2), the median time to presentation in the clinic after injury was 12.0 (IQR = 8.0, 17.0) days postinjury, and the median initial total PCSS score was 17.0 (IQR = 4.0, 38.0). Females represented a significantly higher proportion of adolescent patients than they did of paediatric patients (Table 2). The most common sports in which patients were injured included: ice hockey (21%), American football (20%), soccer (13%) and basketball (13%). Among the different predictor variables for the child age group, age was significantly collinear with emotional, somatic, cognitive and sleep domain scores, and thus removed from the model. Significant collinearity was not detected among the different predictor variables for the adolescent age group.

Each of the five initial symptom domain scores met criteria for inclusion in the logistic regression model for children (Table 3). Prior treatment for headaches and a prior history of migraines were also identified as potential predictors, but the low number of observations of these variables prohibited their inclusion in the model (Table 3). All 5 initial symptom domain scores met criteria for inclusion in the logistic regression model for adolescents, along with amnesia at the time of injury and the number of prior concussions sustained (Table 4). After adjusting for the effect of all included variables in a regression model, no independent association between any predictor variables and prolonged symptom duration was found for children 8–12 years of age (Table 5). Among adolescents, however, initial somatic symptom severity was independently associated with prolonged symptom duration (Table 5) even after adjusting for the effect of all included variables in the model. No other potential predictor variables demonstrated a significant independent association with prolonged symptom duration for adolescents.

DISCUSSION

Initial somatic symptoms are independently associated with symptom duration among adolescents who have sustained sport-related concussions. Our data suggest that, among the symptom domains, somatic symptoms may be the best predictor of prolonged symptom

duration after concussions sustained by adolescents. Clinicians should be particularly aware of adolescent patients who report a high somatic symptom severity upon initial examination, as they may have an increased risk of developing persistent symptoms.

Our findings build upon prior work that demonstrates an association between initial symptom burden and prolonged symptom duration following concussion (8). Somatic symptoms, however, were the only domain associated with prolonged symptom duration among adolescents in our study. Previously, others have used symptom domain assessments to ascertain the likelihood that an individual may go on to develop persistent symptoms. The migraine domain, similar to the somatic domain used in our study, has been categorised as the strongest contributor to the development of protracted recovery (14). However, the study defined protracted recovery as a time of >14 days postinjury to receive clearance to return to play (14), which differed from our symptom resolution time cut-off of >28 days postinjury. Headache is the most common symptom following concussion with 86% of athletes report experiencing a headache after concussion (27). Headache is also the most frequently reported symptom in children with prolonged concussion symptoms, and the initial presence of a headache is associated with an increased risk of the presence of symptoms 3 months postinjury (6). As headache is one of the symptoms rated in the somatic symptom domain, initial presence of headache as an indicator of injury severity may be useful in the prognosis of adolescents during the initial examination. Clinician awareness of headache severity may assist in the recognition of those at elevated risk for persistent symptoms and help in implementation of management strategies to reduce this burden (6). While the reason for this apparent association between somatic symptoms and prolonged symptom duration is unclear, it may be that adolescents are able to perceive the physical signs and symptoms of concussion (e.g. headache, head pressure, photosensitivity, etc.) to a greater degree than cognitive or balance dysfunction (13). Additionally, headache may be more apparent acutely following concussion than cognitive or balance dysfunction as environments where such deficits may be noticed most, such as school or sports, are typically restricted following injury (9).

Among children, however, none of the symptom domains were significantly associated with prolonged symptom duration. Recently, the International Consensus Statement on Concussion in Sport has recommended a different version of symptom rating for this age group, as athletes younger than 13 years may report the symptoms of a concussion differently than adolescents or adults (9). Children under the age of 13 in our study rated their symptoms using the original symptom inventory used for older athletes. Thus, the lack of association between somatic symptom score and prolonged symptoms in the younger patients may be attributable, in part, to the use of a scale meant for older athletes. It may be, however, that initial somatic symptom severity is less predictive in younger populations. Future research should seek to validate the child symptom rating scale to increase understanding of its role in predicting the likelihood of persistent symptoms following concussion, and to identify the role of parental input.

Our study differed from previous investigations (10,11) as we separated vestibular–ocular symptoms into a separate domain to examine whether initial self-reported balance problems/dizziness, vision problems or hearing problems were associated with prolonged symptom

duration. As children who present with vestibular abnormalities take longer to return to school or sports than those without vestibular abnormalities (17), we hypothesised that self-reported vestibular–ocular symptoms at initial presentation may be associated with prolonged symptom resolution. The lack of any significant association, however, indicates that vestibular–ocular symptoms are less predictive of prolonged symptom duration than somatic symptoms in adolescents. Furthermore, as balance control deficits can outlast symptom duration in adolescents (23,28), it may be difficult for athletes to accurately perceive their recovery of vestibular–ocular functions due to the subtle nature of these impairments following concussion (13). The advantage to identification of these deficits following concussion is that targeted therapeutic interventions may be employed earlier in the course of treatment (29), potentially decreasing the time required to achieve symptom resolution.

Findings from this study must be viewed in the light of their limitations. All participants in the study reported to a specialty concussion clinic and likely represent a different cohort than the general population of athletes that sustain concussions, thus limiting the generalisability of our results. Furthermore, neurocognitive and balance assessments were not used to determine recovery from concussion, instead using symptom resolution time as a method to determine recovery. Although such tests provide a valuable addition to the postconcussion examinations, symptom inventories represent a way to assess concussion recovery which many healthcare professionals use to make management decisions. In addition, balance assessments and neurocognitive assessments are only measured at clinic visits. Thus, we have no way of knowing the precise date at which these functions returned to baseline; we only know whether they were back to baseline by the time of the next clinic visit. Although we found no independent association between symptom domain scores and symptom duration among child athletes, there were significantly less ($N = 68$) included in the study than adolescents. A larger number of participants may have allowed for detection of a smaller effect. Finally, the PCSS was significantly lower in those patients who were included in the study with a reliable date of symptom resolution compared to those excluded due to the lack of such data, potentially resulting in a selection bias of those included in our study.

In conclusion, in a cohort of adolescent athletes, initial somatic symptoms were independently associated with prolonged symptom duration; no such association was observed among child athletes. These findings suggest that, particularly among adolescent athletes, a high initial somatic symptom burden may be more predictive of an increased risk of persistent symptoms beyond 28 days postinjury than other symptom domains.

Abbreviations

PCSS	Post-Concussion Symptom Scale
aOR	adjusted Odds Ratio

References

1. Gessel LM, Fields SK, Collins CL, Dick RW, Comstock RD. Concussions among United States high school and collegiate athletes. *J Athl Train*. 2007; 42:495–503. [PubMed: 18174937]

2. Meehan WP 3rd, d'Hemecourt P, Collins CL, Comstock RD. Assessment and management of sport-related concussions in United States high schools. *Am J Sports Med.* 2011; 39:2304–10. [PubMed: 21969181]
3. Grubenhoff JA, Deakyne SJ, Comstock RD, Kirkwood MW, Bajaj L. Outpatient follow-up and return to school after emergency department evaluation among children with persistent post-concussion symptoms. *Brain Inj.* 2015; 29:1186–91.
4. McCrea M, Guskiewicz K, Randolph C, Barr WB, Hammeke TA, Marshall SW, et al. Incidence, clinical course, and predictors of prolonged recovery time following sport-related concussion in high school and college athletes. *J Int Neuropsychol Soc.* 2013; 19:22–33. [PubMed: 23058235]
5. Kontos AP, Elbin RJ, Lau B, Simensky S, Freund B, French J, et al. Posttraumatic migraine as a predictor of recovery and cognitive impairment after sport-related concussion. *Am J Sports Med.* 2013; 41:1497–504. [PubMed: 23698389]
6. Babcock L, Byczkowski T, Wade SL, Ho M, Mookerjee S, Bazarian JJ. Predicting postconcussion syndrome after mild traumatic brain injury in children and adolescents who present to the emergency department. *JAMA Pediatr.* 2013; 167:156–61. [PubMed: 23247384]
7. Tator CH, Davis H. The postconcussion syndrome in sports and recreation: clinical features and demography in 138 athletes. *Neurosurgery.* 2014; 75(Suppl 4):S106–12.
8. Meehan WP, Mannix RC, Monuteaux MC, Stein CJ, Bachur RG. Early symptom burden predicts recovery after sport-related concussion. *Neurology.* 2014; 83:2204–10. [PubMed: 25381296]
9. McCrory P, Meeuwisse WH, Aubry M, Cantu RC, Dvořák J, Echemendia RJ, et al. Consensus statement on concussion in sport: the 4th International Conference on Concussion in Sport, Zurich, November 2012. *J Athl Train.* 2013; 48:554–75. [PubMed: 23855364]
10. Pardini D, Stump J, Lovell M, Collins M, Moritz K, Fu F. The Post Concussion Symptom Scale (PCSS): a factor analysis. *Br J Sports Med.* 2004; 38:661–2.
11. Lau BC, Kontos AP, Collins MW, Mucha A, Lovell MR. Which on-field signs/symptoms predict protracted recovery from sport-related concussion among high school football players? *Am J Sports Med.* 2011; 39:2311–18. [PubMed: 21712482]
12. Lovell MR, Iverson GL, Collins MW, Podell K, Johnston KM, Pardini D, et al. Measurement of symptoms following sports-related concussion: reliability and normative data for the post-concussion scale. *Appl Neuropsychol.* 2006; 13:166–74. [PubMed: 17361669]
13. Sandel NK, Lovell MR, Kegel NE, Collins MW, Kontos AP. The relationship of symptoms and neurocognitive performance to perceived recovery from sports-related concussion among adolescent Athletes. *Appl Neuropsychol Child.* 2013; 2:64–9. [PubMed: 23427778]
14. Lau BC, Collins MW, Lovell MR. Sensitivity and specificity of subacute computerized neurocognitive testing and symptom evaluation in predicting outcomes after sports-related concussion. *Am J Sports Med.* 2011; 39:1209–16. [PubMed: 21285444]
15. Merritt VC, Arnett PA. Premorbid predictors of postconcussion symptoms in collegiate athletes. *J Clin Exp Neuropsychol.* 2014; 36:1098–111. [PubMed: 25493542]
16. Morgan CD, Zuckerman SL, Lee YM, King L, Beaird S, Sills AK, et al. Predictors of postconcussion syndrome after sports-related concussion in young athletes: a matched case-control study. *J Neurosurg Pediatr.* 2015; 15:589–98. [PubMed: 25745949]
17. Corwin DJ, Wiebe DJ, Zonfrillo MR, Grady MF, Robinson RL, Goodman AM, et al. Vestibular Deficits following Youth Concussion. *J Pediatr.* 2015; 166:1221–5. [PubMed: 25748568]
18. Mucha A, Collins MW, Elbin RJ, Furman JM, Troutman-Enseki C, DeWolf RM, et al. A Brief Vestibular/Ocular Motor Screening (VOMS) assessment to evaluate concussions: preliminary findings. *Am J Sports Med.* 2014; 42:2479–86. [PubMed: 25106780]
19. Guskiewicz KM, Register-Mihalik J, McCrory P, McCrea M, Johnston K, Makdissi M, et al. Evidence-based approach to revising the SCAT2: introducing the SCAT3. *Br J Sports Med.* 2013; 47:289–93. [PubMed: 23479486]
20. Collins MW, Iverson GL, Lovell MR, McKeag DB, Norwig J, Maroon J. On-field predictors of neuropsychological and symptom deficit following sports-related concussion. *Clin J Sport Med.* 2003; 13:222–9. [PubMed: 12855924]

21. Covassin T, Elbin RJ, Harris W, Parker T, Kontos A. The role of age and sex in symptoms, neurocognitive performance, and postural stability in athletes after concussion. *Am J Sports Med.* 2012; 40:1303–12. [PubMed: 22539534]
22. Gordon KE, Dooley JM, Wood EP. Is migraine a risk factor for the development of concussion? *Br J Sports Med.* 2006; 40:184–5. [PubMed: 16432009]
23. Howell DR, Osternig LR, Chou L-S. Adolescents demonstrate greater gait balance control deficits after concussion than young adults. *Am J Sports Med.* 2015; 43:625–32. [PubMed: 25540297]
24. McCrea M, Guskiewicz KM, Marshall SW, Barr W, Randolph C, Cantu RC, et al. Acute effects and recovery time following concussion in collegiate football players: the NCAA concussion study. *JAMA.* 2003; 290:2556–63. [PubMed: 14625332]
25. Simon, L. Detecting multicollinearity using variance inflation factors. 2015. Available at: <https://onlinecourses.science.psu.edu/stat501/node/347> (accessed on March 4, 2015)
26. Meehan WP, Mannix RC, Straccioli A, Elbin RJ, Collins MW. Symptom severity predicts prolonged recovery after sport-related concussion, but age and amnesia do not. *J Pediatr.* 2013; 163:721–5. [PubMed: 23628374]
27. Guskiewicz KM, Weaver NL, Padua DA, Garrett WE. Epidemiology of concussion in collegiate and high school football players. *Am J Sports Med.* 2000; 28:643–50. [PubMed: 11032218]
28. Howell DR, Osternig LR, Chou L-S. Dual-task effect on gait balance control in adolescents with concussion. *Arch Phys Med Rehabil.* 2013; 94:1513–20. [PubMed: 23643687]
29. Ciuffreda KJ, Rutner D, Kapoor N, Suchoff IB, Craig S, Han ME. Vision therapy for oculomotor dysfunctions in acquired brain injury: a retrospective analysis. *Optometry.* 2008; 79:18–22. [PubMed: 18156092]

Key notes

- Upon initial examination, higher somatic symptoms, but no other symptom domains were associated with prolonged symptom duration in adolescent athletes while controlling for potential confounding variables.
- Among child athletes, no single symptom domain was associated with prolonged symptom duration.
- The finding that initial somatic symptom severity is associated with prolonged symptom duration can help guide clinical decision-making in the acute management of sport-related concussion.

Table 1

The 5 symptom domains assessed as a part of the Post-Concussion Symptom Scale (PCSS)

Somatic symptoms (Range = 0–36)	Headache
	Pressure in head
	Neck pain
	Nausea or vomiting
	Sensitivity to light
	Sensitivity to noise
Vestibular–ocular symptoms (Range = 0–18)	Vision problems
	Hearing problems/ringing
	Balance problems or dizziness
Cognitive symptoms (Range = 0–30)	Do not feel right
	Confusion
	Feeling like ‘in a fog’
	Difficulty concentrating
	Difficulty remembering
Sleep symptoms (Range = 0–24)	Feeling slowed down
	Drowsiness
	Fatigue or low energy
	Trouble falling asleep
Emotional symptoms (Range = 0–24)	More emotional than usual
	Irritable
	Sadness
	Nervous or anxious

Table 2

Demographic characteristics and clinical visit data for each of the age groups. Continuous variables are presented as medians (IQR); categorical variables are presented as N (%)

Variable	Children (Age 8–12, n = 68)	Adolescents (Age 13–18, n = 250)
Age (Years)	11.7 (IQR = 10.6, 12.1)	15.2 (IQR = 14.2, 16.8)
Sex (Females)	14 (21%)	94 (38%)
Initial visit		
Days Since Injury	12.0 (IQR = 8.0, 16.0)	12.0 (IQR = 8.0, 17.0)
Total PCSS Score	13.0 (IQR = 4.3, 30.5)	20.0 (IQR = 7.0, 41.0)
First follow-up visit		
Days Since Injury	30.0 (IQR = 22.0, 37.0)	30.5 (IQR = 23.0, 39.8)
Total PCSS Score	0.0 (IQR = 0.0, 4.0)	1.0 (IQR = 0.0, 10.0)

Table 3

Univariate comparisons of potential predictor variables for the child age group (8–12 years old)

Predictor variable	Patients with symptoms 28 days (n = 47)	Patients with symptoms >28 days (n = 21)	p value
Continuous variables: median (Interquartile range)			
Initial somatic symptom score *	1.0 (0.0–7.0)	8.0 (3.0–14.0)	0.001
Initial vestibular–ocular symptom score *	0.0 (0.0–1.0)	1.0 (0.0–3.0)	0.004
Initial cognitive symptom score *	1.0 (0.0–3.0)	5.0 (1.0–8.0)	0.005
Initial sleep symptom score *	1.0 (0.0–6.0)	5.0 (2.5–14.0)	0.004
Initial emotional symptom score *	0.0 (0.0–1.0)	1.0 (0.0–5.0)	0.013
Age *	11.3 (9.9–11.9)	11.8 (11.3–12.1)	0.045
Prior concussions	0.0 (0.0–1.0)	0.0 (0.0–0.5)	0.523
Categorical variables: n (%)			
Female sex	9 (20)	5 (24)	0.751
Loss of consciousness at time of injury	14 (33)	8 (42)	0.568
Amnesia at time of injury	15 (33)	8 (40)	0.779
Prior treatment for headache *	4 (9)	6 (29)	0.058
Prior treatment for migraine *	2 (4)	5 (24)	0.025
Family history of concussion	18 (38)	9 (43)	0.792

* Potential predictor variables included in the logistic regression model ($p < 0.20$).

Table 4

Univariate comparisons of potential predictor variables for the adolescent age group (13–18 years old)

Predictor variable	Patients with symptoms 28 days (n = 163)	Patients with symptoms >28 days (n = 87)	p value
Continuous variables: median (Interquartile range)			
Initial somatic symptom score *	2.0 (0.0–6.0)	11.0 (7.0–17.0)	<0.001
Initial vestibular–ocular symptom score *	0.0 (0.0–1.0)	2.0 (1.0–4.0)	<0.001
Initial cognitive symptom score *	0.0 (0.0–4.0)	8.0 (4.0–14.0)	<0.001
Initial sleep symptom score *	1.0 (0.0–5.0)	7.0 (3.0–12.0)	<0.001
Initial emotional symptom score *	0.0 (0.0–1.0)	2.0 (0.0–6.0)	<0.001
Age	15.2 (14.2–16.6)	15.2 (14.1–16.9)	0.464
Prior concussions *	1.0 (0.0–1.0)	0.0 (0.0–1.0)	0.003
Categorical variables: n (%)			
Female sex	59 (36)	35 (40)	0.585
Loss of consciousness at time of injury	30 (18)	17 (20)	0.866
Amnesia at time of injury *	53 (33)	36 (41)	0.169
Prior treatment for headache	20 (12)	9 (10)	0.836
Prior treatment for migraine	16 (10)	7 (8)	0.819
Family history of concussion	69 (42)	37 (43)	0.999

* Potential predictor variables included in the logistic regression model ($p < 0.20$).

Table 5

Results for the logistic regression model performed for the child and adolescent age groups

	aOR*	95% CI Lower	95% CI Upper
Child age group			
Initial somatic symptoms	1.068	0.905	1.260
Initial vestibular–ocular symptoms	0.897	0.666	1.208
Initial cognitive symptoms	0.903	0.710	1.149
Initial sleep symptoms	1.183	0.992	1.410
Initial emotional symptoms	1.086	0.833	1.416
Adolescent age group			
Initial somatic symptom score [†]	1.162	1.060	1.275
Initial vestibular–ocular symptom score	0.950	0.775	1.164
Initial cognitive symptom score	1.035	0.941	1.139
Initial sleep symptom score	0.965	0.869	1.073
Initial emotional symptom score	1.031	0.925	1.150
Number of prior concussions	0.921	0.704	1.206
Amnesia at time of injury	1.012	0.538	1.902

* aOR represents the difference in odds per point of the given variable.

[†] 95% confidence interval (CI) does not include 1.