Concussion-Symptom Rating Correlation Between Pediatric Patients and Their Parents

Tatiana Patsimas, MD*; David R. Howell, PhD, ATC†‡; Morgan N. Potter, BA‡; Aaron J. Provance, MD†‡; Michael W. Kirkwood, PhD§||; Julie C. Wilson, MD*†‡

Departments of *Pediatrics, †Orthopedics, and §Physical Medicine and Rehabilitation, University of Colorado School of Medicine, Aurora; ‡Sports Medicine Center and ||Rehabilitation Medicine, Children’s Hospital Colorado, Aurora

Context: Understanding how parents and their children perceive concussion symptoms may provide insights into optimal concussion-management strategies.

Objective: To examine patient-parent correlations and agreement on concussion-symptom ratings, to identify differences in patient-parent symptom reporting between children (8–12 years of age) and adolescents (13–18 years of age), and to evaluate the correlation between patient and parent initial symptom-severity ratings with symptom duration and return-to-play time.

Design: Cross-sectional study.

Setting: Primary care sports medicine clinic.

Patients or Other Participants: A total of 267 patients aged 8 to 18 years seen for care within 21 days of sustaining a concussion. Patients were classified as children (n = 65; age = 11.3 ± 1.4 years; age range, 8–12 years) or adolescents (n = 202; age = 15.5 ± 1.4 years; age range, 13–18 years).

Main Outcome Measure(s): Each patient and his or her parent (or legal guardian) completed a concussion-symptom-frequency inventory, the Health and Behavior Inventory (HBI), at the initial postinjury examination. Patients were followed until they no longer reported concussion symptoms (symptom-resolution time) and were allowed to return to unrestricted sport participation (return-to-play time).

Results: At the initial examination (8.9 ± 5.2 days post-injury), the symptom-frequency correlation between children and their parents was high (r = 0.88; 95% confidence interval [CI] = 0.80, 0.95). Adolescents’ symptom-frequency reports were also highly correlated with those of their parents (r = 0.78; 95% CI = 0.71, 0.85). However, the child-parent correlation was higher than the adolescent-parent agreement (z = 2.21, P = .03). Greater patient (consolidated child and adolescent) HBI ratings were associated with longer symptom-resolution times (coefficient = 0.019; 95% CI = 0.007, 0.031; P = .002) and longer return-to-play times (coefficient = .012; 95% CI = 0.002, 0.022; P = .02), whereas parent HBI ratings were not.

Conclusions: Our findings may help to set expectations regarding concussion-symptom durations and return-to-play timing for pediatric patients and their families. The patient-parent correlations in our sample, substantial reporting discrepancies between patients and their parents may be a relevant factor for clinicians to investigate further during concussion evaluations.

Key Words: adolescence, mild traumatic brain injury, symptom severity, sports

Key Points

- The total Health and Behavior Inventory (HBI) score was highly correlated between patients and their parents, but correlations between children (8–12 years of age) and their parents were greater than between adolescents (13–18 years of age) and their parents.
- Patient-reported HBI scores were associated with symptom durations and return-to-play times, whereas parent-reported HBI scores were not.
- Clinicians may find the evaluation of symptom-reporting similarities or differences between parents and children useful when setting expectations regarding concussion-symptom durations and return-to-play timing for patients and their families.
- During acute concussion evaluations, clinicians may also want to consider large reporting discrepancies between patients and their parents.

Concussion, defined as mild traumatic brain injury inflicted via biomechanical forces, accounts for substantial injury among youth. The authors of an epidemiologic study estimated the incidence of sport- and recreation-related concussions in children and adolescents in the United States to be between 1.1 and 1.9 million annually. Without pathognomonic imaging findings or laboratory tests available, health care professionals who diagnose and treat pediatric patients with concussion rely heavily on self-reported symptom inventories to gauge injury severity and develop management strategies. Although longitudinal research indicated that most youth who sustained concussions did not demonstrate long-term symptoms or neurocognitive impairment, investigators have proposed that children and adolescents are more likely to experience prolonged recovery periods than adults. In the small subset of youth who experienced prolonged symptoms or neurocognitive problems, negative effects on various domains of health-related quality of life have been well described. Therefore, careful
evaluation and monitoring of concussion symptoms are of clinical importance.

Parental involvement may be critical to the overall management of concussion in youth, as parents can monitor the development and resolution of these symptoms on an ongoing basis outside of the health care setting. Additionally, parental attitudes and knowledge have been found to influence their children’s knowledge of concussion and concussion symptoms. Therefore, understanding the agreement between pediatric patients and their parents regarding concussion symptoms may assist providers in developing appropriate treatment plans and managing expectations during recovery. To determine the most problematic symptoms for a patient after a concussion and parental awareness of symptoms, clinicians often assess postconcussion symptoms using validated instruments, such as the Health and Behavior Inventory (HBI). Patient-parent agreement on the HBI has been studied in patients 8 to 15 years of age. These researchers reported modest agreements for postconcussion symptoms, but they did not distinguish agreement by age group (child versus adolescent). Also, agreement between high school athletes and their parents regarding the presence and severity of individual concussion symptoms on the Sport Concussion Assessment Tool 2 has been studied, with agreement varying greatly depending on the specific symptom. Overall, the relationship of reported symptom frequency between pediatric patients and their parents remains equivocal. Therefore, our study had 3 main purposes: (1) to examine patient-parent correlations and agreement on measures of concussion-symptom frequency after pediatric sport-related concussion, (2) to identify differences in patient-parent agreement between children (8–12 years of age) and adolescents (13–18 years of age), and (3) to evaluate the adjusted association of HBI scores with symptom duration and return-to-play (RTP) time. We hypothesized that patient-parent agreement on the HBI would be higher than that reported in similar studies published in 2009 and 2010, given recent heightened public awareness of concussion through multiple legislative efforts and increased concussion reporting among youth. Additionally, we proposed that children would demonstrate stronger agreement with parents than adolescents would, given increased autonomy in adolescence compared with childhood. Finally, we hypothesized that higher HBI scores, whether patient or parent reported, would predict longer symptom duration and RTP time. This hypothesis was based on several studies in which researchers showed that initial postconcussion symptoms were reliably associated with measures of symptom resolution and RTP time.

**METHODS**

**Study Design and Participants**

We analyzed data collected from a prospective clinical registry of patients with concussion seen for care at the Children’s Hospital Colorado Sports Medicine Center between January 1, 2015, and August 31, 2017. Patients were referred for care to this sports medicine clinic from various sources, including local urgent care providers, emergency department providers, athletic trainers, primary care providers, or self-referrals. Overall, 934 patient records were reviewed. Included patients had a diagnosed concussion and were seen for care within 21 days of the injury, were between the ages of 8 and 18 years, and were accompanied by a parent or legal guardian at the initial visit. We excluded patients from our analysis if they had no diagnosis of concussion (n = 7), had a nonsport injury mechanism (n = 229), were seen more than 21 days postconcussion (n = 328), were outside the specified age range (n = 15), had traumatic abnormalities on neuroimaging (n = 2), had incomplete symptom-reporting data (n = 76), or sustained a subsequent concussion before resolution of the initial symptoms (n = 10). After applying these exclusion criteria, our analysis involved 267 patients who were evaluated 8.9 ± 5.2 days postconcussion; 76% (n = 202) were classified as adolescents (age range, 13–18 years), and 72% (n = 192) were male (Table 1). Depending on their clinical needs, patients were followed in the sports medicine clinic until they were cleared for return to sport participation or referred to another specialist for additional care. All concussions were diagnosed by a board-certified pediatric sports medicine physician and defined consistently using the International Consensus Statement on Concussion in Sport. Before we conducted the study, the Colorado Multiple Institutional Review Board of the University of Colorado Denver approved the protocol.

**Clinical Evaluation**

At each clinic visit, patients completed the child’s version of the HBI, a 20-item assessment of concussion symptoms validated in the pediatric population. The number of clinic visits that patients made after the initial visit depended on the clinical needs of each individual. Most (65%, n = 174) completed 2, 18% (n = 48) returned for 3, and 6% (n = 16) required >3 clinic visits. On the HBI, patients rated the frequency of each symptom on a 4-point Likert-type scale: 0 (never), 1 (rarely), 2 (sometimes), or 3 (often). The total HBI score from each patient’s initial visit was then calculated as the sum of all responses, ranging from 0 (no symptoms) to 80 (maximum symptom frequency for all symptoms). The HBI items were also grouped into 2 rating domains: cognitive (11 items) and somatic (9 items). Parents completed the parent version of the HBI, which instructs parents to rate their child’s symptom frequency and is scored in the same way as the patient version.
All patients and their parents completed a set of standardized intake forms during the initial clinical evaluation. These included documentation of any previous concussions and a history of diagnosed attention-deficit/hyperactivity disorder, anxiety, or depression. We also identified the time from injury until the patient no longer reported any concussion symptoms (symptom-resolution time) and the time from injury until the physician cleared the patient to return to unrestricted sport participation (RTP time). This elapsed-time variable was calculated as count data in days from the initial visit.

**Age Classification**

We considered age a continuous variable and calculated the elapsed time (in days) between the patient’s date of concussion and date of birth and then converted days to years by dividing by 365.25. Consistent with the most recent international guidelines on concussion in sport,\(^1\) we grouped patients into age categories with a cutoff of 13 years, so our groups were children aged 8 to 12 years and adolescents aged 13 to 18 years. Those who were less than 13 years of age (eg, 12.5 years of age) were placed in the child age group.

**Statistical Analysis**

Continuous variables are presented as mean ± SD if they were normally distributed or median (interquartile range) if they displayed nonnormal distribution. Categorical variables are presented as the number included and corresponding percentage. We assessed potential differences in symptom-frequency ratings for the total HBI score between patients and their parents using a series of Wilcoxon signed-rank tests. The relationship between patients and their parents was assessed using the Spearman rank-order correlation (r\(s\)). To identify the association of patient and parent ratings with symptom duration and RTP time and to account for the right (positive) skew and count nature of our dependent variables, we used negative binomial regression models. Our predictor variables were child total HBI rating and parent total HBI rating, our outcome variables were symptom duration and RTP time in each respective model, and covariates were sex and time from injury to clinical assessment.

We assessed the correlation of patient and parent HBI ratings for children and adolescents separately using Spearman rank-order correlations. The 95% confidence intervals (CIs) for the estimates were computed by bootstrapping (1000 resamples). We used the following ranges to interpret the clinical value of the patient-parent correlation results: 0.90 to 1.00 (very high), 0.70 to 0.89 (high), 0.50 to 0.69 (moderate), 0.30 to 0.49 (low), and <0.30 (negligible).\(^13\) The correlations (r\(s\) values) between patient and parent ratings were compared between age groups using the Fisher r to z transformation. Bland-Altman plots were then generated to examine agreement, heteroscedasticity, and systematic error between patient and parent HBI ratings.\(^14\) The Bland-Altman plots provided possible systematic deviations, or bias, and 95% limits of agreement. We also assessed the degree of patient-parent disagreement on total HBI score (absolute value difference between the patient and parent HBI ratings) with time to symptom resolution using the Spearman rank-order correlation. The \(\alpha\) level was set at .05. All statistical analyses were performed using Stata (version 15; StataCorp, College Station, TX).

**RESULTS**

Patients reported higher overall, cognitive, and somatic HBI scores than their parents (Table 2). For total HBI score, the correlation between children and their parents was high (r\(s\) = 0.88; 95% CI = 0.80, 0.95; Figure 1). Adolescent scores were also highly correlated with their parents’ scores (r\(s\) = 0.78; 95% CI = 0.71, 0.85; Figure 1). However, patient-parent correlation ratings were higher for the child age group than the adolescent age group (z = 2.21, \(P = .03\); Figure 1). Bland-Altman plots indicated that the average disagreement was 2.7 ± 8.3 HBI score, suggesting some evidence for systematic disagreement between patient and parent HBI ratings, although patients tended to report higher symptom-frequency ratings than their parents (Figure 2).

Negative binomial regression analyses indicated that after covariate adjustment, patient (consolidated child and adolescent group) HBI ratings obtained at the initial postinjury evaluation were associated with symptom-resolution time (coefficient = 0.0188; 95% CI = 0.0067, 0.0309; \(P = .002\)) and RTP time (coefficient = 0.0118; 95% CI = 0.0019, 0.0216; \(P = .02\)), but parent HBI ratings were not (Table 3). This indicated that, if patients were to increase their initial HBI scores by 1 point, the difference in the logs of expected counts would be expected to increase by 0.0188 days for symptom-resolution time and by 0.0118 days for RTP time while holding all other variables in the model constant. The magnitude of patient-parent disagreement and symptom-resolution time demonstrated a low correlation (r\(s\) = 0.37; 95% CI = 0.25, 0.50; \(P < .001\); Figure 3).

**DISCUSSION**

The primary goal of our study was to determine patient-parent correlations for concussion-symptom frequency after pediatric sport-related concussion. Consistent with our hypothesis, our results indicated high correlations between patients and their parents on measures of total concussion-symptom frequency, as well as cognitive- and somatic-symptom frequency. These findings underscored how
Figure 1. Scatterplot and line of best fit (solid line = children, dotted line = adolescents) describing the linear relationship between the patient and parent Health and Behavior Inventory ratings among children aged 8 to 12 years and adolescents aged 13 to 18 years.

Figure 2. Bland-Altman plot for the patient and parent Health and Behavior Inventory ratings.

- \( a \) 95% upper limit of agreement.
- \( b \) Systematic error (mean difference) between the patient and parent ratings.
- \( c \) 95% lower limit of agreement.

Table 3. Association Between Initial Health and Behavior Inventory Ratings for Patients and Parents With Symptom Duration and Return-to-Play Time After Adjusting for Sex and Time From Injury to Clinical Presentation

| Outcome Variable      | Predictor Variable                          | Coefficient | Standard Error | 95% Confidence Interval | \( P \) Value |
|-----------------------|---------------------------------------------|-------------|----------------|-------------------------|--------------|
| Symptom-resolution time | Patient Health and Behavior Inventory rating | 0.0188      | 0.0062         | 0.0067, 0.0309          | .002         |
|                       | Parent Health and Behavior Inventory rating | 0.0109      | 0.0072         | -0.0031, 0.0250         | .13          |
| Return-to-play time   | Patient Health and Behavior Inventory rating | 0.0118      | 0.0050         | 0.0019, 0.0216          | .02          |
|                       | Parent Health and Behavior Inventory rating | 0.0102      | 0.0056         | -0.0006, 0.0211         | .07          |

* Patient Health and Behavior Inventory ratings were associated with symptom-resolution time and return-to-play time \((P < .05)\).
Online First

Parental perspectives may be associated with postconcussion symptoms in children and adolescents. Given this correlation, clinicians may feel confident including parental perspectives in the clinical assessment of concussion and in the long-term monitoring of concussion symptoms. For example, allowing parents to monitor resolution of concussion symptoms at home could lead to fewer office visits for pediatric patients recovering from concussion.

The difference in the strength of correlation noted in our study compared with previous studies is likely multifactorial. Methodologically, in these previous investigations, parents and patients independently completed postconcussion surveys, whereas our patients and parents were not separated and were able to work together (e.g., while in the waiting room), perhaps leading to a higher correlation than previously observed. In addition, our agreement analysis (Bland-Altman) suggested that, although a small mean difference existed between parents and patients, the wide limits of agreement reflected substantial variability between parents and patients in some cases. The difference in the strength of agreement may have also been partially attributable to increased public awareness of the prevalence of concussion in the pediatric population through substantial media attention and legislative efforts.

Since the publication of the aforementioned studies on HBI agreement, concussion laws have been passed in all 50 states and Washington, DC, and athletes of all ages are now more likely to report concussions than they were a decade ago. Increased communication between young athletes and their coaches or parents may also explain the overall improvement in patient-parent agreement noted in our study relative to similar investigations published in the past decade. Furthermore, the analytic approaches varied between our study and previous work (e.g., Spearman correlations and Bland-Altman analysis versus κ coefficients), potentially also leading to different observations.

The second goal of our study was to identify differences in patient-parent correlation between the child and adolescent age groups. As hypothesized, we found better patient-parent correlation among children than among their adolescent counterparts. This result may be due to a variety of factors, including decreased time spent by parents and their children in child care activities as children grow older or increased autonomy in adolescence compared with childhood. Therefore, clinicians may need to pay particular attention to adolescents to ensure accurate symptom reporting, as this is a time of rapid brain maturation and patients may be particularly vulnerable to prolonged recovery of concussion symptoms.

In addition to the high patient-parent correlation, we also found a low correlation between the magnitude of difference between parents and patients with prolonged symptom-recovery time. Therefore, substantial discrepancies on the HBI may also be a relevant factor for clinicians to consider during acute concussion evaluations. Large patient-parent differences regarding concussion symptoms could be secondary to symptom masking or minimization by the patient, perhaps in an attempt to remain active with the team. Large discrepancies between parents and patients should also encourage the clinician to evaluate parental and patient knowledge of concussion symptoms more closely, as an apparent difference could point to a need for increased education. Finally, a large difference in symptom reports may reflect undercommunication between patients and parents regarding recovery status after sport-related concussion.

The third goal of our study was to evaluate the adjusted association between HBI scores and symptom duration, as well as RTP time. Projecting the timing of concussion recovery is important, but it is often difficult and frustrating for families and clinicians, as symptom types and durations can vary widely. Researchers have found that the initial symptom burden is the factor most consistently

Figure 3. The linear association between absolute patient-parent disagreements for overall Health and Behavior Inventory rating assessed at the initial clinical visit and time to symptom resolution.
associated with symptom duration and recovery time. We also demonstrated a relationship that was different between initial HBI score and both symptom duration and RTP time. Although the clinical meaningfulness of this relationship may be small, this association may prove useful to clinicians when providing concussion education and anticipatory guidance, in addition to an estimated time for recovery.

Based on our results, collecting HBI scores from both patients and parents at the initial concussion clinic visit has clinical value. Given that we found high correlations between patients and their caregivers, disagreement among patients and their parents on the HBI may prompt a clinician to investigate reasons for disagreement, provide additional concussion education, or request closer follow-up with the patient. However, if the patient is feeling poorly and is unable to complete the symptom inventory at the initial visit, based on our results, parental report may be a reasonable method of obtaining symptom ratings.

We acknowledge several limitations to our study. We did not control for the manner in which patients and parents answered the HBI as previous researchers\(^{10-12}\) have done, and some families may have completed the symptom rating scales together, which could have artificially inflated the strength of correlation we observed between patients and their parents. As such, our data may have been susceptible to systematic bias. Furthermore, all patients and parents who participated in the study sought care from a specialty concussion sports medicine clinic. Therefore, our findings may not be generalizable to patients who seek care from other points of care in the health care system. Finally, our initial examination findings were cross-sectional and obtained as part of a clinical registry rather than a prospective cohort study.

CONCLUSIONS

We observed a high correlation between patients and their parents on total HBI score, although the correlations between children and their parents were greater than correlations between adolescents and their parents. Additionally, patient-reported HBI scores were associated with symptom duration and RTP time, whereas parent-reported HBI scores were not. Clinicians may find these relationships useful when setting expectations regarding concussion-symptom duration and RTP timing for patients and their families. Substantial reporting discrepancies between patients and their parents may also be a relevant factor for clinicians to consider during evaluations of patients with acute concussions.

ACKNOWLEDGMENTS

Dr Howell receives research support not related to this study from the Eunice Kennedy Shriver National Institute of Child Health & Human Development grant R03HD094560 and the National Institute of Neurological Disorders and Stroke grants R01NS100952 and R41NS103698.

REFERENCES

1. McCrory P, Meeuwisse W, Dvorak J, et al. Consensus statement on concussion in sport—the 5th International Conference on Concussion in Sport held in Berlin, October 2016. Br J Sports Med. 2017;51(11):838–847.
2. Bryant MA, Rowhani-Rahbar A, Comstock RD, Rivara F; Seattle Sports Concussion Research Collaborative. Sports- and recreation-related concussions in US youth. Pediatrics. 2016;138(1):e20154635.
3. Halstead ME, Walter KD, Moffatt K; Council on Sports Medicine and Fitness. Sport-related concussion in children and adolescents. Pediatrics. 2018;142(6):e20183074.
4. Babikian T, Satz P, Zaucha K, Light R, Lewis RS, Asarnow RF. The UCLA longitudinal study of neurocognitive outcomes following mild pediatric traumatic brain injury. J Int Neuropsychol Soc. 2011;17(5):886–895.
5. Committee on Sports-Related Concussions in Youth; Board on Children, Youth, and Families; Institute of Medicine; National Research Council; Graham R, Rivara FP, Ford MA, Spicer CM, eds. Sports-Related Concussions in Youth: Improving the Science. Changing the Culture. Washington, DC: National Academies Press; 2014.
6. Valovich McLeod TC, Wagner AJ, Bacon CE. Lived experiences of adolescent athletes following sport-related concussion. Orthop J Sports Med. 2017;5(12):2325967171774503.
7. Howell DR, Wilson JC, Kirkwood MW, Grubenhoff JA. Quality of life and symptom burden one month after concussion in children and adolescents. Clin Pediatr. 2019;58(1):42–49.
8. Stein CJ, MacDougall R, Quatman-Yates CC, et al. Young athletes’ concerns about sport-related concussion: the patient’s perspective. Clin J Sport Med. 2016;26(5):386–390.
9. Hajek CA, Yeates KO, Taylor HG, et al. Agreement between parents and children on ratings of post-concussive symptoms following mild traumatic brain injury. Child Neuropsychol. 2010;17(1):17–33.
10. Ayr LK, Yeates KO, Taylor HG. Brown M. Dimensions of postconcussive symptoms in children with mild traumatic brain injuries. J Int Neuropsychol Soc. 2009;15(1):19–30.
11. Rowhani-Rahbar A, Chrisman SP, Drescher S, Schiff MA, Rivara FP. Agreement between high school athletes and their parents on reporting athletic events and concussion symptoms. J Neurotrauma. 2016;33(8):784–791.
12. Gibson TB, Herring SA, Kutcher JS, Broglio SP. Analyzing the effect of state legislation on health care utilization for children with concussion. JAMA Pediatr. 2015;169(2):163–168.
13. LaRoche AA, Nelson LD, Connelly PK, Walter KD, McCrea MA. Sport-related concussion reporting and state legislative effects. Clin J Sport Med. 2016;26(1):33–39.
14. Wray-Lake L, Crouter AC, McHale SM. Developmental patterns in decision-making autonomy across middle childhood and adolescence: European American parents’ perspectives. Child Dev. 2010;81(2):636–651.
15. Heyer GL, Schaffer CE, Rose SC, Young JA, McNally KA, Fischer AN. Specific factors influence postconcussion symptom duration among youth referred to a sports concussion clinic. J Pediatr. 2016;174:33–38.e2.
16. Meehan WP III, Mannix RC, Monuteaux MJ, Stein CJ, Bachur RG. Early symptom burden predicts recovery after sport-related concussion. Neurology. 2014;83(24):2204–2210.
17. Meehan WP III, Mannix RC, Stracciolini A, Elbin RJ, Collins MW. Symptom severity predicts prolonged recovery after sport-related concussion, but age and amnesia do not. J Pediatr. 2013;163(3):721–725.
18. Iverson GL, Gardner AJ, Terry DP, et al. Predictors of clinical recovery from concussion: a systematic review. Br J Sports Med. 2017;51(12):941–948.
19. Mukaka MM. Statistics corner: a guide to appropriate use of correlation coefficient in medical research. Malawi Med J. 2012;24(3):69–71.
20. Bland JM, Altman DG. Statistical methods for assessing agreement between two methods of clinical measurement. Lancet. 1986;327(8476):307–310.
21. Zick CD, Bryant WK. A new look at parents’ time spent in child care: primary and secondary time use. *Soc Sci Res*. 1996;25(3):260–280.

22. Zemek R, Barrowman N, Freedman SB, et al; Pediatric Emergency Research Canada (PERC) Concussion Team. Clinical risk score for persistent postconcussion symptoms among children with acute concussion in the ED. *JAMA*. 2016;315(10):1014–1025.

23. Chrisman SP, Quitiquit C, Rivara FP. Qualitative study of barriers to concussive symptom reporting in high school athletics. *J Adolesc Health*. 2013;2(3):330–335.

24. Kirkwood MW, Peterson RL, Connery AK, Baker DA, Grubenhoff JA. Postconcussive symptom exaggeration after pediatric mild traumatic brain injury. *Pediatrics*. 2014;133(4):643–650.

Address correspondence to David R. Howell, PhD, ATC, Sports Medicine Center, Children’s Hospital Colorado, 13123 East 16th Avenue, B060 Aurora, CO 80045. Address e-mail to David.Howell@ucdenver.edu.