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Concussion-Like Symptoms in Child and Youth Athletes at Baseline: What Is "Typical"?

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Context: After a concussion, guidelines emphasize that an athlete should be asymptomatic before starting a return-to-play protocol. However, many concussion symptoms are nonspecific and may be present in individuals without concussion. Limited evidence exists regarding the presence of "typical" or preinjury (baseline) symptoms in child and youth athletes.

Objective: To describe the frequency of symptoms reported at baseline by child and youth athletes and identify how age, sex, history of concussion, and learning factors influence the presence of baseline symptoms.

Design: Cross-sectional cohort study.

Setting: Baseline testing was conducted at a hospital research laboratory or in a sport or school setting (eg, gym or arena).

Patients or Other Participants: A total of 888 child (9–12 years old, n = 333) and youth (13–17 years old, n = 555) athletes participated (46.4% boys and 53.6% girls, average age = 13.09 ± 1.83 years).

Main Outcome Measure(s): Demographic and symptom data were collected as part of a baseline protocol. Age-appropriate versions of the Post-Concussion Symptom Inventory (a self-report concussion-symptoms measure with strong psychometric properties for pediatric populations) were administered. Demographic data (age, sex, concussion history, learning factors) were also collected.

Results: Common baseline symptoms for children were feeling sleepier than usual (30% boys, 24% girls) and feeling nervous or worried (17% boys, 25% girls). Fatigue was reported by more than half of the youth group (50% boys, 67% girls). Nervousness was reported by 32% of youth girls. Headaches, drowsiness, and difficulty concentrating were each reported by 25% of youth boys and girls. For youths, a higher total symptom score was associated with increasing age and number of previous concussions, although these effects were small (age $r_s = 0.143$, number of concussions $r_s = .084$). No significant relationships were found in the child group.

Conclusions: Children and youths commonly experienced symptoms at baseline, including fatigue and nervousness. Whether clinicians should expect complete symptom resolution after concussion is not clear.

Key Words: brain injuries, pediatrics, symptoms, baseline testing

Key Points

- Up to 67% of healthy child and youth athletes experienced mild to moderate symptoms at baseline, including fatigue, nervousness, and drowsiness.
- In youths, more symptoms were reported with increasing age and number of previous concussions.
- In the absence of preinjury baseline data, complete symptom resolution after concussion should not necessarily be expected, particularly regarding fatigue-related symptoms.

Concussion is defined as "a complex pathophysiologic process affecting the brain, induced by traumatic biomechanical forces."[1] Concussion is a considerable public health concern in children and youths, with conservative estimated incidences of 754 and 440 per 100 000 boys and girls, respectively.[2] Symptom assessment is an important part of clinical evaluation and is integral in guiding decision making for the ongoing management of patients with concussion.[3,4] Expert consensus is that return to play can be initiated when an athlete is asymptomatic or when symptoms and other cognitive and physical measures have either resolved or returned to baseline levels.[1,5,6] Currently available normative values for baseline tests have been derived from adult, collegiate, or high school populations,[4,7–9] making comparisons problematic for children and younger youths. Understanding the differential presentations of preinjury baseline symptoms in children and youth athletes may enhance concussion management.

Pediatric concussion-management guidelines[5] suggest that care providers consider preseason baseline assessment for youth athletes in high-risk sports. Baseline assessment may include computerized neurocognitive assessment (eg, ImPACT; ImPACT Applications Inc, Pittsburgh, PA)[6] and measures of physical function (eg, balance, coordination).[10] After concussion, these measures are readministered and self-reported symptoms are collected and compared with preinjury scores to guide decision making regarding return to activity (eg, school or sport).[3,4,6,7] Scales to quantify subjective symptom reporting have been developed to help clinicians detect and monitor the presence of changes in symptoms and are often used as part of the preseason baseline assessment for athletes.[4,6,7] However, not all children and youths have completed baseline assessments, and care providers may not always have access to baseline-test results.

Self-report measures created specifically for the child and youth population were designed to offer a developmentally sensitive approach to concussion assessment.[3,11] Cognitive skills, reading levels, vocabulary, sense of time, familiarity with symptom language, and social-emotional maturity are developmental factors that vary in children and youths and may affect how they respond to symptom-reporting scales.[3,11] The Post-Concussion Symptom Inventory (PCSI),[3,11] a self-report concussion-symptoms measure with strong psychometric properties,[11] was created to address these developmental factors. Specific versions of the PCSI are available for age groups that span 5 to 18 years. Authors of a psychometric study[11] of the PCSI provided data on a normative sample of healthy children and youths, but this sample was not athlete specific. In healthy youths ages 13 to 18 years, the most commonly reported symptoms at baseline were fatigue (35%), difficulty falling asleep (27%), drowsiness (26%), headache (24%), nervousness (24%), and difficulty concentrating (23%). For younger children (ages 8–12 years), the highest percentages of self-reported baseline symptoms were fatigue (45%), headache (34%), numbness or tingling (34%), irritability (33%), nervousness (31%), drowsiness (30%), nausea (25%), and difficulty falling asleep (27%). Sex differences in symptoms were not reported in this study. These results suggest that symptoms were present preinjury in a considerable number of healthy children and youths from a sample population that was not athlete specific. How child and youth athletes' baseline symptoms compare with this normative sample is not known.

Understanding baseline characteristics for child and youth athletes is important given that youths involved in organized sports are nearly 6 times more likely to experience a concussion with loss of consciousness than those involved in other physical activities.[12] In collegiate athletes, evidence indicates that normative baseline symptom data can be used to provide accurate comparisons when individual baseline data are unavailable.[13] However, data specific to child and youth athletes are lacking. Athletes have unique activity demands that may influence physical, cognitive, emotional, and fatigue symptoms. Participation in physical activity, for example, has positive effects on neurocognitive functions.[14–16] A better understanding is needed of how demographic and health history factors, such as age, sex, concussion history, and the presence of learning-related variables (eg, attention-deficit disorder), affect symptom reporting at baseline in child and youth athletes.

Emerging research has identified sex differences in the presence and nature of concussion-like symptoms at baseline in youth and collegiate athletes. A recent systematic review and meta-analysis[17] of concussion-like symptoms at baseline indicated that females (ages 12–26 years) were 43% more likely than males to report any symptom associated with concussion. Further, females had greater odds than males of reporting baseline symptoms of headache; problems with concentration, vision, hearing, or sleep; reduced energy; and emotional symptoms.[17] Lovell et al[4] observed no difference in total baseline symptom scores between high school and university students on the Post-Concussion Scale but did find that females reported more symptoms than males in both age groups. In another study,[18] investigators using ImPACT to measure baseline symptom reporting in elite youth athletes also noted that adolescent girls reported more symptoms than boys at baseline. Snyder et al[19] demonstrated similar findings using the Sport Concussion Assessment Tool 2 (SCAT2) in their sample of 761 children and youths ages 9 to 18 years. Explanations for these differences include hormone variations,[17] differences between sexes in willingness to disclose symptoms,[20,21] and limited utility of measures for younger children.[22]

Age and a history of previous concussion affect symptom reporting at baseline. McKay et al[18] described a higher level of baseline symptoms on ImPACT in older (16–17 years) athletes than in younger ones (13–15 years). Brooks et al[23] found that youth athletes with a history of 2 or more previous concussions had more symptoms at baseline on the ImPACT than those without such a history. However, little information is available that is specific to younger athletes (ie, ages 12 years and under) or addresses other symptom-report measures.

Learning problems and developmental factors were associated with greater baseline symptom reports in a study[24] of more than 6000 high school athletes. However, the relationship between preinjury baseline symptom reports and learning-related factors in younger athletes has not been examined.

In the absence of preinjury baseline data, understanding what is typical for youth athletes on baseline symptom measures may contribute to the ability of care providers to manage recovery in this unique population. Therefore, the purpose of our study was to characterize baseline symptom reporting in child and youth athletes. Specific objectives were to (1) describe symptoms reported at baseline according to age and sex on the PCSI and (2) explore the influence of age, sex, concussion history, and learning-related variables (eg, learning disability) on self-reported symptoms.

METHODS

Study Design

Baseline data were collected as part of a prospective cross-sectional cohort study of child and youth athletes. We obtained approval from all necessary institutional ethics boards. Participants aged 16 years and older provided informed consent; younger participants and their parents provided assent and consent, respectively.

Participants

A convenience sample of 901 child and youth athletes was recruited from local community, school, and sports organizations. Data from 888 participants were analyzed. Thirteen participants were excluded due to invalid PCSI data because they failed to complete the instrument or completed the incorrect version. Participants were to be excluded from the baseline study if they did not speak and read English fluently or had any significant developmental delay or neurologic impairment. However, no participants were excluded for these reasons.

Measures

Two primary measures were used to collect data for the purposes of this study. One measure was the PCSI.[17] The PCSI is a symptom-assessment scale designed to determine postconcussion symptoms in pediatric populations. Developmental differences in children and youths are taken into account via different versions of the scale for different age groups. The versions designed for younger children offer simplified vocabulary and response scales and ask fewer questions related to sleep. We administered 2 versions: a 17-item version of the PCSI-SR8 (PCSI-C) was used for children ages 9 to 12 years and a 22-item version of the PCSI-SR13 (PCSI) was used for youths ages 13 to 17 years. The PCSI-C asks children to rate the presence of symptoms on a 3-point scale (0 = *symptom not present*, 1 = *a little*, and 2 = *a lot*). The PCSI has a 7-point rating scale ranging from 0 to 6 (0 = *not a problem*, 3 = *somewhat of a problem*, and 6 = *severe problem*).

The second measure, a study-specific demographic form, was used to collect personal information about participants (ie, general health; academic and health histories; and learning-related factors, including involvement in speech therapy or special education, diagnosed learning disability, or attention-deficit or attention-deficit/hyperactivity disorder) and previous concussion history. We also gathered data regarding the type and competition level of the primary sport played.

Procedures

After informed consents and assents were obtained, participants took part in a preinjury baseline testing protocol that consisted of measures of physical and cognitive function and PCSI administration.[10] Testing occurred at either a hospital-based concussion research center or the participant's school or sports arena. A consistent team of trained assessors with backgrounds in rehabilitation or kinesiology or both conducted the testing in all settings. Demographic information was collected by the assessor during an initial face-to-face individual interview with each participant. The age-appropriate version of the PCSI was administered as part of the baseline testing protocol.[10] Although most participants were able to complete the test independently, assessors were available to assist as needed. For questions relating to health, previous concussion, and learning-related factors, participants were asked if they were ever told by a health care or educational professional that they had condition X (ie, previously diagnosed concussion, learning disability, attention-deficit or attention-deficit/hyperactivity disorder).

Statistical Analyses

Descriptive statistics (eg, frequencies) were used to describe demographic data and participant responses to individual questions on the PCSI or PCSI-C and at baseline, according to age group and sex. Because this was a preinjury baseline study, we anticipated that most participants would report minimal if any symptoms. Accordingly, we expected that the distribution of the total PCSI scores would be positively skewed. Descriptive analyses were also conducted to illustrate the non-normally distributed outcomes.

Table 1. Participant Demographics

Variable	Group, Version of Post-Concussion Symptom Inventory (PCSI): Ages 9–12, 17-Item Version of PCSI-SR8 (n = 333)	Ages 13–18, 22-Item Version of PCSI-SR13 (n = 555)
Demographics		
Age, y (mean ± SD)	11.19 ± 0.86	14.27 ± 1.23
Sex, % (n)		
Males	50.8 (169)	43.8 (243)
Females	49.2 (164)	56.2 (312)
Learning-related factors, % (n)		
Learning disability	4.2 (14)	4.9 (27)
Attention-deficit or attention-deficit/hyperactivity disorder	3 (10)	3.2 (18)
Speech therapy	10.2 (34)	8.8 (49)
Special education	8.4 (28)	6.5 (36)
Concussion history, % (n)		
History of previous concussion	16.8 (56)	30.6 (170)
Previous concussions		
1	15 (50)	19.5 (108)
2	0.3 (1)	6.3 (35)
3	1.5 (5)	4 (22)
4	0 (0)	0.9 (5)

As a result of the skewed distribution of the data, nonparametric univariate analyses were conducted to identify relationships between self-reported symptoms at baseline (total PCSI-C or PCSI score) and other variables (age, sex, number of previous concussions, and learning variables). To identify symptom clusters, we grouped PCSI scores according to physical, cognitive, emotional, and fatigue domains. Self-reported scores at baseline were also analyzed according to each domain score. Nonparametric analyses were conducted separately for the child and youth age groups due to the differences in scales and item scoring for each PCSI version. The independent variables were age, sex, history of previous concussion (*yes*/*no*), and number of previous concussions. Dichotomous variables (*yes*/*no*) representing the presence of learning disabilities, participation in speech therapy or special education, and attention-deficit disorders were included in the initial analyses. Independent-samples Mann-Whitney *U* tests were used to investigate the relationship between a dichotomous predictor (ie, sex [*male*/*female*], history of concussion [*yes*/*no*], and total PCSI score). Spearman ρ correlations were used to investigate the association between continuous variables (eg, age and number of previous concussions) and total PCSI score. The statistical threshold for significance was set at $P \leq .05$. All analyses were conducted using SPSS (version 22; IBM Corp, Armonk, NY).

RESULTS

Participants were 888 child (n = 333) and youth (n = 555) athletes, ages 9 to 17 years (mean = 13.09 ± 1.83 years; 46.4% boys and 53.6% girls). Demographic results are reported in Table 1, and descriptive analyses of the data are presented in Table 2. Although all participants were athletes, 85.7% played at the elite level (eg, competitive

Table 2. Total Post-Concussion Symptom Inventory Symptom Score By Sex, Age, and Concussion History in Uninjured Child and Youth Athletes

Variable	n	Mean[a]	Median[a]	SD[a]	Range[a]	Skew[a]	Kurtosis[a]
Child group							
Sex							
Males	169	1.79	1	2.46	0–13	1.77	3.30
Females	164	1.45	1	2.09	0–11	2.13	4.91
Age, y							
9	13	0.92	1	0.76	0–2	0.14	–1.50
10	59	1.64	1	2.27	0–8	1.49	1.32
11	112	1.62	0.5	2.56	0–11	2.27	5.66
12	149	1.68	1	2.18	0–9	1.61	2.18
Concussion history?							
Yes	56	2.39	1	3.28	0–13	1.55	1.56
No	274	1.46	1	2.01	0–11	1.76	3.18
Previous concussions, No.	56	2.39	1	3.28	0–13	1.55	1.56
1	50	2.28	1	3.20	0–13	1.71	2.33
2	1	1	1	N/A	N/A	N/A	N/A
3	5	2.75	1.5	3.59	0–8	1.70	3.01
Youth group							
Sex							
Males	241	5.08	2	7.67	0–44	2.77	8.72
Females	310	5.45	3	6.37	0–43	2.36	7.89
Age, y							
13	190	4.06	2	5.09	0–35	2.27	10.87
14	160	5.48	3	8.43	0–44	2.97	9.45
15	107	5.69	3	6.90	0–38	2.02	5.13
16	64	6.06	3.5	6.29	0–31	1.56	3.23
17	29	9.17	5	8.67	0–28	0.99	–0.03
Concussion history?							
Yes	167	6.35	3	8.15	0–44	2.29	6.19
No	384	4.82	3	6.33	0–40	2.74	9.90
Previous concussions, No.							
1	108	5.32	3	6.52	0–37	2.24	6.35
2	34	7.71	3	10.68	0–43	1.94	3.44
3	20	8.1	4.5	10.40	0–44	2.37	7.05
4	5	12.2	11	7.98	3–25	1.07	2.48

Abbreviation: N/A, not applicable.

[a] Statistics based on total Post-Concussion Symptom Inventory score.

travel teams). The remaining 14.3% played sports at a house-league or recreational level. The majority of participants (64%) stated that ice hockey was their primary sport, followed by soccer (14%). The remaining athletes were active in other team (eg, basketball, volleyball, baseball) and individual (eg, cross-country, tennis, skiing, swimming) sports. A history of at least 1 previous concussion (as diagnosed by a physician) was reported by 17% (n = 56) of children ages 9 to 12 years and 30% (n = 167) of youth ages 13 to 17 years. In the younger age group, less than 2% (n = 6) reported 2 or more previous concussions in contrast to 11% (n = 62) in the older group.

Self-reported symptoms at baseline according to age and sex are provided in Table 3 (ages 9–12 years) and Table 4 (ages 13–17 years). Symptoms according to symptom domain are shown in Table 5. The most frequently reported symptoms (ie, a score of at least 1, indicating *a little*) by boys in the child group were feeling sleepier than usual (30%), more tired than usual (25%), and nervous or worried (17%). Girls between the ages of 9 and 12 reported feeling nervous or worried (26%), sleepier than usual (23%), and more tired than usual (16%). Headaches were reported by 10% of both boys and girls. With respect to symptoms that were not frequently reported, boys between the ages of 9 and 12 years gave scores of 0 (*not a problem*) most often for balance (97%), sensitivity to noise (96%), and blurry vision (96%). For girls in the child group, balance also received the most frequent score of 0 (99%), followed by sensitivity to light and noise and feeling slowed down (96% each).

In the youth group, boys between the ages of 13 and 17 identified fatigue (50%), drowsiness (30%), headache (24%), difficulty concentrating (24%), and nervousness (20%). Youth girls reported fatigue (66%), nervousness (32%), headache (28%), difficulty concentrating (23%), and drowsiness (22%). Fatigue ratings of 3, indicating *somewhat of a problem*, were reported by 8.6% of youth boys and 11.2% of youth girls. Scores of 0 (*not a problem*) were reported most frequently by boys for feeling more emotional (95%), balance problems (94%), double/blurry

Table 3. Frequencies of Self-Reported Symptoms on the 17-Item Post-Concussion Symptom Inventory-SR8 at Baseline in Uninjured Child Athletes (9–12 Years Old) by Sex

Symptom	Sex (n)	17-Item Post-Concussion Symptom Inventory-SR8 Score, % (n)		
		0 = *Not Present*	1 = *A Little*	2 = *A Lot*
Headache[a]	Males (169)	89.9 (152)	10.1 (17)	0 (0)
	Females (164)	89.6 (147)	10.4 (17)	0 (0)
Nausea[a]	Males (169)	91.7 (155)	7.7 (13)	0.6 (1)
	Females (164)	95.1 (156)	4.9 (8)	0 (0)
Dizziness[a]	Males (169)	94.1 (159)	5.9 (10)	0 (0)
	Females (163)	96.3 (158)	3.0 (5)	0 (0)
Grumpy[b]	Males (169)	94.1 (159)	4.7 (8)	1.2 (2)
	Females (164)	93.3 (153)	6.7 (11)	0 (0)
Hard to pay attention[c]	Males (169)	85.8 (145)	12.4 (21)	1.8 (3)
	Females (164)	87.8 (144)	11.6 (19)	0.6 (1)
Sleepier than usual[d]	Males (169)	69.8 (118)	26.6 (45)	3.6 (6)
	Females (164)	76.8 (126)	22.6 (37)	0.6 (1)
Sensitivity to light[a]	Males (169)	94.7 (160)	5.3 (9)	0 (0)
	Females (164)	96.3 (158)	3.7 (6)	0 (0)
Sensitivity to noise[a]	Males (169)	95.9 (162)	3.6 (6)	0.6 (1)
	Females (164)	96.3 (158)	3.7 (6)	0 (0)
Balance problems[a]	Males (169)	97.0 (164)	2.4 (4)	0.6 (1)
	Females (164)	98.8 (162)	1.2 (2)	0 (0)
Feeling sad[b]	Males (169)	94.1 (159)	5.9 (10)	0 (0)
	Females (164)	95.1 (156)	4.3 (7)	0.6 (1)
Feeling nervous or worried[b]	Males (169)	82.8 (140)	17.2 (29)	0 (0)
	Females (164)	74.4 (122)	23.8 (39)	1.8 (3)
Feeling slowed down (moving)[a]	Males (169)	91.7 (155)	8.3 (14)	0 (0)
	Females (164)	96.3 (158)	3.7 (6)	0 (0)
Feeling slowed down (thinking)[c]	Males (168)	90.5 (153)	7.7 (13)	1.2 (2)
	Females (162)	91.5 (150)	7.3 (12)	0 (0)
Hard to think clearly[c]	Males (169)	94.7 (160)	5.3 (9)	0 (0)
	Females (164)	97 (159)	2.4 (4)	0.6 (1)
Feeling more tired than usual[d]	Males (167)	74 (125)	22.5 (38)	2.4 (2)
	Females (164)	83.5 (137)	15.2 (25)	1.2 (2)
Difficulty remembering[c]	Males (169)	94.7 (160)	4.7 (8)	0.6 (1)
	Females (164)	94.5 (155)	5.5 (9)	0 (0)
Blurry vision[a]	Males (169)	97.0 (164)	2.4 (4)	0.6 (1)
	Females (164)	95.7 (157)	4.3 (7)	0 (0)
Total score, median (range, minimum = 0, maximum = 34)	Males (169)		1 (0–13)	
	Females (164)		1 (0–11)	

[a] Physical domain.
[b] Emotional domain.
[c] Cognitive domain.
[d] Fatigue domain.

vision (93%), sensitivity to noise (92%), sensitivity to light (91%), sadness (91%), and dizziness (91%). Older girls most often gave scores of 0 to sensitivity to noise (95%), double/blurry vision (93%), nausea (92%), and sadness (91%).

The results of the nonparametric analyses are presented in Table 5. The relationship between learning factors and total PCSI score was not significant for either age group. For the child group (ages 9–12 years), a significant relationship was identified whereby more self-reported fatigue symptoms occurred with increasing age ($r_s = 0.125$, $P = .022$). Older children in this age group reported more fatigue symptoms at baseline compared with younger children in this age group. Sex had a nonsignificant association with the physical, cognitive, emotional, and fatigue domains and the total PCSI-C score. A history of concussion in the child group had a significant relationship with self-reported cognitive symptoms (U = 8681, $P = .034$) and fatigue symptoms (U = 8763, $P = .047$); those children who said *yes* to having had a previous concussion reported significantly more cognitive and fatigue symptoms. The number of previous concussions in this age group also had a significant relationship with self-reported cognitive ($r_s = 0.120$, $P = .029$) and fatigue ($r_s = 0.110$, $P = .046$) symptoms. Those children who reported more previous concussions had increased self-reports of cognitive and fatigue symptoms.

For the youth group, a significant relationship was identified for age, sex, and number of previous concussions. Age had a significant effect on the physical ($r_s = 0.141$, $P = .001$), cognitive ($r_s = 0.176$, $P = .000$), and fatigue ($r_s = 0.114$, $P = .007$) domains as well as on total PCSI score ($r_s = 0.143$, $P = .001$), such that older youths in the age group reported more physical, cognitive, and fatigue symptoms than younger youths. Sex also had a significant effect on the emotional (U = 43230.5, $P = .000$) and fatigue (U = 41241, $P = .031$) domains. Females in the youth group reported significantly more emotional and fatigue symptoms than their male youth counterparts. In addition, sex had a significant effect on total PCSI score (U = 42152.5, $P =$

Table 4. Frequencies of Self-Reported Symptoms on the 22-Item Post-Concussion Symptom Inventory-SR13 at Baseline in Uninjured Youth Athletes (13–17 Years Old) by Sex

Symptom	Sex (n)	22-Item Post-Concussion Symptom Inventory-SR13 Score, % (n)						
		0 = *Not a Problem*	1	2	3 = *Moderate Problem*	4	5	6 = *Severe Problem*
Headache[a]	Males (243)	76.1 (185)	18.1 (44)	4.1 (10)	1.6 (4)	0 (0)	0 (0)	0 (0)
	Females (312)	72.8 (227)	14.1 (44)	9.3 (29)	2.9 (9)	1.0 (3)	0 (0)	0 (0)
Nausea[a]	Males (243)	88.1 (214)	9.9 (24)	0.8 (2)	1.2 (3)	0 (0)	0 (0)	0 (0)
	Females (312)	92.0 (287)	4.8 (15)	1.3 (4)	1.3 (4)	0.6 (2)	0 (0)	0 (0)
Balance problems[a]	Males (243)	93.8 (228)	4.9 (12)	0.8 (2)	0.4 (1)	0 (0)	0 (0)	0 (0)
	Females (312)	89.7 (280)	8.3 (26)	1.0 (3)	0.6 (2)	0.3 (1)	0 (0)	0 (0)
Dizziness[a]	Males (242)	91.4 (222)	6.6 (16)	0.8 (2)	0.4 (1)	0.4 (1)	0 (0)	0 (0)
	Females (311)	88.5 (276)	8.0 (25)	2.2 (7)	0.3 (1)	0.6 (2)	0 (0)	0 (0)
Fatigue[b]	Males (242)	50.2 (122)	23.9 (58)	14.8 (36)	8.6 (21)	1.2 (3)	0.8 (2)	0 (0)
	Females (311)	33.3 (104)	33.3 (104)	18.6 (58)	11.2 (35)	2.9 (9)	0 (0)	0.3 (1)
Sleep more than usual[b]	Males (242)	82.7 (201)	11.1 (27)	3.7 (9)	0.8 (2)	0.4 (1)	0.4 (1)	0.4 (1)
	Females (309)	82.7 (258)	10.3 (32)	3.5 (11)	1.6 (5)	0.3 (1)	0.6 (2)	0 (0)
Drowsiness[b]	Males (243)	70.8 (172)	17.3 (42)	7.8 (19)	2.9 (7)	1.2 (3)	0 (0)	0 (0)
	Females (312)	78.8 (246)	14.4 (45)	4.5 (14)	1.6 (5)	0.3 (1)	0.3 (1)	0 (0)
Sensitivity to light[a]	Males (243)	90.9 (221)	5.3 (13)	2.5 (6)	0.8 (2)	0 (0)	0.4 (1)	0 (0)
	Females (312)	89.1 (278)	7.7 (24)	2.2 (7)	0.6 (2)	0.3 (1)	0 (0)	0 (0)
Sensitivity to noise[a]	Males (243)	91.8 (223)	5.3 (13)	1.2 (3)	0.8 (2)	0 (0)	0.4 (1)	0.4 (1)
	Females (312)	94.6 (295)	3.5 (11)	1.9 (6)	0 (0)	0 (0)	0 (0)	0 (0)
Irritability[c]	Males (241)	82.7 (201)	10.3 (25)	3.7 (9)	1.6 (4)	0.4 (1)	0.4 (1)	0 (0)
	Females (312)	80.1 (250)	12.8 (40)	5.1 (16)	1.0 (3)	0 (0)	0.3 (1)	0.6 (2)
Sadness[c]	Males (243)	90.5 (220)	6.6 (16)	1.2 (3)	0.4 (1)	0.4 (1)	0.4 (1)	0.4 (1)
	Females (312)	90.7 (283)	6.4 (20)	2.2 (7)	0.6 (2)	0 (0)	0 (0)	0 (0)
Nervousness[c]	Males (243)	80.2 (195)	11.1 (27)	5.8 (14)	2.9 (7)	0 (0)	0 (0)	0 (0)
	Females (312)	68.2 (213)	24.4 (76)	3.2 (10)	3.5 (11)	0.6 (2)	0 (0)	0 (0)
Feeling more emotional[c]	Males (243)	94.7 (230)	3.3 (8)	1.2 (3)	0.4 (1)	0.4 (1)	0 (0)	0 (0)
	Females (312)	86.5 (270)	9.3 (29)	2.6 (8)	1.3 (4)	0.3 (1)	0 (0)	0 (0)
Feeling slowed down[d]	Males (243)	83.5 (203)	9.9 (24)	4.5 (11)	2.1 (5)	0 (0)	0 (0)	0 (0)
	Females (312)	84.6 (264)	11.2 (35)	3.5 (11)	0.6 (2)	0 (0)	0 (0)	0 (0)
Feeling mentally foggy[d]	Males (243)	87.2 (212)	9.9 (24)	0.8 (2)	1.6 (4)	0.4 (1)	0 (0)	0 (0)
	Females (312)	86.9 (271)	9.0 (28)	3.5 (11)	0.3 (1)	0.3 (1)	0 (0)	0 (0)
Difficulty concentrating[d]	Males (243)	76.5 (186)	16.0 (39)	2.9 (7)	1.6 (4)	0.8 (2)	2.1 (5)	0 (0)
	Females (312)	76.9 (240)	16.0 (50)	4.8 (15)	1.3 (4)	0.6 (2)	0 (0)	0.3 (1)
Difficulty remembering[d]	Males (242)	83.1 (202)	11.5 (28)	3.7 (9)	0.4 (1)	0.4 (1)	0.4 (1)	0 (0)
	Females (312)	88.1 (275)	7.4 (23)	1.6 (5)	1.6 (5)	0.3 (1)	0.6 (2)	0 (0)
Visual problems (double vision,	Males (243)	93.0 (226)	5.3 (13)	1.6 (4)	0 (0)	0 (0)	0 (0)	0 (0)
blurring)[a]	Females (311)	92.9 (290)	5.1 (16)	1.6 (5)	0 (0)	0 (0)	0 (0)	0 (0)
Get confused with directions	Males (243)	89.3 (217)	7.4 (18)	2.1 (5)	0.4 (1)	0.8 (2)	0 (0)	0 (0)
or tasks[d]	Females (312)	87.8 (274)	9.0 (28)	1.9 (6)	1.0 (3)	0 (0)	0.3 (1)	0 (0)
Move in a clumsy manner[a]	Males (243)	89.7 (218)	7.0 (17)	2.5 (6)	0.8 (2)	0 (0)	0 (0)	0 (0)
	Females (312)	88.5 (276)	8.7 (27)	2.6 (8)	0.3 (1)	0 (0)	0 (0)	0 (0)
Answer questions more slowly[d]	Males (n = 243)	88.5 (215)	7.8 (19)	1.2 (3)	1.6 (4)	0.4 (1)	0.4 (1)	0 (0)
	Females (312)	89.7 (280)	8.0 (25)	1.3 (4)	0.6 (2)	0.3 (1)	0 (0)	0 (0)
Total score, median (range)	Males (243)				2 (0–44)			
	Females (312)				3 (0–43)			

[a] Physical domain.
[b] Fatigue domain.
[c] Emotional domain.
[d] Cognitive domain.

.009), whereby females (median = 3, range = 0–43) had a higher total PCSI score than males (median = 2, range = 0–44). A history of previous concussion was significantly associated with self-reported cognitive symptoms (U = 35276, $P = .034$), whereby those youths who said *yes* to having sustained a previous concussion reported more cognitive symptoms. The previous number of concussions also had a significant effect on the cognitive domain ($r_s = 0.104$, $P = .015$) and on total PSCI score ($r_s = 0.084$, $P = .049$) for youths ages 13 to 17 years, such that those who reported a higher number of previous concussions had more self-reports of cognitive symptoms and a higher overall total PCSI score compared with those youths who had a smaller number of previous concussions.

DISCUSSION

This is one of the first studies to present baseline symptom ratings using the PCSI according to age and sex in a large sample of child and youth athletes. Investigating responses using the PCSI, a developmentally sensitive measure of symptoms, and the influence of concussion history, learning factors, and symptom domains are also unique features of our study. We developed frequency

Table 5. Nonparametric Univariate Analyses: Relationship Between the Post-Concussion Symptom Inventory and Total Symptom and Domain Scores and Age, Sex, and History of Concussion in Uninjured Child and Youth Athletes

	Group, Instrument									
	Child (Age = 9–12 y), 17-Item Post-Concussion Symptom Inventory-SR8					Youth (Age = 13–17 y), 22-Item Post-Concussion Symptom Inventory-SR13				
		Domain					Domain			
Variable	Total Score	Physical	Cognitive	Emotional	Fatigue	Total Score	Physical	Cognitive	Emotional	Fatigue
Age, r_s (*P* value)	0.045 (.412)	−0.017 (.762)	0.012 (.832)	0.041 (.455)	0.125 (.022[a])	0.143 (.001[a])	0.141 (.001[a])	0.176 (<.000[a])	0.062 (.149)	0.114 (.007[a])
Sex, U (*P* value)	13 273.5 (.456)	12 893 (.149)	13 231.5 (.315)	14 989 (.089)	12 549 (.069)	42 152.5 (.009[a])	40 246 (.087)	38 063 (.665)	43 230.5 (<.001[a])	41 241 (<.001[a])
History of concussion? (*yes/no*), U (*P* value)	8625 (.135)	8328 (.207)	8681 (.034[a])	7596 (.833)	8763 (.047[a])	34 986 (.087)	34 346.5 (.145)	35 276 (.034[a])	32 895 (.580)	34 614 (.126)
Previous concussions, No., r_s (*P* value)	0.083 (.132)	0.07 (.203)	0.120 (.029[a])	−0.013 (.813)	0.110 (.046[a])	0.084 (.049[a])	0.079 (.065)	0.104 (.015[a])	0.029 (.493)	0.064 (.136)

Abbreviations: r_s, Spearman correlation; U, independent-samples Mann-Whitney *U* test.

[a] Denotes statistically significant result.

tables to describe baseline symptoms according to age group and sex. These data may be useful for care providers as part of a multimodal approach to assessment and management of child and youth athletes after concussion in the absence of preconcussion baseline data.

An important finding is the considerable presence of symptoms related to fatigue and drowsiness across all ages and sexes. The percentages of symptom endorsement, although substantial in both age groups, increased from 30% of boys and 22% of girls in the younger age group (9–12 years) to 50% of boys and 66% of girls in the older age group (13–17 years). Approximately 20% of our older group rated fatigue as a moderate problem (ie, score of at least 3 on the PCSI). Results from another large cohort study[11] of children and youth at baseline indicated that fatigue was also the most often reported symptom, albeit to a lesser extent (younger children = 45% and older youth = 35%). We speculate that this may reflect the unique characteristics of our sample: namely elite athletes, who, especially at older ages, spent 3 to 7 days per week participating in their sport in addition to fulfilling academic demands. This finding is consistent with previous literature[18,19] and the results of our regression analysis (ie, that symptom reporting increased with age), which may reflect developmental factors.

Headache symptoms increased from the younger age group (10% in both boys and girls) to the older group (28% in girls, 24% in boys). Our findings are similar to those of Sady et al[11] in older youths but less than those in younger children (24%). Although we noted similar percentages of headaches across the sexes, results from a recent meta-analysis[17] suggest that females (ages 12–26 years) were more likely than males to report baseline symptoms of headache. Our observations also differ from those of a systematic review[25] regarding the incidence of headache in children and youth (58.4%). Further study is required, but our results may reflect a protective effect of regular exercise on headache incidence or severity.[26]

It is disconcerting that symptoms of nervousness or worry were reported by 17% to 32% of our sample. Girls in both age groups reported this symptom in higher percentages than boys. Our regression analysis demonstrated that girls ages 13 to 17 years reported significantly higher scores for the emotional and fatigue symptom clusters than did boys. These symptoms (nervousness or worry) were also reported in the Sady et al[11] study at similar levels (28% by younger children, 22% by older children). It is not clear whether these symptoms are unique to youth athletes or children and youths in general or reflect a baseline testing situation in which child and youth athletes feel pressure to perform at their best. It is also possible that sex differences in reporting specific symptom clusters may be related to hormonal differences that become more ubiquitous in adolescence.[27] The prevalence of anxiety disorders in children and youths has been estimated to be 2% to 20%,[28] suggesting that our findings, which were higher than this range, may be unique to the athlete population and deserve further investigation.

The percentage of children and youths with at least 1 previous concussion in our sample is worth considering. Simply having a previous concussion did not affect the total PCSI symptom score in either age group. However, the number of previous concussions did affect the total PCSI symptom score: PCSI scores increased with the number of concussions. In addition, a history of concussion was associated with increased symptom reporting in both age groups whereby children aged 9 to 12 years old with a history of concussion reported more cognitive and fatigue symptoms and those aged 13 to 17 years old reported more cognitive symptoms. Our results may indicate a selection bias (ie, those who volunteer for research studies), yet they are also consistent with those of Brooks et al,[23] who demonstrated increased symptom reports (with a medium effect size) by adolescent athletes with 2 or more concussions. Together, these results may support an emerging trend in the youth athlete group: that symptom reporting at baseline is higher for athletes with a history of multiple concussions. Distinguishing whether these differences are due to residual effects of concussion or increased awareness of symptoms and symptom reporting is an important area for future study. Clinically, these findings highlight the importance of collecting information about concussion history at the baseline assessment due to the possible influence of previous concussions.

LIMITATIONS AND FUTURE DIRECTIONS

The uniqueness of our sample is both a strength and a limitation. Most of the elite athletes in our sample were hockey players from socially, educationally, and economically advantaged backgrounds. Thus, our results may not be generalizable to general youth populations, such as those recruited from hospital or emergency department settings. Our participant numbers in the 9-year-old age group were small; therefore, our findings in this group are not as robust as in other age groups. Participant recall bias may have affected our results, as demographic data (eg, history of concussion, presence of learning disabilities) were self-reported by the child and youth participants. Future authors could corroborate this information with parents or health care providers.

Many sensory-related symptoms were hardly reported in our baseline sample but are frequently reported after concussion. Researchers should seek to gain a better understanding of how sensory symptoms, compared with other commonly reported baseline symptoms (eg, fatigue, nervousness), change after concussion. The presence of sensory symptoms after concussion may indicate specific injury to the cranial or vestibular nerve pathways. Whether symptoms such as sensitivity to noise and light, blurred vision, balance, dizziness, and nausea indicate the presence of other diagnoses (eg, traumatic optic neuropathy) in addition to concussion is important to determine as this may affect clinical care (eg, referral to a specialist care provider or visual or vestibular rehabilitation program).

Given our findings, namely that a sizable number of children and youths experienced symptoms at baseline, it is not clear that having a baseline of no symptoms (ie, PCSI score = 0) should be expected for every athlete. This information has important implications for whether clinicians should expect complete symptom resolution after concussion. The clinical utility of baseline symptom data requires further study, particularly in relation to guiding return to play and differentiating physical symptoms at baseline due to intense practice and play in specific sports (eg, high-impact football, hockey, or soccer versus low-impact cross-country, golf, or tennis). Differences in baseline symptoms in athlete and nonathlete youth populations require further examination.

CONCLUSIONS

Baseline symptoms of fatigue, drowsiness, and nervousness appear to be present for many child and youth athletes. Fatigue was reported by more than half of youth athletes in this study. These results provide clinicians with an understanding of what is typical for child and youth athletes at baseline. Further, our results challenge whether clinicians should expect complete symptom resolution before the athlete reengages in activity after concussion.

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REFERENCES

1. McCrory P, Meeuwisse WH, Aubry M, et al. Consensus statement on concussion in sport: the 4th International Conference on Concussion in Sport held in Zurich, November 2012. *Br J Sports Med*. 2013; 47(5):250–258.
2. MacPherson A, Fridman L, Scolnik M, Corallo A, Guttmann A. A population-based study of paediatric emergency department and office visits for concussions from 2003 to 2010. *Paediatr Child Health*. 2014;19(10):543–546.
3. Gioia GA. Multimodal evaluation and management of children with concussion: using our heads and available evidence. *Brain Inj*. 2015; 29(2):195–206.
4. Lovell MR, Iverson GL, Collins MW, et al. Measurement of symptoms following sports-related concussion: reliability and normative data for the post-concussion scale. *Appl Neuropsychol*. 2006;13(3):166–174.
5. Zemek R, Duval S, Dematteo C, et al. Guidelines diagnosing and managing pediatric concussion. Ontario Neurotrauma Foundation Web site. www.onf.org/documents/guidelines-diagnosing-and-managing-pediatric-concussion. Accessed August 25, 2016.
6. Kirkwood MW, Randolph C, Yeates KO. Returning pediatric athletes to play after concussion: the evidence (or lack thereof) behind baseline neuropsychological testing. *Acta Paediatr*. 2009;98(9): 1409–1411.
7. Iverson GL, Silverberg ND, Mannix R, et al. Factors associated with concussion-like symptom reporting in high school athletes. *JAMA Pediatr*. 2015;169(12):1132–1140.
8. Covassin T, Swanik CB, Sachs M, et al. Sex differences in baseline neuropsychological function and concussion symptoms of collegiate athletes. *Br J Sports Med*. 2006;40(11):923–927.
9. Iverson GL, Lange RT. Examination of 'postconcussion-like' symptoms in a healthy sample. *Appl Neuropsychol*. 2003;10(3): 137–144.
10. Reed N, Murphy J, Dick T, et al. A multi-modal approach to assessing recovery in youth athletes following concussion. *J Vis Exp*. 2014;(91):51892.
11. Sady MD, Vaughan CG, Gioia G. Psychometric characteristics of the postconcussion symptom inventory in children and adolescents. *Arch Clin Neuropsychol*. 2014;29(4):348–363.

12. Browne GJ, Lam LT. Concussive head injury in children and adolescents related to sports and other leisure physical activities. *Br J Sports Med*. 2006;40(2):163–168.
13. Schmidt JD, Register-Mihalik JK, Mihalik JD, Kerr ZY, Guskiewicz KM. Identifying impairments after concussion: normative data versus individualized baselines. *Med Sci Sports Exerc*. 2012;44(9):1621–1628.
14. Hillman CH, Kamijo K, Scudder M. A review of chronic and acute physical activity participation on neuroelectric measures of brain health and cognition during childhood. *Prev Med*. 2011;52(suppl 1):S21–S28.
15. Tomporowski PD, Lambourne K, Okumura MS. Physical activity interventions and children's mental function: an introduction and overview. *Prev Med*. 2011;52(suppl 1):S3–S9.
16. Khan NA, Hillman CH. The relation of childhood physical activity and aerobic fitness to brain function and cognition: a review. *Pediatr Exerc Sci*. 2014;26(2):138–146.
17. Brown DA, Elsass JA, Miller AJ, Reed LE, Reneker JC. Differences in symptom reporting between males and females at baseline and after sports-related concussion: a systematic review and meta-analysis. *Sports Med*. 2015;45(7):1027–1040.
18. McKay CD, Brooks BL, Mrazik M, Jubinville AL, Emery CA. Psychometric properties and reference values for the ImPACT neurocognitive test battery in a sample of elite youth ice hockey players. *Arch Clin Neuropsychol*. 2014;29(2):141–151.
19. Snyder AR, Bauer RM, Health IMPACTS for Florida Network. A normative study of the sport concussion assessment tool (SCAT2) in children and adolescents. *Clin Neuropsychol*. 2014;28(7):1091–1103.
20. Register-Mihalik JK, Guskiewicz KM, Valovich McLeod TC, Linnan LA, Mueller FO, Marshall SW. Knowledge, attitude, and concussion-reporting behaviors among high school athletes: a preliminary study. *J Athl Train*. 2013;48(5):645–653.
21. Williamson IJS, Goodman D. Converging evidence for the under-reporting of concussions in youth ice hockey. *Br J Sports Med*. 2006;40(2):128–132.
22. Gioia GA, Schneider JC, Vaughan CG, Isquith PK. Which symptom assessments and approaches are uniquely appropriate for paediatric concussion? *Br J Sports Med*. 2009;43(suppl 1):13–22.
23. Brooks BL, McKay CD, Mrazik M, Barlow KM, Meeuwisse WH, Emery CA. Subjective, but not objective, lingering effects of multiple past concussions in adolescents. *J Neurotrauma*. 2013;30(17):1469–1475.
24. Mannix R, Iverson GL, Maxwell B, Atkins JE, Zafonte R, Berkner PD. Multiple prior concussions are associated with symptoms in high school athletes. *Ann Clin Transl Neurol*. 2014;1(6):433–438.
25. Abu-Arafeh I, Razak S, Sivaraman B, Graham C. Prevalence of headache and migraine in children and adolescents: a systematic review of population-based studies. *Dev Med Child Neurol*. 2010;52(12):1088–1097.
26. Fricton J, Velly A, Ouyang W, Look J. Does exercise therapy improve headache? A systematic review with meta-analysis. *Curr Pain Headache Rep*. 2009;13(6):413–419.
27. Wunderle K, Hoeger KM, Wasserman E, Bazarian JJ. Menstrual phase as predictor of outcome after mild traumatic brain injury in women. *J Head Trauma Rehabil*. 2014;29(5):E1–E8.
28. Beesdo K, Knappe S, Pine DS. Anxiety and anxiety disorders in children and adolescents: developmental issues and implications for DSM-V. *Psychiatr Clin North Am*. 2009;32(3):483–524.

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