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Sex Differences on the Concussion Clinical Profiles Screening in Adolescents With Sport-Related Concussion

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Context: Sex differences influence symptom presentations after sport-related concussion and may be a risk factor for certain concussion clinical profiles.

Objective: To examine sex differences on the Concussion Clinical Profile Screen (CP Screen) in adolescents after sport-related concussion.

Design: Cross-sectional study.

Setting: A concussion specialty clinic.

Patients or Other Participants: A total of 276 adolescent (age = 15.02 ± 1.43 years; girls = 152 [55%]) athletes with a recently diagnosed concussion (≤30 days).

Main Outcome Measure(s): The 5 CP Screen profiles (anxiety mood, cognitive fatigue, migraine, vestibular, ocular) and 2 modifiers (neck, sleep), symptom total, and symptom severity scores were compared using a series of Mann-Whitney *U* tests between boys and girls.

Results: Girls (n = 152) scored higher than boys (n = 124) on the cognitive fatigue ($U = 7160.50$, $z = -3.46$, $P = .001$) and anxiety mood ($U = 7059$, $z = -3.62$, $P < .001$) factors but not on the migraine ($U = 7768$, $z = -2.52$, $P = .01$) factor. Girls also endorsed a greater number of symptoms (n = 124; $U = 27233$, $z = -3.33$, $P = .001$) and scored higher in symptom severity ($U = 7049$, $z = -3.60$, $P < .001$) than boys.

Conclusions: Among adolescents, symptom endorsement on the CP Screen varied based on sex, and clinicians need to be aware of these differences, especially when evaluating postconcussion presentation in the absence of baseline data.

Key Words: mild traumatic brain injuries, symptoms, youth athletes

Key Points

- The Concussion Clinical Profiles Screen is an emerging clinical assessment tool that is intended to categorize the symptom presentations of patients with concussion.
- Similar to other concussion symptom assessments, female participants reported more and worse symptoms than their male counterparts.
- Females specifically endorsed higher cognitive fatigue, anxiety mood, and ocular symptom profiles compared with their male counterparts.

The Concussion Clinical Profiles Screening (CP Screen)[1] is a new self-report symptom assessment created to assist in the identification of concussion clinical profiles.[2,3] This measure addresses the shortcomings of traditional symptom inventories (eg, Post-Concussion Symptom Scale [PCSS]) that are nonspecific to concussion (ie, overlap with comorbidities such as anxiety and depression) and is primarily focused on rating the severity of a specific symptom rather than on more specific symptom occurrences of the concussion profiles (eg, visual aura symptoms indicative of a migraine profile). For example, a patient completing the PCSS would likely endorse a "headache," whereas the CP Screen provides the patient with more specific headache items (eg, "headache when you wake up," "headache with nausea or upset stomach"). This extra detail provides clinicians with additional information that will better guide their clinical interview and assist in identifying the clinical profile and a corresponding treatment.[1,3,4] Kontos et al[1] reported high reliability for the CP Screen in both healthy (nonconcussed) adolescents and adolescents with concussion and excellent predictive validity for identifying concussion. The CP Screen profiles for anxiety mood, cognitive fatigue, migraine, ocular, and vestibular were moderately to highly correlated with the physical, cognitive, affective, and sleep postconcussion symptom factors on the PCSS.[1] These

findings support the clinical utility of the CP Screen as a part of the recommended multifaceted approach to concussion assessment and management,[5] especially in terms of learning more about the patient's symptoms, which can help in identifying the involved concussion clinical profile(s).

Sex differences influence postconcussion symptom presentations[6–8] and are proposed as a risk factor for certain concussion clinical profiles.[1] Several researchers[9–12] observed that adolescent and young adult females exhibited a higher number of symptoms and greater symptom severity after concussion than their male counterparts. In addition to the overall symptom burden, sex differences are documented for several symptom factors (ie, clusters).[7] More specifically, females endorsed more symptoms in the affective,[3] somatic,[6] and cognitive-migraine-fatigue[8] symptom clusters[7] as measured by the PCSS. Kontos et al[3] suggested female sex was a risk factor for the posttraumatic migraine clinical profile, and McEvoy et al[13] noted that females experienced more persistent posttraumatic headaches than males. Despite these findings, the influence of sex on the concussion symptoms that are proposed to underlie concussion clinical profiles is unknown.

The previous reports of sex differences on the PCSS,[6–8] together with the documented relationship among CP Screen scores and PCSS scores,[1] provide a rationale to evaluate sex differences on the CP Screen. Therefore, the purpose of our study was to examine sex differences in CP Screen scores among adolescents aged 13 to 18 years within 30 days of a sport-related concussion (SRC). We hypothesized that females would report higher scores on the anxiety mood, cognitive fatigue, and migraine profiles than males. We also hypothesized that females would endorse a higher number of items and greater symptom severity scores than males. Our second aim was to document the prevalence of CP Screen score classifications among males and females.

METHODS

Research Design

This study was a retrospective review of electronic health records (EHRs) gathered from a concussion specialty clinic between August 2015 and December 2020.

Participants

Adolescents between the ages of 13 and 18 years with a diagnosed SRC within 30 days were enrolled in the study. Any patient who had incomplete clinical data (eg, missing demographic information or incomplete CP Screen data), did not complete the clinical interview and assessment in English, or sustained the concussion from a nonsport activity (eg, motor vehicle accident) was excluded from the analysis.

Measures and Instrumentation

Definition of Concussion. Participants were diagnosed with an SRC through a comprehensive clinical evaluation (eg, clinical interview or examination, symptom, neurocognitive, vestibular and ocular motor assessment) completed by a clinical neuropsychologist with specialty training in concussion. All concussions were confirmed by the clinical neuropsychologist. Clinical neuropsychologists have extensive training in the administration and interpretation of cognitive testing as well as mood dysfunction, which have been advocated as part of the multifaceted approach to the assessment and management of patients with concussion.[1,5,14] Clinicians in this medical specialty are well trained in the differential diagnosis, which is important given the significant overlap[15–17] between concussion and other medical conditions (eg, anxiety and depression). Moreover, multidisciplinary clinical care models[6,14] include experts in neuropsychology and athletic training as part of a collaborative medical team that supervises an athlete's safe return to play. The following criteria were implemented for the diagnosis of concussion: a confirmed sport-related mechanism of injury, the presence of at least 1 on-field sign of concussion (eg, loss of consciousness, vomiting, disorientation, balance difficulties), the presence of at least 1 concussion symptom (eg, headache, nausea, mental fogginess) within 72 hours of injury, deficits in neurocognitive composite scores outside of reliable change indices, or all of these. Our criteria were consistent with those provided in consensus statements.[6,18]

Demographics. Participant age, sex, history of concussion (*yes* or *no*), learning disorder (*yes* or *no*), attention-deficit/hyperactivity disorder (*yes* or *no*), migraines (*yes* or *no*), anxiety (*yes* or *no*), depression (*yes* or *no*), motion sickness (*yes* or *no*), and ocular motor dysfunction (*yes* or *no*) were extracted from the EHR.

The CP Screen. The CP Screen is a 29-item, self-report symptom inventory used to calculate subscores for 5 clinical profile scores: anxiety mood (eg, difficulty turning off your thoughts, rumination), cognitive fatigue (eg, increased headache after cognitive activity), migraine (eg, headache when you wake up), and visual aura (eg, flashes, stars, spots, flickering light) with or without headache, vestibular (eg, dizziness when you move your head), and ocular (eg, trouble focusing your eyes while reading) and 2 modifier scores for neck (eg, neck pain or stiffness) and sleep (eg, difficulty staying asleep) to help clinicians understand the presentation of each individual injury.[1] The CP Screen uses a 4-point Likert scale ranging from 0 (*none*) to 3 (*severe*). We employed 3 scoring approaches for the CP Screen—total, severity, and factor scores. The total number of symptoms endorsed is calculated by counting the number of symptoms with a score of ≥ 1. Symptom severity is calculated by summing the scores across all items. To calculate profile scores, individual items are averaged to generate specific symptom factor scores that describe anxiety mood, cognitive fatigue, migraine, ocular, and vestibular items that correspond to the 5 concussion clinical profiles.[1] In addition, items that measure sleep and neck symptoms are averaged into scores for sleep and neck modifiers. For our second aim, the scores for each profile were categorized as positive (>0) or negative ($= 0$) to identify the frequency of profiles for males and females. The CP Screen had high internal consistency in concussed adolescents (Cronbach $\alpha = 0.93$).[1] In addition, the instrument displayed excellent predictive validity for distinguishing individuals with concussion from control individuals for all CP Screen profile and modifier scores, with excellent predictive validity for the migraine (area under the curve [AUC] = 0.93), ocular (AUC = 0.88),

vestibular (AUC = 0.85), and cognitive (AUC = 0.81) profiles.[1]

Procedures

This study was approved by an institutional review board. Participant demographics were gathered via the standard clinical interview, and the CP Screen was administered at the first clinical visit by a trained clinician in a dedicated patient room as part of a standard clinical evaluation for patients with SRC.

Data Analysis

Means, SDs, frequencies, and percentages were used to describe sample demographics, and a series of t tests and χ^2 analyses were performed to evaluate sex differences in age, time to first clinical appointment, concussion history, learning disorder, migraine history, anxiety, depression, motion sickness, and ocular dysfunction. The CP Screen profile scores were inspected for normality with the Shapiro-Wilk test, and the data were decidedly nonnormal for anxiety mood (Shapiro-Wilk = 0.88, $P < .001$), cognitive fatigue (Shapiro-Wilk = 0.107, $P = .002$), migraine (Shapiro-Wilk = 0.127, $P < .001$), ocular (Shapiro-Wilk = 0.95, $P = .006$), vestibular (Shapiro-Wilk = 0.92, $P < .001$), sleep (Shapiro-Wilk = 0.84, $P < .001$), neck (Shapiro-Wilk = 0.66, $P < .001$), and total symptom severity (Shapiro-Wilk = 0.96, $P < .001$). Therefore, we calculated a series of nonparametric Mann-Whitney U tests to compare CP Screen symptom total and symptom severity scores between males and females. A series of Mann-Whitney U tests was computed to compare differences between males and females in mean symptom scores for the anxiety mood, cognitive fatigue, migraine, vestibular, and ocular CP Screen factor scores, as well as the neck and sleep modifiers. Common language effect sizes (CLESs)[14] were determined using the cumulative probability divided by 1.41 via CLES = Φd2 and are presented with 95% CIs. A Bonferroni correction ($P \leq .006$) was applied to control for multiple comparisons and reduce the risk of type I error.[19] The corrected P value for the Bonferroni correction was calculated by dividing $P = .05$ by the number of comparisons (9) to find the new α value of .006. To address the second aim, we conducted 5 χ^2 tests for independence and odds ratios with the independent variable of sex and the dependent variables of positive (any score > 0) and negative (scores = 0) profile scores for anxiety mood, cognitive fatigue, migraine, vestibular, and ocular as well as the 2 modifiers: sleep and neck. A second Bonferroni correction ($P \leq .007$) was used to interpret the χ^2 results. Analyses were conducted with SPSS (version 26; IBM Corp).

RESULTS

Participant Demographics

A total of 1806 patient EHRs were reviewed, and 889 (49%) patients were within the study age range (13–18 years). Of these, 209 (12%) were excluded due to the injury not having a sport-related mechanism, 56 (3%) were excluded because they were not evaluated within 30 days of injury, and 348 (19%) were excluded because they had incomplete data or did not have a confirmed diagnosed concussion. Two participants completed part of their clinical assessment in Spanish. These participants met other exclusion criteria as well. The final sample consisted of 276/1806 (15.3%) of the original patients identified from the EHRs. Participants (15.02 ± 1.43 years) consisted of 124 boys (45%) and 152 girls (55%) who completed their first clinical visit 7.69 days after injury (± 6.49; interquartile range = 7.00 days; range = 1–30 days).

Table 1. Medical History Demographics for Males, Females, and Overall Sample

Variable	No. (%)		
	Males (N = 124)	Females (N = 152)	Total (N = 276)
Loss of consciousness	8 (6)	7 (5)	15 (5)
Previous concussion	56 (45)	63 (42)	119 (43)
History			
Migraine	19 (15)	26 (17)	45 (16)
Ocular dysfunction	16 (13)	12 (8)	28 (10)
Motion sickness	35 (28)	51 (33)	86 (31)
Anxiety	26 (21)	29 (19)	55 (20)
Depression	11 (9)	15 (10)	26 (9)
Attention-deficit/hyperactivity disorder[a]	23 (19)	13 (9)	36 (13)
Learning disorder	11 (9)	15 (10)	26 (9)

[a] $P < .05$.

Boys and girls did not differ in their history of concussion ($\chi^2_1 = 0.384$, $P = .54$), learning disorder ($\chi^2_1 = 0.08$, $P = .78$), migraine ($\chi^2_1 = 0.159$, $P = .69$), anxiety ($\chi^2_1 = 0.15$, $P = .70$), depression ($\chi^2_1 = 0.08$, $P = .78$), motion sickness ($\chi^2_1 = 0.11$, $P = .74$), or ocular dysfunction ($\chi^2_1 = 1.88$, $P = .17$). Additionally, boys (mean = 7.05 ± 5.79) and girls (mean = 8.21 ± 6.98) did not differ in the number of days to the first clinical visit ($t = 1.49$, $P = .14$). However, boys (mean = 15.23 ± 1.50 years) were older than girls (14.85 ± 1.35; $t_{274} = 2.20$, $P = .03$) and reported a higher frequency of attention-deficit/hyperactivity disorder in their medical history ($\chi^2_1 = 6.02$, $P = .01$; Table 1).

Sex Differences in the CP Screen Symptom Total, Severity, and Factor Scores

Results of the Mann-Whitney U tests revealed a higher (ie, worse) total number of symptoms for females (median = 17.00) than males (median = 14.50; $U = 27\,233$, $z = -3.33$; $P = .001$). Females (median = 26.50) also endorsed greater symptom severity than males (median = 19.00; $U = 7049$, $z = -3.60$; $P < .001$). Females scored higher (ie, worse) than males in the cognitive fatigue ($U = 7160.50$, $z = -3.46$; $P = .001$) and anxiety mood ($U = 7059$, $z = -3.62$, $P < .001$) factor scores but not in the migraine ($U = 7768$, $z = -2.52$; $P = .01$) factor scores. Further analyses also revealed higher (ie, worse) ocular factor scores ($U = 6740.50$, $z = -4.08$; $P < .001$) for females than males but similar scores for the vestibular ($U = 8143.00$, $z = -1.90$; $P = .05$) factor and sleep ($U = 8196$, $z = -1.90$; $P = .06$) and neck ($U = 8303$, $z = -1.89$; $P = .06$) modifiers among the groups. Means, medians, SDs, and effect sizes for these analyses are presented in Table 2.

The Prevalence of CP Screen Profiles and Modifiers

Boys and girls did not differ in the frequency of their vestibular ($t_1 = 0.01$, $P = .92$), ocular ($t_1 = 4.82$, $P = .03$), migraine ($t_1 = 3.51$, $P = .06$), and cognitive fatigue ($t_1 =$

Table 2. Post-Concussion Symptom Scale and Concussion Clinical Profile Screen Scores in Males and Females

Score	Males (n = 124)				Females (n = 152)				Effect Size (95% CI)	*z* Value	√(N)	*R* Value	Interpretation
	IQR	Median	Mean	SD	IQR	Median	Mean	SD					
Post-Concussion Symptom Scale													
No. of symptoms[a]	10.00	14.50	13.82	6.81	8.75	17.00	16.53	6.50	0.61 (0.16, 0.64)	−3.33	16.61325	−0.20044	Small
Symptom severity[a]	19.00	19.00	20.56	12.95	20.50	26.50	26.95	14.83	0.63 (0.22, 0.70)	−3.6	16.61325	−0.21669	Small
Concussion Clinical Profile Screen													
Anxiety mood[a]	0.80	0.40	0.49	0.49	1.00	0.60	0.77	0.66	0.63 (0.23, 0.72)	−3.46	16.61325	−0.20827	Small
Cognitive fatigue[a]	0.67	1.00	1.05	0.68	1.00	1.33	1.34	0.71	0.62 (0.18, 0.66)	−3.62	16.61325	−0.2179	Small
Migraine	0.80	0.80	0.85	0.62	0.80	1.00	1.04	0.61	0.31 (0.07, 0.55)	−2.52	16.61325	−0.15169	Small
Ocular[a]	1.00	0.80	0.91	0.62	1.20	1.20	1.24	0.68	0.64 (0.26, 0.75)	−4.08	16.61325	−0.24559	Medium
Vestibular	0.80	0.60	0.68	0.56	0.80	0.80	0.84	0.66	0.26 (0.02, 0.50)	−1.9	16.61325	−0.11437	Small
Sleep	0.75	0.25	0.49	0.53	0.75	0.50	0.60	0.54	0.56 (−0.03 to 0.44)	−1.9	16.61325	−0.11437	Small
Neck	0.50	0.00	0.40	0.66	1.00	0.00	0.51	0.67	0.17 (−0.07 to 0.40)	−1.89	16.61325	−0.11376	Small

Abbreviation: IQR, interquartile range.

[a] $P < .006$.

1.98, $P = .16$) profile scores or sleep ($t_1 = 3.95$, $P = .05$) and neck ($t_1 = 4.16$, $P = .04$) modifiers. However, females were 2.60 times more likely to have a positive anxiety mood profile score than their male counterparts ($t_1 = 9.72$, $P = .002$). Please see Table 3 for the frequency of each profile score in the CP Screen.

DISCUSSION

We are the first to examine sex differences on the CP Screen among adolescent athletes with concussion. Our primary findings were that females reported higher (ie, worse) anxiety mood, cognitive fatigue, and ocular factor scores as well as a greater number and severity of symptoms on the CP Screen than males. These results support our hypotheses and align with the previous literature that indicated higher (ie, worse) concussion-related symptoms among females.[6–11,14,20] The findings in this study also extend earlier work by identifying sex as a potential factor associated with specific concussion clinical profiles.

The hypothesis that girls endorsed higher (ie, worse) anxiety mood symptom scores than boys was supported by the data. In addition to reporting higher symptom scores, we found a higher prevalence of positive anxiety mood profiles in girls than boys. These sex differences on the anxiety mood CP Screen factor score are similar to previous observations.[7,21,22] One explanation for this result is that a higher incidence of premorbid anxiety in females may influence postconcussion symptom reporting.[17] However, a history of anxiety was evenly distributed between the sexes in the current sample, thereby negating this hypothesis. It has also been suggested that males may be more likely to minimize affective symptoms (eg, sadness, feeling more emotional) than females. This minimization of affective symptoms among males may be related to *sport socialization* (ie, the learning process by which athletes glean social norms specific to their sport), *sport ethic* (ie, beliefs about what it means to be an athlete and the importance of striving for athletic excellence), or both.[23,24] Although we did not measure this, females may have also been more likely to exhibit certain personality traits (eg, perfectionism) that are associated with greater anxiety and affective symptoms than males.[25]

Table 3. Frequency of Clinical Profile Screening Scores Among Males, Females, and Total Sample

Profile or Modifier	No. (%)		
	Males (n =124)	Females (n = 152)	Total Sample (N = 276)
Anxiety mood[a]	89 (72)	132 (87)	221 (80)
Vestibular	105 (85)	128 (84)	233 (84)
Ocular	112 (90)	147 (97)	259 (94)
Migraine	111 (90)	145 (95)	256 (93)
Cognitive fatigue	112 (90)	144 (95)	256 (93)
Sleep	83 (67)	118 (78)	201 (73)
Neck	46 (37)	75 (49)	121 (44)

[a] $P < .007$.

The current findings also supported our hypothesis that females would have higher cognitive fatigue CP Screen scores than males. This outcome parallels the reported sex differences in postconcussion neurocognitive testing (ie, females reportedly demonstrated worse reaction time and memory).[9,16,20] This result may also reflect a higher overall symptom burden, as the cognitive fatigue CP Screen factor shares some similarities with the global cognitive-migraine-fatigue factor identified in earlier studies.[8,16] In contrast to the outcomes for the cognitive fatigue factor, no sex differences in the migraine factor were seen, which does not align with the increased prevalence of migraine history[26] and posttraumatic headache presentation in females.[13] This null finding may be attributed to the lack of variability in preexisting migraine history between boys and girls. Moreover, the items in the migraine factor on the CP Screen are more specific to migraine symptoms and triggers (eg, increased headache after physical activity or upon waking up in the morning), which may not differ between males and females.

Further, girls reported higher scores on the ocular factor than males. Sex differences in visual symptoms (eg, trouble focusing eyes while reading) are understudied in the concussion literature. In related studies, females were reported to exhibit worse visual memory[20] and a worse vestibular ocular reflex[27] after concussion. However, the

authors did not directly assess sex differences in specific ocular symptoms, which limits their application to our results and supports the need for additional investigation to better understand these sex differences.

Girls and boys scored similarly on the neck and sleep modifiers. The lack of sex differences for the neck modifier is worth noting because previous research[28–30] suggested marked physical differences between sexes in neck strength, girth, endurance, and biomechanics. Perhaps the neck symptom items in the CP Screen are insufficient to quantify these sex-related differences, and a physical examination (including strength and range of motion evaluations) is indicated if a concurrent cervical injury is suspected.[31,32] Also, no differences between sexes in the sleep modifier scores were shown, which was slightly unexpected given the higher scores for girls in anxiety mood and vestibular profile scores. Earlier authors proposed that patients with anxiety mood or vestibular profiles or both displayed higher sleep symptom scores.[33] Future investigators should parse the interactions of sex, anxiety mood, vestibular, neck, and sleep symptoms after concussion and how these affect CP Screen values.

In the current study, we add to the research documenting sex differences in the overall or total symptom burden after concussion. Our female participants endorsed a greater number of symptom items and reported higher total symptom severity scores on the CP Screen than males. This pattern is similar to the increased symptoms noted in other concussion symptom inventories (ie, PCSS, Post-Concussion Symptom Inventory).[9–12] Several researchers[24] suggested that females may be more forthright and honest about their concussion symptoms than males. In addition, males may downplay their symptoms and injury more than females.[24,34–36]

Limitations and Future Directions for Study

Several limitations of our work warrant mentioning. The wide range of days (up to 30 days) since injury could be a limitation, given the documented acute and subacute changes in concussion outcomes[7,37] and recovery.[37] However, boys and girls did not differ in the days until the first clinical visit, and most of the sample (70%) completed their first visit between 4 and 30 days. Therefore, this wide timeframe is more of a threat to the external validity of our findings than to the internal validity of our results. The current findings should not be applied to acute or sideline clinical settings. Future authors should sample specific times since injury in cohorts of females and males to better examine the effect of symptom presentations across time by sex. Although we compared CP Screen factor scores between girls and boys, we did not compare clinically relevant levels of clinical profiles or subtypes using a cutoff approach, such as that implemented with the Vestibular/Ocular Motor Screening tool.[38] Future researchers should identify CP Screen factor score clinical cutoffs to evaluate if sex is associated with clinically meaningful levels of each clinical profile. Further, we did not collect data on whether participants were receiving treatment (ie, pharmaceutical or therapy interventions) for anxiety, depression, or attention-deficit/hyperactivity disorder, which could have affected symptom presentations after the injury. In addition, we did not gather sport information for participants; therefore, we were unable to control for the effect of sport type on outcomes.

CONCLUSIONS

Clinicians who use the CP Screen for concussion management should be aware of the sex differences in scoring between boys and girls. Girls exhibited higher CP Screen anxiety mood, cognitive fatigue, and ocular profile scores than boys. These findings are in concordance with previous literature[15,24,39,40] in which authors have also documented sex differences in other concussion symptom measures. In sum, males and females differ in their concussion symptom reporting, even on the CP Screen, and these differences should be considered by the treating clinician when determining impairment and recovery status after concussion.

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Dr Collins is a former shareholder and board member of ImPACT Applications, Inc (relationship ended on December 16, 2019). Drs Collins and Kontos received book royalties from APA Books. Dr Womble has received payment from ImPACT Applications, Inc, for providing continuing education talks.

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