Concussion Clinical Profiles Screening (CP Screen) Tool: Preliminary Evidence to Inform a Multidisciplinary Approach

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BACKGROUND: Current concussion symptom inventories emphasize total number or symptoms and severity and overlap with other conditions, such as mental health disorders, which may limit their specificity and clinical utility.

OBJECTIVE: To develop and test the reliability and validity of a new Concussion Clinical Profiles Screening tool (CP Screen) in both healthy controls and concussed.

METHODS: CP Screen is a 29-item self-report, clinical profile-based symptom inventory that measures the following 5 concussion clinical profiles: 1) anxiety/mood, 2) cognitive/fatigue, 3) migraine, 4) ocular, and 5) vestibular; and the following 2 modifying factors: 1) sleep and 2) neck. Post-Concussion Symptom Scale (PCSS), vestibular/ocular motor screening (VOMS) tool, and Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT) were conducted. CP Screen was administered in community a concussion surveillance program and 2 sports medicine concussion clinics. Responses include 248 athletes, 121 concussed, and 127 controls, enrolled between 2018 and 2019.

RESULTS: Internal consistency of the CP Screen in the control (Cronbach's alpha = .87) and concussed (Cronbach's alpha = .93) samples was high. Moderate to high correlations among the CP Screen factors and PCSS factors and VOMS items, supporting concurrent validity. ROC curve analysis for identifying concussed from controls was significant ($P < .001$) for all CP Screen factor and modifier scores with excellent AUCs for migraine (.93), ocular (.88), vestibular (.85), and cognitive (.81) factors, demonstrating predictive validity.

CONCLUSION: The CP Screen demonstrated strong reliability, concurrent validity with commonly used concussion assessment (ie, PCSS, VOMS, and ImPACT), and predictive validity for identifying concussion. The CP Screen extends current symptom inventories by evaluating more specific symptoms that may reflect clinical profiles and inform better clinical care.

KEY WORDS: Clinical profiles, Concussion, mTBI, Symptoms

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Symptom inventories represent a key component of a comprehensive evaluation of concussion. When used in combination with other tools (eg, neurocognitive testing, vestibular, ocular, and balance), symptom inventories provide clinicians with direct information from the patient that is generally not biased by questioning from the provider or others (eg, parents). There are several concussion symptom inventories including the Post-Concussion Symptom Scale (PCSS),[1,2] graded symptom checklist

ABBREVIATIONS: AUC, area under the curve; **GSC,** graded symptom checklist; **HIS,** Head Injury Scale; **ImPACT,** Immediate Post-Concussion Assessment and Cognitive Testing; **ICC,** intraclass correlation coefficient; **MANOVA,** multivariate analysis of variance; **NPC,** near point convergence; **PCSS,** Post-Concussion Symptom Scale; **ROC,** receiver operating characteristic; **RPQ,** Rivermead Post-Concussion Symptoms Questionnaire; **TBI,** traumatic brain injury; **VVOR,** vertical vestibulo-ocular reflex; **VOMS,** vestibular/ocular motor screening; **VMS,** visual motion sensitivity

(GSC),[3] and Rivermead Post-Concussion Symptoms Questionnaire (RPQ).[4] These inventories include items such as symptoms like headache, dizziness, fogginess, and sleep problems. Individual items are then aggregated into total number and symptom severity scores. Concussion symptom inventories are reliable, with test-retest reliability ranging from .72 to .89[5,6] and have documented construct and content validity.[5-8] However, symptoms in current inventories tend to be general in nature, reflecting conditions from concussion to mental health disorders, which may limit their specificity.[9-11]

Recently, researchers and clinicians have proposed multidisciplinary conceptual models of clinical care that emphasize concussion clinical profiles or subtypes.[12-14] One conceptual model includes vestibular, ocular, cognitive, post-traumatic migraine (migraine), and anxiety/mood clinical profiles.[15,16] In addition, neck (ie, cervical) pathology and sleep disturbance have also been identified by researchers as important concussion modifiers.[14] Recently, researchers described the characteristics of each clinical profile and provided the first empirical evidence for the prevalence and overlap of clinical profiles.[17] However, current concussion symptom inventories are not designed to assess concussion clinical profiles and may lack specific information to inform a more targeted approach to assessment and treatment. Instead, current inventories assess symptoms on a more global level and emphasize symptom severity. For example, current inventories can indicate if a patient has a headache and how severe it might be, but they cannot delve into the type of headache (eg, migraine or ocular).

The purpose of the current study was to develop and test the reliability and validity of a new Concussion Clinical Profiles Screening (CP Screen) inventory in both healthy controls and concussed athletes. The study had the following 3 primary objectives: 1) evaluate the reliability of the CP Screen and compare it to the reliability of current symptom inventories (ie, PCSS in both healthy and concussed samples); 2) examine the concurrent validity of the CP Screen with commonly used concussion symptom inventories (ie, PCSS), neurocognitive testing (ie, Immediate Post-Concussion Assessment and Cognitive Testing [ImPACT]), and vestibular/ocular motor screening (VOMS) measures; and 3) examine the predictive validity of the CP Screen to identify concussed from healthy controls.

METHODS

Participants

Data for this study were drawn from healthy control and concussed samples. Healthy controls included athletes that participated in a community-based, concussion baseline-testing, and surveillance program in northwest Arkansas during the 2018 to 2019 sport season. Participants between the ages of 12 and 19 yr, with no concussion during the previous 3 mo, were eligible to be in the study. The concussed sample included symptomatic athletes who had sustained a diagnosed concussion—per current consensus guidelines[18] (ie, clear mechanism of injury, initial signs/symptoms, currently symptomatic or impaired)—during sport within the past 30 d (in accordance with normal recovery timelines for youth populations). Concussed athletes were recruited from 2 sport concussion clinics in western Pennsylvania (n = 65, 47.5%), northern Virginia (n = 44, 32.1%) and at the Arkansas site (n = 28, 20.4%). Exclusion criteria for both samples included prior brain surgery, moderate to severe traumatic brain injury (TBI), neurological disorder, treatment for substance abuse, or psychiatric condition. In addition, concussed athletes with a diagnosed concussion within the past 3 mo or a history of 3+ concussions were excluded. The study was reviewed and approved by the University of Pittsburgh Institutional Review Board as an expedited study (PRO18080439), by the University of Arkansas (186073) and INOVA Health System (17-2780). Patients and parents (if minors) provided informed written consent for participation.

Measures

Concussion Clinical Profiles Screening (CP Screen) Tool

The CP Screen is a 29-item, self-report, clinical profile-based symptom inventory (Figure 1). The items represent the following 5 concussion clinical profiles:[17] 1) anxiety/mood (5 items), 2) cognitive/fatigue (3 items), 3) migraine (5 items), 4) ocular (5 items), and 5) vestibular (5 items); and the following 2 modifiers: 1) sleep (4 items), and 2) neck (cervical) (2 items). Participants respond to each item that they are "currently experiencing" on a 0 (none) to 3 (severe) Likert-type scale. The CP Screen total score ranges from 0 to 87. Individual subscale scores range from 0 to 15 for anxiety/mood, migraine, ocular, and vestibular; 0 to 9 for cognitive/fatigue; 0 to 12 for sleep; and 0 to 6 for neck. The CP Screen takes 4 to 6 min to complete and is designed for use in children and adults aged 12 yr and older.

Post-Concussion Symptom Scale

The PCSS is a 22-item, self-report symptom inventory including physical, cognitive, sleep, and affective items. Participants rate each symptom on a Likert-type scale from 0 (none) to 6 (severe). Total symptom severity scores range from 0 to 132. Symptom factors (physical, cognitive, affective, and sleep) were calculated based on a prior factor analysis.[2] These factors were selected instead of the more global symptom factors from Kontos et al,[1] as they more closely reflect the clinical profiles approach from which the CP Screen was based. The PCSS takes 3 to 5 min to complete. The PCSS is a valid measure with high reliability and internal consistency.[19]

Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT)

The ImPACT is a computerized neurocognitive test comprising 6 neurocognitive subtests that yield 4 composite scores in the following: 1) verbal memory, 2) visual memory, 3) visual motor processing speed, and 4) reaction time. The ImPACT test takes 25 to 30 min to administer. ImPACT is a valid neurocognitive test with good reliability.[20-25]

Vestibular/Ocular Motor Screening (VOMS) Tool

The VOMS is a brief screening tool that assesses vestibular and oculomotor symptoms and impairment on the following: 1) smooth pursuits, 2) horizontal saccades, 3) vertical saccades, 4) horizontal vestibular ocular reflex, 5) vertical vestibulo-ocular reflex (VVOR), 6) visual motion sensitivity (VMS), and 7) near point convergence (NPC) distance. Participants self-report headache, dizziness, nausea, and fogginess following

A PLEASE PRINT FULL NAME: _____ DATE: _____

INSTRUCTIONS: Please indicate if you are **currently** experiencing any of the following symptoms.

Symptom	*Please indicate your symptom severity below:*			
1. *Feeling sad*	☐ None (Not Experiencing This Symptom)	☐ Mild	☐ Moderate	☐ Severe
2. *Headache when you wake up*	☐ None (Not Experiencing This Symptom)	☐ Mild	☐ Moderate	☐ Severe
3. *Difficulty or headache when looking at a phone or computer screen*	☐ None (Not Experiencing This Symptom)	☐ Mild	☐ Moderate	☐ Severe
4. *Dizziness when you move your head*	☐ None (Not Experiencing This Symptom)	☐ Mild	☐ Moderate	☐ Severe
5. *Difficulty turning off your thoughts (e.g., rumination)*	☐ None (Not Experiencing This Symptom)	☐ Mild	☐ Moderate	☐ Severe
6. *Headache with nausea or upset stomach*	☐ None (Not Experiencing This Symptom)	☐ Mild	☐ Moderate	☐ Severe
7. *Trouble focusing your eyes while reading*	☐ None (Not Experiencing This Symptom)	☐ Mild	☐ Moderate	☐ Severe
8. *Frontal headache*	☐ None (Not Experiencing This Symptom)	☐ Mild	☐ Moderate	☐ Severe
9. *Difficulty or discomfort in busy environments*	☐ None (Not Experiencing This Symptom)	☐ Mild	☐ Moderate	☐ Severe
10. *Constantly thinking about your symptoms*	☐ None (Not Experiencing This Symptom)	☐ Mild	☐ Moderate	☐ Severe
11. *Headache with sensitivity to light or noise*	☐ None (Not Experiencing This Symptom)	☐ Mild	☐ Moderate	☐ Severe
12. *Feeling motion sick ("sea or car sick")*	☐ None (Not Experiencing This Symptom)	☐ Mild	☐ Moderate	☐ Severe
13. *Feeling more tired at the end of the day*	☐ None (Not Experiencing This Symptom)	☐ Mild	☐ Moderate	☐ Severe
14. *Blurry or double vision*	☐ None	☐ Mild	☐ Moderate	☐ Severe

B

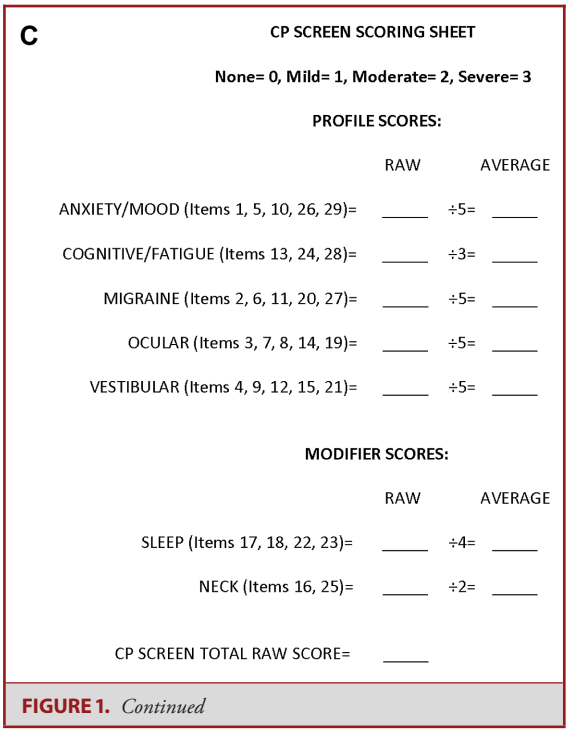
	(Not Experiencing This Symptom)			
15. *Feeling or sensation of slow wavy dizziness (i.e., lightheadedness)*	☐ None (Not Experiencing This Symptom)	☐ Mild	☐ Moderate	☐ Severe
16. *Neck pain or stiffness*	☐ None (Not Experiencing This Symptom)	☐ Mild	☐ Moderate	☐ Severe
17. *Sleeping more than usual*	☐ None (Not Experiencing This Symptom)	☐ Mild	☐ Moderate	☐ Severe
18. *Sleeping less than usual*	☐ None (Not Experiencing This Symptom)	☐ Mild	☐ Moderate	☐ Severe
19. *Eye strain (eyes feel tired) during visual activities*	☐ None (Not Experiencing This Symptom)	☐ Mild	☐ Moderate	☐ Severe
20. *Visual aura (e.g., flashes, stars, spots, flickering light) with or without headache*	☐ None (Not Experiencing This Symptom)	☐ Mild	☐ Moderate	☐ Severe
21. *Feeling or sensation of fast spinning dizziness (i.e., vertigo)*	☐ None (Not Experiencing This Symptom)	☐ Mild	☐ Moderate	☐ Severe
22. *Difficulty falling asleep*	☐ None (Not Experiencing This Symptom)	☐ Mild	☐ Moderate	☐ Severe
23. *Difficulty staying asleep*	☐ None (Not Experiencing This Symptom)	☐ Mild	☐ Moderate	☐ Severe
24. *Trouble remembering things (e.g., what you completed today or having to re-read information)*	☐ None (Not Experiencing This Symptom)	☐ Mild	☐ Moderate	☐ Severe
25. *Difficulty moving your neck*	☐ None (Not Experiencing This Symptom)	☐ Mild	☐ Moderate	☐ Severe
26. *Feeling nervous or anxious*	☐ None (Not Experiencing This Symptom)	☐ Mild	☐ Moderate	☐ Severe
27. *Increased headache following physical activity*	☐ None (Not Experiencing This Symptom)	☐ Mild	☐ Moderate	☐ Severe
28. *Increased headache following cognitive activity*	☐ None (Not Experiencing This Symptom)	☐ Mild	☐ Moderate	☐ Severe
29. *Feeling more stressed than usual*	☐ None (Not Experiencing This Symptom)	☐ Mild	☐ Moderate	☐ Severe

FIGURE 1. **A** *to* **C**, *Pages of the concussion clinical profile screen (CP Screen).*

each VOMS item on a Likert-type scale ranging from 0 (none) to 10 (severe). NPC is assessed using symptoms and an average of 3 measures of NPC distance. The VOMS take 5 to 7 min to administer. VOMS has high internal consistency.[26-28]

Procedures

Controls completed the CP Screen and PCSS as part of baseline preseason testing. Controls were tested in a group setting of 10 or fewer athletes by trained researchers and/or clinicians. Concussed



C

CP SCREEN SCORING SHEET

None= 0, Mild= 1, Moderate= 2, Severe= 3

PROFILE SCORES:

	RAW		AVERAGE
ANXIETY/MOOD (Items 1, 5, 10, 26, 29)=	_____	÷5=	_____
COGNITIVE/FATIGUE (Items 13, 24, 28)=	_____	÷3=	_____
MIGRAINE (Items 2, 6, 11, 20, 27)=	_____	÷5=	_____
OCULAR (Items 3, 7, 8, 14, 19)=	_____	÷5=	_____
VESTIBULAR (Items 4, 9, 12, 15, 21)=	_____	÷5=	_____

MODIFIER SCORES:

	RAW		AVERAGE
SLEEP (Items 17, 18, 22, 23)=	_____	÷4=	_____
NECK (Items 16, 25)=	_____	÷2=	_____

CP SCREEN TOTAL RAW SCORE= _____

FIGURE 1. *Continued*

participants completed the CP Screen, PCSS, ImPACT, and VOMS at their first clinic visit following concussion. All postconcussion testing was completed in individual exam rooms by clinicians.

Statistical Methods

Based on a null hypothesis of Cronbach's alpha ≤.70, scale reliability of Cronbach's alpha ≥.80, $P < .05$, 80% power, and 29 items in the CP Screen, a sample size of at least 100 participants per group was indicated for 80% power for the primary reliability analysis. Independent samples *t*-tests for continuous variables, and Chi square tests for categorical variables were performed to compare controls and concussed on demographics and CP Screen subscale and total scores. Interitem Pearson product-moment correlations were performed on the CP Screen items and subscale scores. Reliability was assessed using internal consistency (ie, Cronbach's alpha) for the CP Screen and PCSS in both control and concussed samples. Concurrent validity of the CP Screen in the concussed sample was tested using Pearson product-moment correlations among the CP Screen subscale and total scores; and PCSS factor and total scores, VOMS item scores, and ImPACT composite scores. Predictive validity was evaluated using multivariate analysis of variance (MANOVA) with post hoc Scheffe tests comparing the CP Screen subscale and modifier scores between controls and concussed. Partial eta-squared values were also derived from MANOVA as a measure of effect size, in which .01 is small, .09 is medium, and .25 is large. Predictive validity of the CP Screen for identifying concussed from controls was evaluated using a receiver operating characteristic (ROC) curve analyses with area under the curve (AUC) for each CP Screen subscale score. Statistical tests were evaluated at $P < .05$ and conducted using Statistical Package for Social Sciences (International Business Machines Corporation, Armonk, New York) version 24.

TABLE 1. Demographic Data for Controls (n = 127), Concussed (n = 121), and the Total Sample (n = 248)

Variable	Controls	Concussed	Total
Age (years), M (SD)	15.79 (1.19)***	18.83 (10.29)***	17.30 (7.44)
Gender (female), # (%)	37 (29%)*	51 (42%)*	88 (35%)
Concussion history (Yes), # (%)	32 (33%)**	52 (43%)**	84 (34%)
Migraine history (Yes), # (%)	14 (11%)**	32 (26%)**	46 (19%)
Attention deficit hyperactivity disorder/ learning disability (yes), # (%)	13 (10%)	21 (17%)	34 (14%)

*$P < .05$, **$P < .01$, ***$P < .001$.

RESULTS

Descriptive Data

All 127 consecutively enrolled control participants met eligibility criteria and were included in the study. The concussed sample included 121/137 (88%) eligible participants. A total of 16/137 (12%) concussed participants were excluded because they were evaluated outside the 30 d within injury time period. A total of 44% (n = 53) of the concussed sample were from the western Pennsylvania site, 33% (n = 40) from the northern Virginia site, and the 23% (n = 28) from the Arkansas site. Descriptive data for the sample are provided in Table 1. The concussed sample was older (t = 3.30, $P = .001$), had more females (Chi square = 4.31, $P = .04$), more concussion history (Chi square = 8.96, $P = .003$), and more migraine history (Chi square = 8.74, $P = .003$) than controls. Time since injury breakdown for the concussed sample was 60% (n = 73) <7 d, 31% (n = 36) 8 to 20 d, and 9% (n = 12) 21 to 30 d. On average, the time since injury for the concussed sample was 8.17 (SD = 7.16) d, with all participants within 30 d of injury.

Content Validity

The CP Screen was rigorously developed based on tool construction principles including the following: 1) review of extant theory and literature, 2) review of existing symptom measures, 3) interviews and discussions with concussion clinical and research experts, and 4) an iterative item development process. The original 31-item CP Screen was sent to 10 concussion clinical and research experts, representing 2 clinics and 2 universities for detailed feedback on content, wording, clarity, representativeness, and instructions. In addition, the experts provided suggestions for items that should be removed and possible new items. In order for an item to be retained, 80% of experts had to agree. Following this process, 2 items were removed from the CP Screen, and 11 items were revised, resulting in the 29-item version described in the Methods (see Figure 1).

TABLE 2. Correlations Among the CP Screen Factor and Modifier Scores in the Concussed Sample (n = 121)

	Anxiety/ mood (AM)	Cognitive (C)	Migraine (M)	Ocular (O)	Vestibular (V)	Sleep (S)
A/M	–					
C	.47*	–				
M	.33*	.56*	–			
O	.44*	.66*	.74*	–		
V	.53*	.58*	.62*	.72*	–	
S	.55*	.57*	.42*	.38*	.47*	–
N	.43*	.38*	.35*	.34*	.33*	.40*

*$P < .001$.

TABLE 3. Correlations Among the CP Screen Factor and Modifier Scores and PCSS Factor Scores in the Concussed Sample (n = 121)

CP Screen factor/modifier	PCSS factor			
	Somatic	Cognitive	Sleep	Affective
Anxiety/mood	.34**	.46**	.48**	.71**
Cognitive	.52**	.71**	.59**	.48**
Migraine	.70**	.50*	.40*	.32*
Ocular	.71**	.67**	.45**	.46**
Vestibular	.71**	.70**	.50**	.52**
Sleep	.39**	.49**	.83**	.42**
Neck	.36**	.36**	.36**	.41**

*$P < .01$, **$P < .001$.

Reliability

Internal consistency of the CP Screen among controls was high (Cronbach's alpha = .87), with all items contributing positively to overall reliability. Average measure ICC for controls using a one-way random model was .86. The internal consistency of the CP Screen among concussed was high (Cronbach's alpha = .92), with all items contributing positively to overall reliability. The average measures intraclass correlation coefficient (ICC) for concussed using a one-way random model was .91. The internal consistency of the PCSS in the current sample was similar with Cronbach's alpha = .93 and the average ICC = .92.

CP Screen Factor Correlations

Pearson product-moment correlations among the CP Screen subscales and modifiers in among concussed are presented in Table 2. All subscales and modifiers were positively correlated ranging from r = .33 to .74 (all $P < .001$). Correlations with the highest magnitude were supported for the following: 1) anxiety/mood and sleep (r = .55); 2) cognitive and ocular (r = .66); 3) migraine and ocular (r = .74); 4) vestibular and ocular (r = .72); 5) sleep and cognitive (r = .57); and 6) neck and anxiety/mood (r = .43).

Concurrent Validity

CP Screen and PCSS

Pearson product-moment correlations among the CP Screen subscale and modifier scores and the PCSS factor scores among concussed are presented in Table 3. All CP Screen subscale and modifier and PCSS factor scores were positively correlated ranging from r = .32 to .83 (all $P < .001$). Correlations with the highest magnitude are as follows: 1) anxiety/mood and affective (r = .71); 2) cognitive and cognitive (r = .71); 3) migraine and somatic (r = .70); 4) vestibular and somatic (r = .71); 5) ocular and somatic (r = .71); 6) sleep and sleep (r = .83); and 7) neck and affective (r = .41).

CP Screen and VOMS

Pearson product-moment correlations among the CP Screen subscale and modifier scores and the VOMS items among concussed are presented in Table 4. All CP Screen subscale and modifier and VOMS symptom provocation item scores were positively correlated, ranging from r = .20 to .67 (all $P < .05$). Correlations with the highest magnitude are as follows: 1) anxiety/mood and VVOR (r = .47); 2) cognitive and horizontal saccades (r = .57); 3) migraine and smooth pursuits (r = .64); 4) ocular and vertical saccades (r = .67) and VMS (r = .67) (tie); 5) vestibular and smooth pursuits (r = .67); 6) sleep and VVOR (r = .38); and 7) neck and VVOR (r = .31) and VMS (r = .31) (tie). NPC distance was not significantly correlated to any CP Screen subscale or modifier.

CP Screen and ImPACT

Pearson product-moment correlations among CP Screen subscale and modifier and ImPACT neurocognitive composite scores in the concussed sample are presented in Table 5. All CP Screen subscale and modifiers (except neck) were significantly correlated to verbal and visual memory scores. However, only 5/14 correlations among CP Screen subscale and modifier scores and visual motor processing speed and reaction time scores were significant (Table 6). The cognitive subscale and sleep modifier from the CP Screen were the only subscales or modifiers that were significantly correlated to all ImPACT composite scores (Table 5). Correlations with the highest magnitude are as follows: 1) anxiety/mood and verbal memory (r = −.23); 2) cognitive and verbal memory (r = −.44); 3) migraine and visual memory (r = −.33); 4) ocular and verbal and visual memory (both r = −.33); 5) vestibular and verbal memory (r = −.35); 5) sleep and verbal memory (r = −.34); and 6) neck and verbal memory (r = −.19).

Predictive Validity

A MANOVA with post hoc Scheffe tests comparing controls and concussed across CP Screen subscales and modifiers was significant (Wilk's lambda = .51, F [df = 7] = 30.72, $P < .001$, partial eta squared = .49) (Table 6). The largest effect size differences were supported for migraine (partial eta squared = .45), ocular (partial eta squared = .42), vestibular (partial eta squared = .36), and cognitive (partial eta squared = .28) CP

TABLE 4. Correlations Among the CP Screen Factor and Modifier Scores and VOMS Item Scores in the Concussed Sample (n = 121)

CP Screen factor/modifier	VOMS item							
	SP	HSAC	VSAC	CONV	HVOR	VVOR	VMS	NPC
Anxiety/mood	.40***	.41***	.40***	.41***	.41***	.47***	.46***	.06
Cognitive	.55***	.57***	.55***	.51***	.51***	.52***	.52***	.17
Migraine	.64***	.62***	.61***	.56***	.61***	.62***	.62***	.16
Ocular	.65***	.66***	.67***	.59***	.64***	.65***	.67***	.17
Vestibular	.67***	.65***	.66***	.58***	.65***	.66***	.65***	.08
Sleep	34***	.35***	.35***	.35***	.34***	.38***	.36***	.06
Neck	.28**	.27**	.24**	.20*	.30**	.31**	.31**	−.09

*$P < .05$, **$P < .01$, ***$P < .001$; SP, smooth pursuits; HSAC, horizontal saccades; VSAC, vertical saccades; CONV, convergence; HVOR, horizontal vestibulo-ocular reflex; VVOR, vertical vestibulo-ocular reflex; VMS, visual motion sensitivity.

TABLE 5. Correlations among the CP Screen Factor and ImPACT Composite Scores in the Concussed Sample (n = 121)

CP Screen factor/modifier	ImPACT composite score			
	Verbal memory	Visual memory	Visual motor processing speed	Reaction time
Anxiety/mood	−.23*	−.22*	−.15	.05
Cognitive	−.44***	−.34***	−.30**	.22*
Migraine	−.32**	−.33***	−.15	.10
Ocular	−.35***	−.35***	−.22*	.14
Vestibular	−.35***	−.31**	−.18	.08
Sleep	−.34***	−.21*	−.31**	.19*
Neck	−.19*	−.13	−.06	.10

*$P < .05$, **$P < .01$, ***$P < .001$.

Screen subscale scores (Table 6). Results from an independent samples *t*-test (t = 12.47, $P < .001$) indicated that the total CP Screen score across all subscales and modifiers was higher for concussed (M = 21.49, SD = 14.10) than controls (M = 4.22, SD = 5.69).

Results from the ROC curve analyses identifying concussed from controls were significant (all $P < .001$) for all CP Screen subscales and modifiers (Figure 2). The AUCs for migraine (AUC = .93), ocular (AUC = .88), vestibular (AUC = .85), and cognitive (AUC = .81) were all excellent (.80-.90) or outstanding (>.90), and the AUC for anxiety/mood (AUC = .71) was good (.70-.80). However, the AUCs for sleep (AUC = .63) and neck (AUC = .64) were poor (.60-.70).

DISCUSSION

Key Results

The primary purpose of the current study was to evaluate the reliability and validity of a newly developed, brief, clinical profile-based symptom inventory; the CP Screen. Preliminary findings indicate that the CP Screen had high reliability in both concussed (Cronbach's alpha = .92, ICC = .91) and controls (Cronbach's alpha = .87, ICC = .86). The reliability of the CP Screen in the current concussed sample was comparable to the reliability of the PCSS from the same sample (ie, Cronbach's alpha = .93, ICC = .92). The reliability of the CP Screen in both samples was comparable to the PCSS in the current study and higher than the reliability reported previously for other symptom questionnaires administered postinjury, such as the RPQ[8] and Head Injury Scale (HIS).[5] In short, the reliability of the CP Screen is consistent with or better than current concussion symptom inventories.

The CP Screen demonstrated high concurrent validity with the PCSS. The correlations among PCSS factors (ie, somatic, cognitive, sleep, and affective) and CP Screen subscales and modifiers were also intuitive, and the magnitude was high. For example, correlations for the CP Screen cognitive subscale and PCSS cognitive symptom factor, and CP Screen anxiety/mood subscale and affective symptom factor, and CP Screen sleep modifier and PCSS sleep symptom factor were all high (>.70). However, the somatic factor from the PCSS was highly correlated with several CP Screen subscales, including migraine, ocular, and vestibular. This pattern suggests that the CP Screen subscales might provide the clinician with more specific symptomology reflective of clinical profiles. In contrast, the PCSS factor scores may provide a more global measure of somatic or physical symptoms that may reflect multiple clinical profiles.

The concurrent validity of the CP Screen and the VOMS was also high. Importantly, the highest correlations were between VOMS items and the vestibular and ocular subscales of the CP Screen. The NPC distance component of the VOMS was not related to any of the CP Screen factors or modifiers. This finding suggests that the NPC distance is measuring a construct that is distinct from the symptom provocation items on the VOMS. The correlations among CP Screen subscale and modifier scores and ImPACT scores were low to moderate. However, the highest correlation was supported for verbal memory and the CP Screen cognitive subscale. In fact, the cognitive factor was the

TABLE 6. Comparison of CP Screen Factor and Modifier Scores between Concussed (n = 121) and Controls (n = 127)

CP Screen factor/modifier	Concussed		Controls		F	Partial eta squared
	M (SD)	95% CI	M (SD)	95% CI		
Anxiety/mood	2.93 (2.92)	2.41-3.45	1.02 (1.56)	1.02-1.29	39.06*	.15
Cognitive	2.98 (2.14)	2.60-3.36	.85 (1.19)	.64-1.06	88.59*	.28
Migraine	4.42 (3.29)	3.83-5.01	.38 (.92)	.22-.54	181.56*	.45
Ocular	4.71 (3.38)	4.11-5.31	.55 (1.16)	.35-.75	164.42*	.42
Vestibular	3.55 (2.97)	3.02-4.08	.38 (.92)	.22-.54	126.68*	.36
Sleep	1.92 (2.32)	1.51-2.33	.89 (1.45)	.64-1.14	16.77*	.07
Neck	.98 (1.55)	.70-1.26	.23 (.57)	.13-.33	24.58*	.10

*$P < .001$.

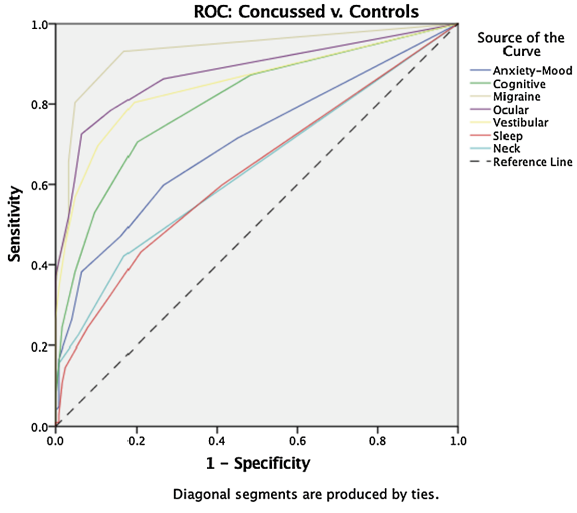


FIGURE 2. *ROC for CP Screen factor and modifier scores for concussed compared to controls.*

only one of the CP Screen subscales that had significant correlations with all neurocognitive test composites, which suggests there is a relationship between perceived cognitive symptoms by the patient and objective performance on neurocognitive testing. The only CP Screen modifier with correlations across neurocognitive composites was sleep. This is not surprising, as poor sleep has been associated with neurocognitive deficits on computerized testing in concussed[29,30] and healthy athletes.[31,32] Other relationships from the current study concurred with previous research, such as the negative correlation between memory and migraine[33] and positive association between ocular dysfunction and cognitive deficits.[34]

With regard to predictive validity, responses to the CP Screen following concussion appear to reflect the injury, as controls reported relatively low scores. Results of the ROC curve analysis were robust and indicate that the migraine, vestibular, ocular, and cognitive CP Screen subscales are effective in identifying concussed from the controls. Provided the nonspecific nature of many concussion symptoms (eg, anxiety) that comprise the CP Screen anxiety/mood subscale and sleep and neck modifiers, it is not surprising that these factors were less effective in identifying concussed from controls. In spite of this finding, concussed reported elevated scores on these subscales and modifiers compared to controls. This finding suggests that these CP Screen subscales and modifiers may help quantify symptoms of anxiety/mood, sleep, and neck problems beyond what is typical in uninjured athletes because of preinjury issues (eg, psychiatric history and sleep difficulties). These findings highlight the need for comprehensive, multifaceted assessment tools in concussion diagnosis and management.

Limitations and Future Directions

The current study was limited by self-report bias from an assumption of accurate and insightful reporting of symptoms. Also, we did not examine test-retest reliability or stability of the CP Screen across time. We also did not explore the role of age, gender, concussion history, migraine history, or time since injury on responses to the CP Screen. Given that the concussed and control samples in the current study were different in age, gender, migraine history, and concussion history, these factors may have influenced the overall group differences in responses on the CP Screen. Moving forward, researchers should evaluate test-retest reliability and examine the effects of age, gender, and time since injury on responses to the CP Screen. Researchers should confirm the factor structure of the CP Screen, which was based on preliminary empirical data.[17] Researchers should also evaluate the utility of the measure to discriminate among different profiles and modifiers. In so doing, the CP Screen could inform clinicians' evaluation of the type and intensity of clinical profiles experienced by patients following concussion, which, in turn, can guide treatment recommendations and help evaluate treatment effectiveness.

CONCLUSION

This preliminary study of the CP Screen indicates that it is a brief, reliable, and valid inventory that can complement current tools. The CP Screen demonstrated strong reliability and concurrent validity with commonly used concussion assessment (ie, PCSS, VOMS, and ImPACT). The CP Screen may extend current symptom inventories by evaluating more specific symptoms and subscales that reflect clinical profiles. In so doing, the CP Screen expands the current emphasis on symptom total and severity.

Disclosures

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COMMENTS

The authors present a new scale, the CP-Screen, which appears to have psychometric properties that are consistent with current concussion symptom inventories. The scale shows good internal consistency, and the study reveals both convergent validation with existing symptom

scales, vestibular-ocular motor measures (eg, VOMS), and neurocognitive measures of memory (eg, ImPACT Verbal and Visual Memory), as well as divergent validation with neurocognitive measures of reaction time and processing speed (eg, ImPACT Reaction Time and Visual Motor Processing Speed).

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The authors describe a new screening tool for evaluation of concussed youth (age 12-19). It was designed for integrate factors associated with concussion felt to be lacking from current screening tools (vestibular, ocular, cognitive, post-traumatic migraine, and anxiety/mood profiles) in an attempt to evaluate concussion in the setting of confounding factors, and to more accurately evaluate important concussion modifiers like cervical pathology and sleep disturbance. The profile was developed with cooperation from 10 clinical and research concussion experts, and feedback was obtained from research participants on the ease and clarity of use. One limitation may be including study participants within 30 days of the injury, as many may have recovered in that time, but the average injury to participation time was 8.17 days (SD 7.16). In comparison to current screening tools (PCSS, ImPACT, VOMS) it showed good validity and reliability. Overall this seems to be a well-designed and validated tool for the screening of this important patient population, and I look forward to seeing it further evaluated in larger numbers.

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