Journal of Athletic Training 2024;59(9):934–940
doi: 10.4085/1062-6050-0325.23
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Reliable Change Indices for the Serial Administration of the Concussion Clinical Profiles Screening Tool

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Context: The Concussion Clinical Profiles Screening Tool (CP Screen) self-report concussion symptom inventory is often administered at weekly intervals. However, 1-week reliable change indices (RCIs) for clinical cutoffs and the test–retest reliability of the CP Screen are unknown.

Objective: To document RCI cutoff scores and 1-week test–retest reliability for each profile and modifier of the CP Screen for men and women.

Design: Case series.

Setting: A large US university.

Patients or Other Participants: One hundred seventy-three healthy college students.

Main Outcome Measure(s): Participants completed 2 administrations of the CP Screen 7 days apart. The CP Screen items yielded 5 clinical profiles and 2 modifiers. Spearman ρ coefficients (r_s), intraclass correlation coefficients (ICCs), single measures, and unbiased estimates of reliability (UERs) were used to assess test-retest reliability. Wilcoxon signed-rank tests assessed differences across time. Reliable change index values and cutoff scores are provided at 90%/95% CIs. All analyses were performed for the total sample and separately for men and women.

Results: Reliable change index cutoffs for clinically significant change (increase/decrease) at a 90% CI for men were as follows: ocular, vestibular >2/>4; anxiety/mood, cognitive/fatigue, and migraine >3/>3; sleep >4/>6; and neck >2/>2. Reliable change index cutoffs for clinically significant change (increase/decrease) at a 90% CI for women were as follows: anxiety/mood ≥2/≥4; cognitive/fatigue, migraine, ocular, vestibular, and sleep ≥3/≥3; and neck ≥1/≥1. Correlations for the CP Screen ranged from 0.51 (migraine) to 0.79 (anxiety/mood) for the total sample, from 0.48 (migraine) to 0.84 (vestibular) for men, and from 0.51 (migraine) to 0.77 (ocular) for women. Test-retest indices for each profile and modifier were moderate to good for the total sample (ICC, 0.64–0.82; UER, 0.79–0.90), men (ICC, 0.60–0.87; UER, 0.76–0.94), and women (ICC, 0.64–0.80; UER, 0.78–0.89).

Conclusion: The CP Screen is reliable and stable across a 1-week interval, and established RCIs for men and women can help identify meaningful change throughout recovery.

Key Words: clinical cutoffs, symptoms

Key Points

- The Concussion Clinical Profiles Screening Tool (CP Screen) is designed to be used as part of the serial evaluation and assessment of concussion to monitor symptom progression throughout recovery.
- The CP Screen is a stable and reliable measure across a 1-week interval.
- The established reliable change index cutoffs for the CP Screen can be used to determine clinically meaningful changes in concussion symptoms that represent clinical profiles.
- Women show greater variation in symptom presentation, resulting in somewhat higher cutoff scores than men.

Concussion, or mild traumatic brain injury, is a heterogeneous injury that is best managed and treated with a targeted, multidomain assessment that involves the identification of concussion clinical profiles.[1–4] Several researchers have proposed 5 concussion clinical profiles that include (1) anxiety/mood, (2) cognitive, (3) migraine/headache, (4) vestibular, and (5) ocular and 2 modifiers that include neck and sleep.[1,2,5,6] The process by which a clinician identifies a clinical profile involves the interpretation of patient-reported information from the clinical interview/exam as well as data from a multidomain assessment battery (eg, neurocognitive, vestibular/ocular motor, balance, symptoms, and mood). Among these domains, patient-reported symptoms are a major component for the identification of clinical profiles. More specifically, the environmental context in which symptoms are experienced and a more nuanced description of symptoms is important information for the clinician to determine a clinical profile. For example, feelings of "slow wavy dizziness" and "trouble focusing your eyes while reading" are indicative of the vestibular and ocular profiles, respectively. Symptom scales that have been traditionally used for the assessment of

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concussion (ie, Post-Concussion Symptom Scale [PCSS]) have lacked this detail and prompted the development of the Clinical Profiles Screen (CP Screen).[7]

The CP Screen includes 29 items that address specific symptoms and how they present in different environments and situations within each of the 5 clinical profiles and the 2 modifiers.[7] The CP Screen is comprised of 29 novel symptom items that are not duplicate items of the PCSS. The presence, absence, and severity of symptoms are assessed on a 4-point Likert scale ranging from 0 to 3 (0 indicating *not experiencing this symptom* and 3 indicating *severe*). The CP Screen is represented by a total symptom score (ie, the sum of items across the entire measure) and an average score for each clinical profile and modifier.[7] Researchers have documented high internal consistency for the CP Screen in both healthy (Cronbach $\alpha = 0.87$) and concussed samples (Cronbach $\alpha = 0.92$), as well as good predictive validity for distinguishing individuals with concussion from those without.[7] This study represented the first steps in documenting the psychometric properties of the CP Screen.

The CP Screen is designed to be included as part of the serial evaluation and assessment of concussion that commonly occurs (eg, every 5 to 7 days) following injury. Given that concussion symptoms are known to fluctuate throughout recovery, it is important for clinicians to monitor progress and adjust treatment/management strategies as necessary.[8–11] For example, an individual with a vestibular and anxiety/mood concussion presentation may require an adjustment of their initial treatment plan to address their mood symptoms as their vestibular symptoms and impairments resolve. Moreover, concussion-like symptoms increase and decrease in healthy individuals as part of normal everyday life.[12] Given these fluctuations, it is important to distinguish between normal and clinically significant changes in symptoms. This can be addressed by documenting test-retest reliability, changes across time, and reliable change indices (RCIs) with an associated clinical cutoff score for a measure. Although correlations document the linear relationship between scores at 2 time points, RCIs provide cutoff scores that reflect the magnitude of change required (at an 80%, 90%, or 95% CI) to reflect a change that occurs beyond chance or normal variation in performance. Incorporating test-retest reliability coefficients, RCIs control for systematic error or variance that is inherent in serial assessment of concussion-related symptomology, allowing for the identification of clinical change that occurs beyond the range of normal variation.[13] However, test-retest reliability and RCIs have not yet been reported for the CP Screen. In addition, researchers have previously reported sex differences on the CP Screen following concussion, and future psychometric investigations should consider these important differences to better inform the use of this tool.[14] The purpose of this study was to examine the 1-week test-retest reliability of the CP Screen in nonconcussed, college-aged individuals. A secondary purpose was to establish RCI cutoffs for each of the CP Screen profile and modifier scores for college-aged men and women.

METHODS

Research Design

A prospective, repeated measures research design was used for this study.

Participants

Participants included men and women from an undergraduate and graduate college-aged (ages 18–25 years) sample. Any student who self-reported either a current medical diagnosis of a head injury or a head injury between assessments was excluded from participation.

Measures/Instrumentation

Demographics and Medical History. Participants were asked to provide information about personal and health history, including their age, sex, history of medically diagnosed concussion, and self-reported (ie, yes/no) history of migraine, motion sickness, depression, anxiety, attention-deficit/hyperactivity disorder, and/or learning disability. These demographic and medical history questions are a recommended part of a clinical evaluation for concussion.[15]

CP Screen. The CP Screen is a 29-item self-report symptom inventory used to calculate subscores for 5 clinical profiles and 2 modifiers based on how participants are currently feeling on a 4-point Likert scale ranging from 0 (*none*) to 3 (*severe*). The clinical profiles include anxiety/mood (5 items), cognitive/fatigue (3 items), migraine (5 items), vestibular (5 items), and ocular (5 items), and the 2 modifiers include neck (2 items) and sleep (4 items).[2] A total score for each clinical profile and modifier was calculated as the sum of all of the CP Screen items that corresponded to that profile. Total scores were used in the current study instead of the average scoring method used in previous research.[7] Total scoring resulted in whole-number RCI cutoff scores rather than real numbers, which made the RCI values more interpretable (ie, avoided decimals as RCI cutoff values). The CP Screen takes approximately 4 to 6 minutes to complete and is designed for children and adults (12 years and older). Current psychometrics for this measure include high internal consistency in both healthy (Cronbach $\alpha = 0.87$) and concussed (Cronbach $\alpha = 0.92$) samples and good predictive validity (partial $\eta^2 = .49$).[7]

Procedure

The study was approved by the university Institutional Review Board. Researchers recruited participants from undergraduate and graduate classes at a large university in the Midwest region of the United States. After the study was explained to students and informed consent was obtained, the demographics and medical health history form and CP Screen were immediately administered to the participants (Time 1) during their class time (ie, group setting). The research team returned to the participating classes 1 week later (Time 2), and participants completed the CP Screen a second time during their class time. Members of the research team supervised all group data collection to ensure a controlled environment for the completion of the questionnaires. If participants did not attend class when Time 2 data were collected, they were excluded from the study and data analysis. All participants who completed measures at Time 1 and Time 2 were entered into a raffle to win gift cards.

Data Analyses

Descriptive statistics (eg, mean, median, SD, and range) were used to describe participant demographics, and total

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CP Screen scores at Times 1 and 2 were calculated for each profile. Normality was assessed for all CP Screen scores, and the Shapiro-Wilks values ranged from 0.51 to 0.90 (all $P < .001$); therefore, data were decidedly nonnormal. Differences in CP Screen scores between Time 1 and Time 2 for the total sample, men, and women were examined with a series of nonparametric Wilcoxon signed-rank tests. Given the number of these repeated-measures analyses (eg, of the 7 profiles and modifiers), a Bonferroni-corrected α level of $P < .007$ was used. However, to better gauge the magnitude of difference, Cohen's *d* was documented as a measure of effect size, with 0.2 denoting a *small* effect size, 0.5 denoting a *medium* effect size, and 0.8 denoting a *large* effect size.[16]

Spearman ρ correlations (r_s) were used to examine the relationship of CP Screen scores between the 2 time points for the total sample. Cutoff values of *low* ($\leq$0.39), *moderate* (0.40 – 0.59), *moderately high* (0.60 – 0.79), and *high* ($\geq$0.80) were used for interpretation.[17] Intraclass correlation coefficients (ICCs) were calculated to distinguish those sets of scores that are merely ranked in the same order from test to retest from those that are not only ranked in the same order but are also in low, moderate, or complete agreement and were used as an indicator of test-retest reliability.[18] The ICC model 2-way mixed type consistency was used, using single measures. Given that systematic error variance may bias or inflate correlation coefficients, ICC analyses also yield an unbiased estimate of reliability (UER), which corrects for any over- or underestimation of the consistency of the measure across 2 time points.[19]

Reliable change indices were calculated for each profile and modifier using 90% and 95% CIs to assess whether a change between repeated assessments was reliable and meaningful.[13] Within a normal distribution of difference scores, 10% and 5% of scores are expected to fall outside of the 90% and 95% CIs, respectively. Reliable change index methodology identifies cutoff scores that are an estimate of the probability that a given difference in score would not be obtained as a result of measurement error[20] and were calculated for the total sample and separately for men and women. Statistical tests were conducted using Statistical Package for Social Sciences (IBM Corporation) version 28.0 and Microsoft Excel (Excel 2019).

RESULTS

A total of 269 participants enrolled in the study and completed the CP Screen at Time 1. Eighty-seven participants (32%) did not attend class to complete the Time 2 study measures, and 9 participants had missing data, so these 96 participants (36%, 96/269) were excluded from final analyses. A final sample of 173 participants (mean age [M_{age}] = 20.66 years, SD = 1.43 years) completed the CP Screen at Times 1 and 2 (ie, 64% response rate). There were 82 men (M_{age} = 20.71 years, SD = 1.38 years) and 91 women (M_{age} = 20.63 years, SD = 1.47 years) in the study. The 2 study visits were 7 days apart. Due to inclement weather and university closure, 48 participants completed their second study visit online instead of in person. The CP Screen scores for this smaller online sample were compared with the in-person scores with a series of Mann-Whitney *U* tests, and there were no significant differences between these responses for any of the outcomes ($P >$. 05). Participant demographics, history of medically diagnosed concussions, and self-reported health histories are presented in Table 1.

Table 1. Participant Demographics for the Total Sample, Men, and Women

	Total (N = 173)	Men (n = 82)	Women (n = 91)
	Frequency (%)		
Race			
White	157 (90.8)	71 (86.6)	86 (94.5)
Black or African American	7 (4.0)	3 (3.7)	4 (4.4)
Asian	6 (3.5)	6 (7.3)	0 (0.0)
Native Hawaiian or Pacific Islander	2 (1.2)	1 (1.2)	1 (1.1)
American Indian or Alaskan Native	1 (0.6)	1 (1.2)	0 (0.0)
Concussion history[a]			
0	129 (75.9)	59 (72.8)	70 (78.7)
1	26 (15.3)	13 (16.0)	13 (14.6)
2	7 (4.1)	3 (3.7)	4 (4.5)
3 or more	8 (4.7)	6 (7.4)	2 (2.2)
Previous health history of			
Migraines	28 (16.18)	10 (12.2)	18 (19.8)
Motion sickness	45 (26.01)	18 (22.0)	27 (29.7)
Depression	31 (17.92)	14 (17.1)	17 (18.7)
Anxiety	73 (42.20)	29 (35.4)	44 (48.4)
ADHD/LD	31 (17.92)	17 (20.7)	14 (15.4)

Abbreviation: ADHD/LD, attention-deficit/hyperactivity disorder/learning disability.

[a] Total sample, N = 170; men, n = 81; and women, n = 89 (3 participants [1 man and 2 women] had missing data for concussion history).

The mean, median, and SDs for the total sample, men, and women are presented in Table 2. A series of Wilcoxon signed rank tests revealed that the anxiety/mood ($z = -3.46$, $P < .001$, $d = 0.15$), cognitive/fatigue ($z = -4.01$, $P < .001$, $d = 0.24$), ocular ($z = -4.28$, $P < .001$, $d = 0.23$), and vestibular ($z = -3.59$, $P < .001$, $d = 0.18$) Time 2 CP Screen scores were significantly lower than Time 1 scores for the total sample, but the magnitude of these differences reflected small effect sizes. The total scores for men were significantly lower at Time 2 than at Time 1 for the anxiety/mood ($z = -2.80$, $P =. 005$, $d = 0.15$), cognitive/fatigue ($z = -3.66$, $P <. 001$, $d = 0.32$), ocular ($z = -3.87$, $P <. 001$, $d = 0.31$), and sleep ($z = -2.91$, $P = .004$, $d = 0.25$) profiles and modifier. By contrast, Time 1 and Time 2 scores did not significantly differ for women ($P \geq .01$) on any CP Screen outcome. Concerning sex, effect sizes were higher for men than for women on the cognitive/fatigue ($d = 0.32$ versus 0.20), migraine ($d = 0.18$ versus 0.01), ocular ($d = 0.31$ versus 0.17), sleep ($d = 0.25$ versus 0.02), and neck ($d = 0.24$ versus -0.04) profiles and modifiers, whereas effect sizes were higher for women on the anxiety/mood ($d = 0.16$ versus 0.15) and vestibular ($d = 0.21$ versus 0.15) profiles. Means, medians, and SDs for CP Screen scores across study time points are presented in Table 2.

Test-Retest Reliability

Spearman correlation coefficients revealed significant, moderate-to-high relationships across the 2 time points for the total sample, ranging from 0.51 (migraine) to 0.79

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Table 2. Descriptive Statistics for Concussion Clinical Profiles Screening Tool Profile and Modifier Scores at Time 1 and Time 2 for the Total Sample (N = 173), Men (n = 82), and Women (n = 91)

	Time 1			Time 2					
	M	Med	SD	M	Med	SD	z^a	Sig[b] (2-tailed)	d^c
Anxiety/mood									
Total	2.95	3.00	2.64	2.56	2.00	2.51	−3.46	<.001	.15
Men	2.34	2.00	2.33	2.00	2.00	2.11	−2.80	.005	.15
Women	3.51	3.00	2.80	3.07	2.00	2.74	−2.26	.02	.16
Cognitive/fatigue									
Total	1.48	1.00	1.40	1.14	1.00	1.45	−4.01	<.001	.24
Men	1.17	1.00	1.24	0.80	0.00	1.07	−3.66	<.001	.32
Women	1.76	1.00	1.49	1.45	1.00	1.66	−2.32	.02	.20
Migraine									
Total	0.73	0.00	1.41	0.62	0.00	0.40	−1.53	.13	.11
Men	0.60	0.00	1.36	0.38	0.00	1.03	−2.21	.03	.18
Women	0.85	0.00	1.46	0.84	0.00	1.63	−0.21	.83	.01
Ocular									
Total	1.40	1.00	1.79	1.01	0.00	1.60	−4.28	<.001	.23
Men	1.17	1.00	1.70	0.71	0.00	1.25	−3.87	<.001	.31
Women	1.60	1.00	1.86	1.29	1.00	1.82	−2.45	.01	.17
Vestibular									
Total	0.88	0.00	1.40	0.64	0.00	1.33	−3.59	<.001	.18
Men	0.80	0.00	1.56	0.59	0.00	1.30	−2.67	.007	.15
Women	0.96	1.00	1.25	0.68	0.00	1.36	−2.50	.01	.21
Sleep									
Total	1.73	1.00	1.96	1.49	1.00	1.81	−2.16	.03	.13
Men	1.74	2.00	1.78	1.30	1.00	1.68	−2.91	.004	.25
Women	1.71	1.00	2.11	1.67	1.00	1.90	−0.17	.87	.02
Neck									
Total	0.42	0.00	0.81	0.34	0.00	0.75	−1.47	.14	.10
Men	0.45	0.00	0.90	0.26	0.00	0.62	−2.43	.02	.25
Women	0.38	0.00	0.73	0.41	0.00	0.84	−0.46	.65	−.04

Abbreviations: M, mean; Med, median; Sig, significance.
[a] Wilcoxon signed-rank test *z* value.
[b] Bonferroni-corrected α, $P < .007$.
[c] Cohen *d*, a measure of effect size.

(anxiety; Table 3). Interclass correction coefficients reflected higher reliability than Spearman *r* across all measures. Anxiety/mood total scores showed the most stability (single ICC = 0.82; lower and upper 95% CIs = 0.77–0.87), followed by ocular (0.78; 0.71–0.83), vestibular (0.78; 0.71–0.83), migraine (0.71; 0.63–0.78), sleep (0.70; 0.61–0.77), cognitive/fatigue (0.68; 0.60–0.76), and neck (0.65; 0.56–0.73). Unbiased estimates of reliability were consistently higher than ICCs (anxiety/mood = 0.90, ocular = 0.88, vestibular = 0.88, migraine = 0.83, sleep = 0.82, cognitive/fatigue = 0.81, and neck = 0.79; Table 3).

Differences in the test-retest reliability between men and women were observed (Table 3). Both men (*r* values = 0.48–0.82) and women (*r* values = 0.51–0.77) had moderate-to-high relationships across the 2 time points. The vestibular profile (ICC = 0.87, UER = 0.94) and neck modifier (ICC = 0.60, UER = 0.76) demonstrated the highest and lowest reliability among men, respectively, whereas the anxiety/mood (ICC = 0.80, UER = 0.89) and cognitive/fatigue (ICC = 0.64, UER = 0.78) profiles demonstrated the highest and lowest reliability among women, respectively.

Reliable Change Indices

The percentage of individuals surpassing RCI cutoffs for each profile and modifier is listed in Table 4 and presented at the 90% and 95% CIs for the total sample and for men and women. After 1 week, 1% to 14% of the scores for the total sample and for men and women fell outside the range of normality, which is considerably close to what is expected for a 90% CI (eg, ≤90%; Table 4). However, although the overall percentage of cases demonstrating reliable change was generally within expected CIs (eg, for anxiety/mood, 90% of cases fell within a 90% CI), there was a consistent imbalance between scores decreasing versus increasing (eg, 7% decreasing and 3% increasing). Given that RCI cutoffs are derived for both improvement and decline but assume equal distribution in both directions, and our data revealed significant declines in median scores (Table 2), we adjusted RCI cutoffs to require an additional point for reliable change in decreased scores.[21] A reference guide for estimating change for each CP Screen profile and modifier total score is presented in Table 5, and additional reliability and RCI outcomes are listed in Table 6. The following RCI cutoffs for estimating clinically significant change (increase/decrease) at the 90% CI for men were used: ocular, vestibular ≥2/≥4; sleep ≥4/≥6; anxiety/mood, cognitive/fatigue, migraine ≥3/≥3; and neck ≥2/≥2. The following RCI cutoffs for estimating clinically significant change (increase/decrease) at the 90% CI for women were used: anxiety/mood ≥2/≥4; cognitive/fatigue, migraine, ocular, vestibular, sleep ≥3/≥3; and

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Table 3. One-Week Test-Retest Reliability Among the Concussion Clinical Profiles Screening Tool Profiles and Modifiers

			ICC 95% CI		
	r[a]	ICC[b]	Bottom	Top	UER
Anxiety/mood					
Total	0.79	0.82	0.77	0.87	0.90
Men	0.82	0.84	0.76	0.89	0.91
Women	0.72	0.80	0.72	0.87	0.89
Cognitive/fatigue					
Total	0.64	0.68	0.60	0.76	0.81
Men	0.70	0.74	0.62	0.82	0.85
Women	0.57	0.64	0.49	0.74	0.78
Migraine					
Total	0.51	0.71	0.63	0.78	0.83
Men	0.48	0.69	0.55	0.79	0.82
Women	0.51	0.72	0.60	0.81	0.84
Ocular					
Total	0.75	0.78	0.71	0.83	0.88
Men	0.71	0.77	0.67	0.85	0.87
Women	0.77	0.77	0.67	0.84	0.87
Vestibular					
Total	0.68	0.78	0.71	0.83	0.88
Men	0.84	0.87	0.81	0.92	0.94
Women	0.54	0.67	0.53	0.77	0.80
Sleep					
Total	0.63	0.70	0.61	0.77	0.82
Men	0.57	0.64	0.49	0.75	0.79
Women	0.70	0.74	0.63	0.82	0.86
Neck					
Total	0.63	0.65	0.56	0.73	0.79
Men	0.55	0.60	0.45	0.73	0.76
Women	0.70	0.71	0.60	0.80	0.84

Abbreviations: ICC, intraclass correlation coefficient, 2-way random, single measures; *r*, Spearman ρ correlations between Time 1 and Time 2 scores; UER, unbiased estimates of reliability.

[a] All *r* values $P < .001$, using Bonferroni-corrected α, $P < .007$.

[b] All ICC values $P < .001$, using Bonferroni-corrected α, $P < .007$.

Table 4. Percentages of the Sample That Would Be Classified as Having a Reliable Increase or Decrease in Profile and Modifier Total Scores Based on the 90%/95% CIs

	Decreased, % 90%/95%	No Change, % 90%/95%	Increased, % 90%/95%
Anxiety/mood			
All participants	7/3	90/94	3/1
Men	4/4	95/95	1/1
Women	5/2	94/98	1/0
Cognitive/fatigue			
All participants	13/2	84/94	3/2
Men	10/10	90/90	0/0
Women	3/3	94/94	3/3
Migraine			
All participants	4/4	94/94	2/2
Men	5/5	94/94	1/1
Women	3/3	94/94	3/3
Ocular			
All participants	6/6	94/94	0/0
Men	5/5	95/95	0/0
Women	7/7	92/92	1/1
Vestibular			
All participants	8/3	90/96	2/1
Men	5/5	95/95	0/0
Women	11/3	86/95	3/2
Sleep			
All participants	6/4	91/94	3/2
Men	9/4	89/95	2/1
Women	4/2	94/96	4/2
Neck			
All participants	3/3	94/94	3/3
Men	6/6	93/93	1/1
Women	0/0	94/94	4/4

neck ≥1/≥1. Overall, women require a greater magnitude of decline than men for anxiety/mood at the 90% and 95% CIs, and men require a greater magnitude of decline than women for ocular, vestibular, and sleep at the 90% and 95% CIs.

DISCUSSION

The current study documented the 1-week test-retest reliability of the CP Screen in nonconcussed college-aged men and women and established RCI cutoffs for each of the CP Screen profile and modifier scores. Overall, the CP Screen profile and modifier scores have moderate to moderately high reliability over a 1-week administration, as reflected by ICCs and UERs. In addition, although there were significant (*P* value) reductions in CP Screen scores across 1 week, the magnitude of change was small (effect size). Given that variation in performance is expected across time intervals, RCIs established that scores at the second assessment were generally within expected parameters, using 90% CIs. As such, these results demonstrate that the CP Screen is a stable measure of concussion symptomology over a 1-week retest interval, and these findings can be used to determine meaningful change in symptoms that underlie concussion clinical profiles.

The current study adds important information to a body of literature that has primarily focused on the identification of concussion symptom factors but has lacked study of the reliability and RCIs for these outcomes.[8,10,22–24] To date, only 1 study has established test-retest reliabilities for these symptom factors, and these researchers reported 6-week test-retest reliability for cognitive, physical, affective, and sleep PCSS symptom factors.[24] The correlations ranged from 0.44 to 0.80, and ICC values ranged from 0.44 to 0.77.[24] Despite a longer retest interval than the one used in the current study (ie, 6 weeks compared with 1 week), the correlations and ICCs across the PCSS symptom clusters and the CP Screen profile scores were comparable (r_s = 0.45 to 0.76, ICC = 0.50 to 0.78).

Table 5. Quick Reference Reliable Change Estimates: 90% and 95% CIs

	Men		Women	
	90% CI	95% CI	90% CI	95% CI
Anxiety/mood	3/3	3/3	2/4	3/5
Cognitive/fatigue	3/3	3/3	3/3	3/3
Migraine	3/3	3/3	3/3	3/3
Ocular	2/4	2/4	3/3	3/3
Vestibular	2/4	2/4	3/3	3/3
Sleep	4/6	5/7	3/3	4/4
Neck	2/2	2/2	1/1	2/2

[a] Reliable change index values reflect the required value for reliable increase/decrease.

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Table 6. SEMs, S_{diff}, and Reliable Change CIs for the Total Sample (N = 173) and Men (n = 82) and Women (n = 91)

					CIs[a]	
	SEM_1	SEM_2	S_{diff}	RCI	Δ90%	Δ95%
Anxiety/mood						
Total	1.21	1.51	1.67	0.24	2.81	3.36
Men	0.99	0.89	1.33	0.26	2.29	2.74
Women	1.48	1.45	2.07	0.21	3.43	4.10
Cognitive/fatigue						
Total	0.84	0.87	1.21	0.28	1.95	2.33
Men	0.68	0.59	0.90	0.41	1.57	1.88
Women	0.97	1.09	1.46	0.21	2.26	2.70
Migraine						
Total	0.99	0.98	1.40	0.08	2.30	2.74
Men	0.98	0.74	1.23	0.18	2.27	2.72
Women	1.02	1.14	1.53	0.01	2.37	2.83
Ocular						
Total	0.90	0.80	1.20	0.32	2.08	2.49
Men	0.91	0.67	1.14	0.41	2.12	2.53
Women	0.89	0.87	1.25	0.26	2.07	2.47
Vestibular						
Total	0.79	0.75	1.09	0.23	1.84	2.20
Men	0.62	0.52	0.81	0.27	1.45	1.73
Women	0.85	0.92	1.24	0.22	1.96	2.34
Sleep						
Total	1.19	1.10	1.62	0.15	2.76	3.30
Men	1.17	1.10	1.61	0.28	2.71	3.24
Women	1.16	1.04	1.56	0.03	2.68	3.20
Neck						
Total	0.50	0.46	0.67	0.12	1.15	1.37
Men	0.61	0.42	0.74	0.26	1.41	1.68
Women	0.40	0.46	0.61	–0.04	0.92	1.10

Abbreviations: SEM, standard error of measures at Times 1 and 2 = standard deviation [standard deviation × sqrt(1 − r_{xy})]; S_{diff}, standard error of difference scores based on Chelune et al[21]: sqrt [(SEM_1^2) + (SEM_2^2)]; RCI, reliable change index.

[a] Δ90% = absolute point change required for reliable change at the 90% and 95% range.

Concerning sex, differences in baseline and postinjury symptom reporting have suggested the need for separate clinical cutoffs on symptom screens.[14,25–27] The current study reported higher RCI cutoff scores for the anxiety/mood profile at both the 90% and 95% CIs for women and higher RCI cutoff scores for the neck modifier at the 90% CI for men. These differences in RCI cutoffs fill the gaps of previous research by providing evidence of sex being associated with clinically meaningful levels of concussion profiles or subtypes based on symptom reporting. However, the RCI cutoff scores established in this study should not be used as a sole determinant in clinical decisions. Rather, they are intended to assist clinicians in determining what constitutes a meaningful change in CP Screen profile and modifier scores throughout recovery. Given the clinical need for documenting meaningful changes in concussion symptoms across recovery, this study is the first to document RCI values and associated cutoffs for men and women using the CP Screen.

Strengths and Limitations

There are several strengths and limitations to the current study. The retest time interval used in the current study was well controlled (ie, all second visits occurred on the seventh day following the first visit) and reflects a weekly retest window that is commonly used for the clinical care of concussion. In addition, the current study included a sufficient sample size for the test-retest design and is comparable to other similar study designs.[7,24,28] However, the current study also had a high dropout rate, which is attributed to participants missing class on the second time that data collection was scheduled. There is no way of knowing if this dropout rate is only attributed to student absence from class or reflects a lack of interest in continued participation in the study. Additionally, the sample age range used in this study is only composed of healthy college-aged students, and these results cannot be applied or generalized to other age groups. Researchers report that adolescent symptom reporting is different than adult symptom reporting, and these differences may result in specific RCI values for these populations.[29] Lastly, the time frame used in this study included only 1 week, and these findings may not be applicable to other retest time frames.

Future Research

There are various directions for future research regarding the clinical use of the CP Screen. More specifically, the retest reliability of this measure should be examined over longer periods (eg, acute, subacute, and chronic) that would better inform improvement and/or deterioration of clinical profile symptoms. In addition, RCI values should be derived for different ages and races as well as other primary risk factors (eg, anxiety and migraine history) to better individualize the clinical use of this tool. Finally, these RCI values should be applied in a clinical sample to determine the percentage of individuals with concussion that exceed RCI values over the course of recovery.

CONCLUSIONS

The present study was the first to establish RCI cutoff scores that can be used to determine significant change and document test-retest reliability for the CP Screen. The findings of this study support the continued use of this tool for the individualized management of concussion and to assist clinicians with determining meaningful changes in symptom reporting across recovery. Moreover, the CP Screen is a stable measure of clinical profile symptoms across 1 week.

ACKNOWLEDGMENTS

We would like to thank all the graduate and undergraduate students who contributed to the data collection and helped make this research possible.

FINANCIAL DISCLOSURES

A.P.K. and M.W.C. receive funding for research through the University of Pittsburgh from the National Football League and royalties from APA Books. M.W.C. was a codeveloper and shareholder for ImPACT applications (ended December 2019).

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