Influences of Mental Illness, Current Psychological State, and Concussion History on Baseline Concussion Assessment Performance

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Investigation performed at 22 CARE Consortium sites

Background: A student-athlete's mental state, including history of trait anxiety and depression, or current psychological state may affect baseline concussion assessment performance.

Purpose: (1) To determine if mental illness (anxiety, depression, anxiety with depression) influences baseline scores, (2) to determine if psychological state correlates with baseline performance, and (3) to determine if history of concussion affects Brief Symptom Inventory–18 (BSI-18) subscores of state anxiety, depression, and somatization.

Study Design: Cross-sectional study; Level of evidence, 3.

Methods: A sample of 8652 collegiate student-athletes (54.5% males, 45.5% females) participated in the Concussion Assessment, Research and Education (CARE) Consortium. Baseline assessments included a demographic form, a symptom evaluation, Standardized Assessment of Concussion, Balance Error Scoring System, a psychological state assessment (BSI-18), and Immediate Post-concussion Assessment and Cognitive Test. Baseline scores were compared between individuals with a history of anxiety (n = 59), depression (n = 283), and anxiety with depression (n = 68) and individuals without a history of those conditions (n = 8242). Spearman's rho correlations were conducted to assess the relationship between baseline and psychological state subscores (anxiety, depression, somatization) (α = .05). Psychological state subscores were compared between individuals with a self-reported history of concussions (0, 1, 2, 3, 4+) using Kruskal-Wallis tests (α = .05).

Results: Student-athletes with anxiety, depression, and anxiety with depression demonstrated higher scores in number of symptoms reported (anxiety, 4.3 ± 4.2; depression, 5.2 ± 4.8; anxiety with depression, 5.4 ± 3.9; no anxiety/depression, 2.5 ± 3.4), symptom severity (anxiety, 8.1 ± 9.8; depression, 10.4 ± 12.4; anxiety with depression, 12.4 ± 10.7; no anxiety/depression, 4.1 ± 6.9), and psychological distress in state anxiety (anxiety, 3.7 ± 4.7; depression, 2.5 ± 3.6; anxiety with depression, 3.8 ± 4.2; no anxiety/depression, 0.8 ± 1.8), depression (anxiety, 2.4 ± 4.0; depression, 3.2 ± 4.5; anxiety with depression, 3.8 ± 4.8; no anxiety/depression, 0.8 ± 1.8), and somatization (anxiety, 2.3 ± 2.9; depression, 1.8 ± 2.8; anxiety with depression, 2.2 ± 2.4; no anxiety/depression, 0.9 ± 1.7). A moderate positive relationship existed between all BSI-18 subscores and total symptom number (n = 8377; anxiety: r_s = 0.43, $P < .001$; depression: r_s = 0.42, $P < .001$; somatization: r_s = 0.45, $P < .001$), as well as total symptom severity (anxiety: r_s = 0.43, $P < .001$; depression: r_s = 0.41, $P < .001$; somatization: r_s = 0.45, $P < .001$). Anxiety, depression, and somatization subscores were greater among student-athletes that self-reported more concussions.

Conclusion: Clinicians should be cognizant that student-athletes with a history of trait anxiety, depression, and anxiety with depression may report higher symptom score and severity at baseline. Individuals with extensive concussion history may experience greater state anxiety, depression, and somatization.

Keywords: concussions; baseline assessments; anxiety; depression; concussion history

Current best practice guidelines in concussion management recommend a multifaceted approach, including a thorough medical history, balance assessment, symptom checklist, neurocognitive assessment, and sideline assessments conducted both at baseline and after injury.[2,15,18,28] Athletic trainers and other health care professionals can gain extensive insight into a student-athlete's medical past and potential factors affecting pre- and postinjury concussion assessment performance. Previous studies suggest that student-athletes with a self or family history of anxiety

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may be more prone to experiencing prolonged recovery after a concussion.[9] Little research has been conducted on effects of anxiety, depression, and anxiety combined with depression on baseline concussion assessment scores.

In addition to medical history, a student-athlete's psychological state at the time of baseline concussion assessment may influence performance. Bailey et al[1] found that psychological distress (anxiety, depression, substance abuse, and suicidal ideation as measured by the Personality Assessment Inventory) had a moderate to large effect on poorer computerized neurocognitive baseline concussion assessment performance. Given these findings, student-athletes experiencing high levels of psychological distress may not perform well on multiple other concussion assessments conducted at baseline. Understanding a student-athlete's psychological distress at baseline may help elucidate variations in test performance.

Previous studies assessed how history of concussions affects health-related quality of life,[23] but little is known regarding how history of concussion (0, 1, 2, 3, 4+) influences psychological state (anxiety, depression, or somatization). It seems possible that student-athletes with extensive concussion histories may experience alterations in psychological state that may then influence their performance on baseline concussion assessments. Previous research has found that athletes with concussion history have been more at risk for developing depression.[6,12,17,22] No previous research has been conducted to investigate the relationship between concussion history and psychological distress as measured by the Brief Symptom Inventory–18 (BSI-18) in collegiate student-athletes.

Our first aim was to determine whether baseline concussion assessments differ between individuals with and without a self-reported physician-diagnosed (trait factor) history of anxiety only, depression only, and anxiety with depression. We hypothesized that individuals with a history of psychological illness would perform more poorly on baseline concussion assessment scores compared with student-athletes without those disorders. The second aim was to determine whether performance on baseline concussion assessments correlates with psychological state assessment (BSI-18 subscores of depression, anxiety, and somatization; state factor). We hypothesized that individuals who indicated greater psychological distress would have poorer performance on baseline concussion assessment tests. The third aim was to compare psychological state between individuals with and without a history of concussion (0, 1, 2, 3, 4+). We hypothesized that participants with a greater history of concussion would exhibit greater psychological distress.

METHODS

Participants

Student-athletes who participated in this study completed a baseline concussion assessment. The first baseline assessment recorded for each student-athlete was used in the analysis. Twenty-two universities across the United States participated in the National Collegiate Athletic Association (NCAA)–Department of Defense Grand Alliance Concussion Assessment, Research and Education (CARE) Consortium. The CARE Consortium consisted of a multiyear study assessing many aspects of concussion management with funding provided by the NCAA and Department of Defense that has been described in detail elsewhere.[4] To participate in this research, participants had to sign a site institutional review board–approved consent form and be a varsity student-athlete at a participating site. Additional approval was obtained by the US Army Medical Research and Materiel Command Human Research Protection Office.[4] Participants were excluded if they did not consent and if they were not a varsity student-athlete. Baseline assessments were completed between January 2014 and September 2016.

Materials and Methods

The baseline concussion assessment tools included a symptom checklist (Sport Concussion Assessment Tool [SCAT] symptom checklist), mental status assessment (Standardized Assessment of Concussion [SAC]), a computerized neurocognitive assessment (Immediate Post-concussion Assessment and Cognitive Testing [ImPACT]), balance assessment (Balance Error Scoring System [BESS]), a brief state psychological distress measure (BSI-18), and demographic questionnaire. The SCAT symptom checklist consists of participants answering a 22-item Likert scale of symptoms.[27] The SAC is composed of 4 domains assessing orientation, immediate memory, concentration, and delayed memory.[26] The BESS is a static balance assessment including 3 stances (feet

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together, single-legged standing on nondominant, tandem stance with nondominant foot behind dominant).[31] The 3 stances are performed on the ground or firm surface, followed by the same 3 stances on a foam surface. Participant movements from the original position (opens eyes, removes hands from iliac crests, moves hips to 30° of abduction, puts foot down during single-legged stance, or remains out of position longer than 5 seconds) are considered errors and are recorded by the test administrator. Administration of the SCAT,[27] SAC,[26] BESS,[31] and ImPACT[25] has been previously described in more detail.

The BSI-18 is an instrument devised to measure state physiological distress and psychiatric disorders.[13] The BSI-18 aims to measure 3 categories, including state anxiety, depression, and somatization.[13] Administration of the BSI-18 requires about 4 to 5 minutes, and the participant is prompted to rate each item in "how much that problem has distressed or bothered you during the past 7 days including today."[13] Each item is scored on a 4-point Likert scale with choices ranging from "not at all" to "extremely." Each of the 18 statements on the BSI-18 relates to 1 subscore. Examples of statements in the anxiety subscore include "nervousness or shakiness inside" or "feeling tense or keyed up." Statements from the depression subscore include items such as "feeling lonely" or "feeling blue." Example statements of the somatization subscore include "pains in chest or heart" and "nausea or upset stomach." The BSI-18 is scored by totaling each response within the subscore (highest score obtainable is 24) and a global score (highest score obtainable is 72).[13] Lancaster et al[24] determined the BSI-18 had good internal consistency, fair-to-poor test-retest reliability, and good convergent validity.

A health history form was included in the demographic questionnaire. Participants were asked, "Have you ever been diagnosed by a physician/MD with . . . anxiety, depression." This indicated a trait factor of anxiety, depression, or anxiety with depression. Participants were asked to select either yes or no. The demographics questionnaire also contains a concussion history section. Participants were given the following definition of a concussion: "A change in brain function after a force to the head, which may be accompanied by temporary loss of consciousness, but is identified in awake individuals with measures of neurologic and cognitive dysfunction."[7] Participants then self-reported if they had ever sustained a concussion (either diagnosed or undiagnosed) based on this definition and common concussion symptoms. If participants responded "yes," they were then asked to report the number of concussions sustained.

Data Analysis

Descriptive analyses were conducted for number of males and females, age (years), mass (kg), and height (cm). Kolmogorov-Smirnov tests for normality were conducted, and all dependent variables violated normality (all P values $<.010$). For aim 1, the following baseline concussion assessment outcomes were compared between individuals with history of trait anxiety only, depression only, anxiety with depression, and no history of anxiety or depression using a Kruskal-Wallis test ($\alpha = .05$): total number of symptoms, total symptom severity, SAC total score, ImPACT composite scores (verbal memory, visual memory, visual motor speed, and reaction time), BESS (total error score), and BSI-18 subscores (state anxiety, depression, and somatization). Effect sizes using Cohen d were also calculated (the pooled standard deviation was calculated as described by Hedges and Olkin[19]). Follow-up Mann-Whitney tests were conducted to determine which groups differed from those without anxiety and depression when appropriate. For aim 2, Spearman rho correlations were used to assess the relationship between baseline concussion assessments and the psychological state assessment subscores (anxiety, depression, somatization) ($\alpha = .05$). For aim 3, we compared psychological state assessment subscores (state anxiety, depression, somatization) between individuals with 0, 1, 2, 3, and 4+ previous concussions using separate 1-way Kruskal-Wallis tests ($\alpha = .05$). Mann-Whitney post hoc tests were also conducted between each BSI-18 subscore and number of previous concussions (0, 1, 2, 3, 4+) as appropriate.

RESULTS

Overall, 8652 collegiate student-athletes consented to participate in this study. This sample consisted of 4713 males (54.5%) and 3939 females (45.5%) with a mean age of 19.4 ± 1.4 years, mass of 78.6 ± 19.7 kg, and height of 177.8 ± 11.2 cm.

Mental Illness Influences

Demographic information based on history of trait anxiety, depression, and anxiety with depression and those with neither condition is included in Table 1. All other descriptive and statistical results for mental illness comparisons are presented in Table 2. Baseline scores were compared between individuals with trait history of anxiety (n = 59), depression (n = 283), anxiety with depression (n = 68), and no history of anxiety or depression (n = 8242) (Table 2).

Participants with trait anxiety, depression, and anxiety with depression had a higher total number of symptoms reported ($P < .001$), symptom severity score ($P < .001$), BSI-18 anxiety subscore ($P < .001$), depression subscore ($P < .001$), and somatization subscore ($P < .001$) compared with individuals without those conditions. Mann-Whitney tests revealed that the total number of symptoms was higher in those with trait anxiety ($P < .001$, $d = 0.53$), depression ($P < .001$, $d = 0.78$), and anxiety with depression ($P < .001$, $d = 0.84$) each separately compared with those without those conditions. Greater symptom severity was also found in those with trait anxiety ($P < .001$, $d = 0.58$), depression ($P < .001$, $d = 0.88$), and anxiety with depression ($P < .001$, $d = 1.19$) each compared with individuals without those conditions. The BSI-18 subscore of anxiety was higher in student-athletes with trait anxiety ($P < .001$, $d = 1.59$), depression ($P < .001$, $d = 0.89$), and anxiety with depression ($P < .001$, $d = 1.61$). Second, BSI-18 subscores of depression were higher in those with trait anxiety ($P < .001$, $d = 0.87$), depression ($P < .001$, $d = 1.25$), and

TABLE 1
Demographic Information Separated by Categories of Anxiety, Depression, Anxiety With Depression, and Without Anxiety or Depression[a]

	Anxiety (n = 59)	Depression (n = 283)	Anxiety With Depression (n = 68)	Without Anxiety or Depression (n = 8242)
Male (n = 4713, 54.5%)	16 (27.1)	94 (33.2)	11 (16.2)	4592 (55.7)
Female (n = 3939, 45.5%)	43 (72.9)	189 (66.8)	57 (83.8)	3650 (44.3)
Age, y	19.42 ± 1.25	19.63 ± 1.34	19.57 ± 1.39	19.41 ± 1.41
Height, cm	174.17 ± 9.75	174.93 ± 11.30	170.51 ± 8.46	177.98 ± 10.82
Mass, kg	72.22 ± 17.34	74.42 ± 19.22	68.76 ± 14.19	78.82 ± 19.59

[a]Data are provided as n (%) or mean ± SD.

anxiety with depression ($P < .001$, $d = 1.60$) each compared with those without those conditions. Mann-Whitney tests also revealed BSI-18 subscores of somatization were higher in those with mental illnesses between all groups and those without the conditions (trait anxiety: $P < .001$, $d = 0.80$; depression: $P < .001$, $d = 0.53$; anxiety with depression: $P < .001$, $d = 0.78$).

Individuals with trait anxiety, depression, and anxiety with depression performed significantly worse on the ImPACT domain of visual memory composite score ($P = .005$) compared with those without those mental illnesses when examined collectively. However, the Mann-Whitney test revealed that only individuals with anxiety performed worse on visual memory composite than those without anxiety or depression ($P = .001$, $d = 0.53$). Group differences also existed between groups for visual motor speed performance ($P = .044$). Follow-up calculations determined those with trait anxiety performed worse on visual motor speed compared with those without anxiety or depression ($P = .005$, $d = 0.36$). No significant differences were observed between those with trait anxiety only, depression only, anxiety with depression, and no history of anxiety or depression for SAC total score, BESS total score, or other neurocognitive domains.

Psychological State Influences

For aim 2, a moderate positive relationship was observed with all BSI-18 subscores and the total symptoms number (n = 8377; anxiety: $r_s = 0.43$, $P < .001$; depression: $r_s = 0.42$, $P < .001$; somatization: $r_s = 0.45$, $P < .001$) and the total symptom severity (anxiety: $r_s = 0.43$, $P < .001$; depression: $r_s = 0.41$, $P < .001$; somatization: $r_s = 0.45$, $P < .001$). These results indicate that individuals who scored higher on the BSI-18 subscores also reported a great number of symptoms and severity.

Several weak relationships were observed for varying BSI-18 subscores and ImPACT neurocognitive domains. A weak positive relationship was found between the anxiety and somatization subscores and the verbal memory composite score (anxiety: n = 6916, $r_s = 0.03$, $P = .013$; somatization: n = 6916, $r_s = 0.03$, $P = .011$). A weak positive relationship was observed between the BSI-18 subscores of anxiety and somatization and visual motor speed (anxiety: n = 6916, $r_s = 0.03$, $P = .008$; somatization: n = 6919, $r_s = 0.02$, $P = .045$). We observed a weak negative relationship between anxiety and somatization subscores and reaction time (anxiety: n = 6912, $r_s = -0.05$, $P < .001$; somatization: n = 6912, $r_s = -0.02$, $P = .033$). No significant relationships were observed between BSI-18 subscores and SAC total score, BESS total errors, or other ImPACT domains.

Concussion History Influences

From our sample, 6214 participants had no previous self-reported concussions, 1639 reported 1 concussion, 415 reported 2 concussions, 138 had 3 concussions, and 70 reported 4 or more concussions (176 missing responses). Generally, we found that those with higher self-reported number of concussions indicated greater state anxiety ($P < .001$), depression ($P < .001$), and somatization ($P < .001$) on the BSI-18 during baseline assessment.

Post hoc analyses revealed that individuals with 4 or more concussions had a significantly higher BSI-18 subscore of anxiety (0 reported concussions: $P < .001$; 1 concussion: $P < .001$; 2 concussions: $P = .003$; 3 concussions: $P = .017$) (Figure 1), depression subscore (0 reported concussions: $P = .005$; 1 concussion: $P = .018$; 2 concussions: $P = .040$) (Figure 2), and somatization subscore (0 reported concussions: $P < .001$; 1 concussion: $P < .001$; 2 concussions: $P = .015$) (Figure 3) compared with other groups. However, individuals with 3 concussions did not significantly differ compared with those with 4 or more concussions for the depression or somatization subscores (depression: $P = .759$; somatization: $P = .218$). We also observed that individuals with a history of 3 concussions had significantly higher state anxiety, depression, and somatization subscores compared with those with no history of concussion (anxiety: $P = .010$; depression: $P = .001$; somatization: $P < .001$) and higher BSI-18 subscores compared with those with 1 concussion (anxiety: $P = .012$; depression: $P = .005$; somatization: $P < .001$). Student-athletes with a history of 3 concussions had significantly higher BSI-18 depression subscores compared with those with 2 concussions ($P = .024$). Participants with a history of 2 concussions had significantly higher BSI-18 anxiety and somatization subscores compared with those with 1 concussion (anxiety: $P = .004$; somatization: $P = .004$) and significantly higher anxiety and somatization subscores compared with those with no concussions (anxiety: $P = .002$; somatization: $P < .001$).

TABLE 2
Results of Baseline Concussion Assessment Scores in Participants With a History of Anxiety, Depression, Anxiety With Depression, and No History of Anxiety or Depression[a]

	Anxiety (n = 59)	Depression (n = 283)	Depression With Anxiety (n = 68)	Without Depression or Anxiety (n = 8242)	*P* Value
SCAT total symptoms					
Mean ± SD	4.3 ± 4.2[b]	5.2 ± 4.8[b]	5.4 ± 3.9[b]	2.5 ± 3.4	<.001[c]
Median	3.0	4.0	6.0	1.0	
n	57	282	65	8125	
Cohen *d*	0.53	0.78	0.84		
SCAT symptom severity					
Mean ± SD	8.1 ± 9.8[b]	10.4 ± 12.4[b]	12.4 ± 10.7[b]	4.1 ± 6.9	<.001[c]
Median	5.0	6.0	11.0	2.0	
n	57	282	65	8125	
Cohen *d*	0.58	0.88	1.19		
SAC total					
Mean ± SD	27.3 ± 2.1	27.0 ± 1.9	27.6 ± 1.7	27.1 ± 2.0	.111
Median	28.0	27.0	28.0	27.0	
n	55	270	64	7855	
Cohen *d*	0.09	0.03	0.26		
BSI-18 (anxiety)					
Mean ± SD	3.7 ± 4.7[b]	2.5 ± 3.6[b]	3.8 ± 4.2[b]	0.8 ± 1.8	<.001[c]
Median	2.0	1.0	3.0	0.0	
n	59	280	67	8040	
Cohen *d*	1.59	0.89	1.61		
BSI-18 (depression)					
Mean ± SD	2.4 ± 4.0[b]	3.2 ± 4.5[b]	3.8 ± 4.8[b]	0.8 ± 1.8	<.001[c]
Median	1.0	1.0	2.0	0.0	
n	59	280	67	8040	
Cohen *d*	0.87	1.25	1.60		
BSI-18 (somatization)					
Mean ± SD	2.3 ± 2.9[b]	1.8 ± 2.8[b]	2.2 ± 2.4[b]	0.9 ± 1.7	<.001[c]
Median	1.0	1.0	2.0	0.0	
n	59	280	67	8040	
Cohen *d*	0.80	0.53	0.78		
BESS total score					
Mean ± SD	12.9 ± 6.3	12.8 ± 6.1	12.6 ± 5.3	12.7 ± 6.1	.985
Median	12.0	12.0	12.0	12.0	
n	51	259	63	7628	
Cohen *d*	0.03	0.01	0.02		
ImPACT verbal memory					
Mean ± SD	85.1 ± 11.2	87.0 ± 11.1	85.5 ± 9.0	86.3 ± 11.0	.321
Median	85.0	89.0	86.5	88.0	
n	46	240	48	6745	
Cohen *d*	0.11	0.07	0.07		
ImPACT visual memory					
Mean ± SD	68.9 ± 14.6[b]	75.1 ± 14.6	75.3 ± 11.8	76.2 ± 13.6	.005[c]
Median	68.0	77.0	77.5	78.0	
n	46	240	48	6745	
Cohen *d*	0.53	0.08	0.07		
ImPACT visual motor speed					
Mean ± SD	38.5 ± 5.6[b]	41.2 ± 6.3	40.7 ± 6.0	40.9 ± 6.7	.044[c]
Median	38.9	41.0	40.7	41.2	
n	46	240	48	6745	
Cohen *d*	0.36	0.03	0.04		
ImPACT reaction time					
Mean ± SD	0.59 ± 0.07	0.59 ± 0.08	0.58 ± 0.08	0.59 ± 0.09	.267
Median	0.61	0.58	0.56	0.58	
n	46	240	48	6741	
Cohen *d*	0.00	0.00	0.11		

[a]BESS, Balance Error Scoring System; BSI-18, Brief Symptom Inventory–18; ImPACT, Immediate Post-concussion Assessment and Cognitive Testing; SAC, Standardized Assessment of Concussion; SCAT, Sport Concussion Assessment Tool.
[b]Indicates significant finding for individual condition compared with those without anxiety or depression at $P < .05$.
[c]Indicates significant finding at $P < .05$.

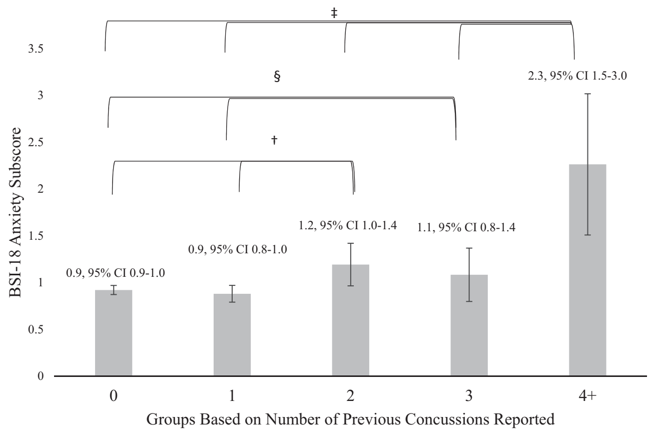

Figure 1. Results based on concussion history and BSI-18 subscore of anxiety. ‡Those with 4 concussions > those with 0, 1, 2, and 3 concussions (0 concussions: *P* < .001; 1 concussion: *P* < .001; 2 concussions: *P* = .003; 3 concussions: *P* = .017). §Those with 3 concussions > those with 0 and 1 concussion (0 concussions: *P* = .010; 1 concussion: *P* = .012*).* †Those with 2 concussions > those with 0 and 1 concussion (0 concussions: *P* = .002; 1 concussion: *P* = .004). BSI-18, Brief Symptom Inventory–18.

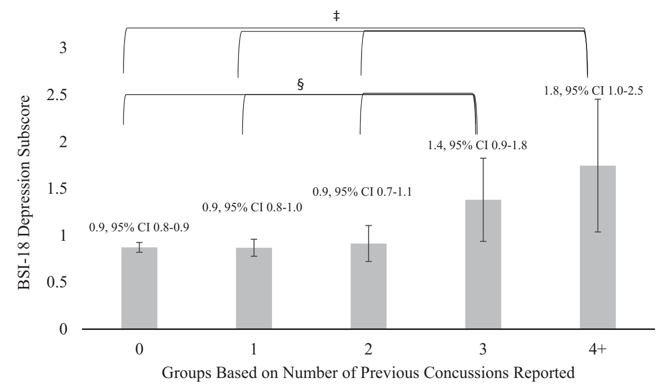

Figure 2. Results based on concussion history and BSI-18 subscore of depression. ‡Those with 4 concussions > those with 0, 1, and 2 concussions (0 concussions: *P* = .005; 1 concussion: *P* = .018; 2 concussions: *P* = .040). §Those with 3 concussions > those with 0, 1, and 2 concussions (0 concussions: *P* = .001; 1 concussion: *P* = .005; 2 concussions: *P* = .024). BSI-18, Brief Symptom Inventory–18.

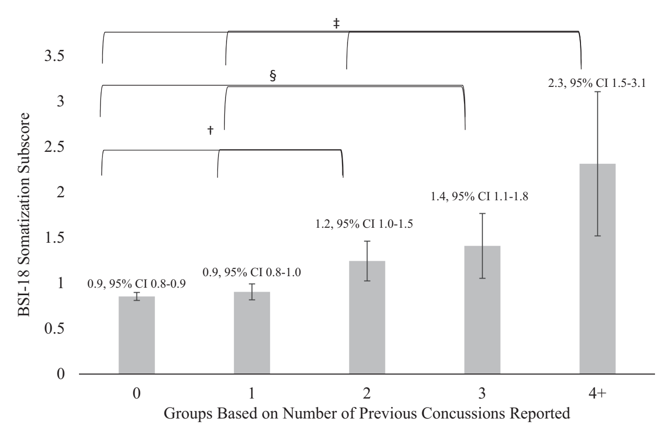

Figure 3. Results based on concussion history and BSI-18 subscore of somatization. ‡Those with 4 concussions > those with 0, 1, and 2 concussions (0 concussions: *P* < .001; 1 concussion: *P* < .001; 2 concussions: *P* = .015). §Those with 3 concussions > 0 and 1 concussion (0 concussions: *P* < .001; 1 concussion: *P* < .001). †Those with 2 concussions > those with 0 and 1 concussion (0 concussions: *P* < .001; 1 concussion: *P* = .004). BSI-18, Brief Symptom Inventory–18.

DISCUSSION

Our results indicate that those with a history of trait anxiety, depression, or both mental illnesses reported a greater number and severity of symptoms and reported higher BSI-18 subscores consistently during their baseline concussion assessments compared with individuals without anxiety or depression. Participants who reported higher levels of psychological distress as measured by the BSI-18 also experienced greater overall number and severity of symptoms. Our results also indicated that participants with a greater number of previous self-reported concussions report greater psychological distress as measured by the BSI-18 at baseline. Readers may question why these results are important if clinicians administer baseline assessments, as they should theoretically be able to compare each athlete's postinjury results with his or her individual baseline. While baseline assessments are suggested to compare a preinjured state to a postinjured state,[2,15] concussion evaluation often occurs in the absence of baseline assessments, requiring the clinician to rely on normative data. Clinicians may be holding patients to postinjury standards that they may never be able to achieve if comparing a person with anxiety, depression, or anxiety with depression to normative data. Second, individuals who complete baseline testing under great psychological distress could underperform, making their baseline values a poor comparison point for guiding clinical decisions. In addition, those in great psychological distress at baseline or postinjury may need interventions or aid to decrease that state psychological distress. Therefore, understanding how the history of mental illnesses, psychological state, and concussion history may influence assessments is useful for clinical practice.

Mental Illness Influences

We had a very large sample size, which may have led to oversampling. (Demographic information based on history of trait anxiety, depression, and anxiety with depression and those with neither condition is included in Table 1. All other descriptive and statistical results for mental illness comparisons are presented in Table 2. The Appendix Tables [available in the online version of this article] include results divided by males and females based on those with anxiety, depression, and anxiety with depression, and individuals without those conditions on baseline assessment performance.) Therefore, these results can be compared with reliable change indices (RCIs). RCIs measure reliable change,[30] meaning if a student-athlete performs an assessment, then performs the same assessment a second time and exceeds RCI values for that particular assessment, meaningful change has occurred between the first and second assessment.[21] Data from the CARE Consortium calculated RCIs.[3] Using RCIs compared with differences in group means indicated that few variables exceeded RCI within our study. Our mean difference for SCAT symptom severity between those with trait depression and those without was 6.3. The RCI for SCAT symptom severity is 4 at the 87.5% CI.[3] Therefore, the RCI for SCAT symptom severity between those with trait depression and those without anxiety or depression revealed a clinically meaningful mark. The RCI for SCAT symptom severity among those with anxiety, depression, and anxiety with depression (mean difference range, 4-8.3) and those without those illnesses was greater than the 87.5% CI, indicating a meaningful difference at baseline between these groups. Second, BSI-18 anxiety and depression subscores either approached or were greater than RCIs for all aim 1 groups (global BSI-18 RCI = 2; anxiety subscore mean difference range, 1.7-3; depression subscore mean difference, 1.6-3). No other significant differences exceeded RCIs between groups with anxiety, depression, and anxiety with depression and those without those conditions.

Recent research has focused on the potential link between concussion history and depression,[32] but few studies have examined how mental illness might influence concussion management. Our results showed that those with a history of trait anxiety, depression, and anxiety with depression indicated a significantly higher number of symptoms, symptom severity, and greater psychological distress as measured by the BSI-18 at baseline. Group mean differences exceeded RCIs for only some of these findings. Our findings were consistent with those of Yengo-Kahn and Solomon[35] that those with a history of depression and/or anxiety not treated with medication reported higher total symptom score and poorer visual memory at baseline than those without those conditions. Researchers have found that when symptoms of depression were found at baseline, those symptoms translated into depressive and anxiety symptoms after injury.[34] It is important for health care professionals to understand that our results indicated student-athletes with anxiety and/or depression experienced higher symptoms (severity and number) and psychological distress at baseline and that an increase in depressive symptoms at baseline can lead to postinjury implications such as symptom burden.[32,34] In a systematic review by Iverson et al,[20] the most consistent predictor of prolonged recovery was a large symptom burden and mental illness. It should also be noted that the presence of these mental illnesses affected symptom presentation and not other baseline concussion assessments, such as mental status, balance, and neurocognitive assessment scores. These results may be useful to potentially identify student-athletes who may need referral to a mental health professional.

Results indicated that the BSI-18 detected differences in psychological state in those with trait anxiety, depression, and anxiety with depression. As mentioned earlier, Lancaster et al[24] determined the BSI-18 had good internal consistency, fair-to-poor test-retest reliability, and good convergent validity. The BSI-18 is a state assessment, which likely influences the test-retest reliability. How patients experience psychological distress changes over time, which causes state instruments to have lower reliability. Even though the BSI-18 has fair-to-poor test-retest reliability, it can still aid the clinician in determining psychological distress at a given time point. Understanding these psychometric properties, and given the ability of the BSI-18 to determine differences in those with psychological diagnoses in this present study, the BSI-18 may be useful clinically to identify those presently in psychological distress.

Psychological State Influences

In the present study, individuals who scored higher on the BSI-18 subscores reported both greater severity and greater total number of symptoms. These results suggest that although the BSI-18 and symptom checklists are different measures, some similar information is gained from each. Both measures assess parallel items, including nausea, dizziness, emotional items (BSI-18: "feeling blue"; symptom assessment: "more emotional" and "sadness"), and nervousness.[13,27] Our results indicated a good relationship in measuring state psychological distress as measured by the BSI-18 and symptoms of a concussion. Therefore, clinicians should consider: is there a need to administer BSI-18 if the symptom checklist is accomplishing a similar task in management? Our results indicated that even though the measures have similarities, they are only moderately correlated, and each serves a purpose in measuring different clinical phenomena. The BSI-18 measures state psychological distress, while the symptom checklist measures symptoms of a concussion. It should also be noted that the BSI-18 is a state assessment of anxiety, depression, and somatization, not a trait assessment to diagnose anxiety or depression.

Finally, the results indicated that those with greater BSI-18 subscores had poorer performance on various neurocognitive assessment domains. Our results, albeit very weak correlations, were contrary to those of Bailey et al,[1] who found that higher levels of state anxiety, depression, and schizophrenia (as measured by the Personality Assessment Inventory) resulted in poorer simple reaction time. Additionally, higher levels of "somatic complaints," anxiety, "alcohol problems," and suicidal ideation correlated with slower identification of complex stimuli. The neurocognitive domain of processing speed was poorer with somatic complaints, "drug problems," and suicidal ideation.[1] Covassin et al[10] also measured how state depression influenced baseline assessments. They found that those categorized into the severe depression group had worse performance on visual memory and higher total symptoms reported.[10] Individuals in our sample with greater state depression reported higher total symptoms at baseline. We did not find a strong relationship between state depression and visual memory performance; however, those with trait anxiety did differ on visual memory compared with those without those conditions. Our results, in addition to Bailey et al[1] and Covassin et al,[10] highlight the relationship between psychological distress and neurocognitive assessment scores at baseline. Clinicians should be cognizant of the relationship between psychological distress and baseline concussion assessment performance. If a patient is in great psychological distress at the time of baseline assessment, neurocognitive testing could potentially be affected, which may warrant delaying the assessment until the source of distress has been addressed and treated.

Concussion History

The effects of multiple concussions have been of great concern within the layperson and research communities. Overall, our findings suggest those with greater history of self-reported concussions had more psychological distress as measured by the BSI-18 during baseline concussion assessment. We consistently found that those with 4 or more concussions had greater psychological distress compared with those with fewer concussions (0, 1, 2, 3). This indicates that student-athletes with extensive concussion histories may need to be monitored for psychological distress. Clinicians should take this into consideration when caring for student-athletes with a concussion history.

Researchers have found that multiple concussions may be associated with depression diagnosis.[12,16,17,22] Also, Spira et al[33] found that concussions, whether recent or distant, were associated with emotional distress. Our results represent unique findings as participants were otherwise healthy, college-aged individuals, and even though participants may not have a clinical psychological diagnosis, results show a trajectory toward greater psychological distress in state anxiety, depression, and somatization with each additional concussion. However, it should also be noted that preconcussion psychological state was not assessed. Therefore, it cannot be determined if multiple concussions increase the likelihood of psychological distress or if psychological distress predisposes those to multiple concussions. The nature of the data does not allow us to determine causality between psychological distress and concussion. Results from this study also show that a greater number of concussions may result in greater psychological distress as measured by the BSI-18 in collegiate athletes.

History of concussion is frequently studied by grouping individuals based on history of 0, 1, 2, or 3+.[5,16,17,23] In this study, we divided groups into 0, 1, 2, 3, and 4+. Generally, our results found that individuals with 4 or more concussions had greater psychological distress as measured by the BSI-18 than other groups. Historically, groupings have been made of 0, 1, 2, and 3+ due to sample size. Our sample size was large enough to group individuals based on concussion history of 0, 1, 2, 3, and 4+. This has allowed us to examine additional intricacies of concussion history. Future research may consider categorizing those with previous concussions in groups of 0, 1, 2, 3, and 4+ when possible, or perhaps more than 4+.

Limitations

Limitations within this study exist. Authors have used the BSI-18 in athletic populations[11,14,24,29]; however, one limitation is that the BSI-18 was not developed for this specific population. For example, one question on the BSI-18 somatization subscore asks if the athlete is "feeling weak in parts of your body."[13] Collegiate student-athletes are involved in strenuous physical activity almost daily and, therefore, may be feeling weak in parts of the body potentially as a result of physical training, such as strength, endurance, or a combination of these. In addition, the BSI-18 has been found to have fair-to-poor test-retest reliability.[24] Although this study did not use the BSI-18 repeatedly, clinicians should understand that psychological state may fluctuate between administrations and should use the tool as a way to better capture those fluctuations.

Student-athletes were asked to self-report diagnosis of anxiety and/or depression, as well as to recall previous concussions. Although the demographic forms ask if "you have ever been diagnosed by a physician/MD" with anxiety or depression, these instructions may have been overlooked. In addition, student-athletes were asked to recall previous concussions, and medical record verification did not occur. Another modifying factor not examined in this study is family history of psychiatric illness. Family history of psychiatric illness should be examined in future research. Again, demographic forms outline the definition of concussion; however, a student-athlete may not recall accurately. Our study examined only total number of previous concussions and not details such as date and time removed from sport that might be more difficult to recall.

We did not record or account for medication use for trait anxiety or depression at the time of baseline assessment. Whether or not a student-athlete was being treated or taking medication, and if that medication was taken before assessments, may have played a role within BSI-18 subscores.[8,35]

Finally and as discussed above, the CARE Consortium has allowed a large sample for examination in concussion research. This specific sample examined results from more than 8000 participants. This amount of data has many positives for research purposes; however, it also may result in oversampling. Even though many significant results were reported, weak relationships, such as BSI-18 subscores and ImPACT neurocognitive domains, are not likely clinically meaningful.

CONCLUSION

Understanding how trait anxiety, depression, and anxiety with depression influence baseline concussion assessment performance is important for clinical practice. Recognizing that individuals with these mental illnesses may report a higher number and severity of symptoms may aid the clinician in interpretation of postinjury assessment and when determining return to play. The extent to which the presence of these conditions affects baseline scores must be considered when the results of postinjury examinations are compared with those at baseline.

The BSI-18 may be useful in detecting psychological distress in those suffering from anxiety and/or depression. A history of multiple concussions may relate to greater psychological distress during baseline concussion assessment. Identifying that student-athletes who self-reported a greater number of concussions indicated higher psychological distress at baseline can help guide treatment and management. Psychological distress is a critical element of concussion evaluation, recovery, and management. Future research should explore the prevalence and severity of psychological distress in those with multiple concussions, as well as the potential need for mental health interventions in this population.

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