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Original Research

The Sport Concussion Assessment Tool-5 (SCAT5): Baseline Assessments in NCAA Division I Collegiate Student-Athletes

KYLE M. PETIT†[1], JENNIFER L. SAVAGE‡[2], ABIGAIL C. BRETZIN‡[3], MORGAN ANDERSON†[1], and TRACEY COVASSIN‡[1]

[1]Department of Kinesiology, Michigan State University, East Lansing, MI, USA; [2]Rudy School of Nursing and Health Professions, Cumberland University, Lebanon, TN, USA; [3]Penn Injury Science Center, University of Pennsylvania, Philadelphia, PA, USA

†Denotes graduate student author, ‡Denotes professional author

ABSTRACT

International Journal of Exercise Science 13(3): 1143-1155, 2020. The purpose of this study was to report baseline values for the SCAT5 in NCAA Division I collegiate student-athletes, while also evaluating if sex, health diagnoses, or sport type influenced baseline performance. A sample of 462 collegiate student-athletes (212 females, 250 males, (19.21±1.32 years)) completed the SCAT5 prior to the 2017-18, 2018-19 or 2019-20 athletic seasons. Descriptive statistics were reported for symptom total (22 possible), symptom severity (132 possible), orientation (5 possible), immediate memory (30 possible), concentration (5 possible), delayed recall (10 possible), total SAC score (50 possible), 3 mBESS stances (10 possible), and mBESS score (30 possible). Separate Mann-Whitney *U* tests were conducted to identify sex, health diagnoses (concussion history, ADD/ADHD, depression/anxiety), and sport type (contact, non-contact) differences for all SCAT5 components. Alpha level was set a priori <.05. Student-athletes reported 1.96± 3.37 symptoms with a severity of 3.43±7.63, and an overall SAC score of 35.14±5.23 (orientation 4.96±0.20, immediate memory 20.18±3.40, concentration 3.60±1.14, delayed recall 6.41±1.94). Student-athletes participating in contact sports, had ADD/ADHD, or depression/anxiety reported more symptoms and at greater severity (p=<.001-.01). Those with ADD/ADHD performed worse on mBESS (p=.01-.03). No sex differences were found for any SCAT5 components (p=.08-.90). This study presents reference values for the SCAT5 by sex, health diagnoses, and sport type. Healthcare professionals may utilize these normative values when individual baseline references are unavailable.

KEY WORDS: Sport-related concussion, symptoms, SAC, mBESS

INTRODUCTION

Sport-related concussions (SRC) occur approximately 1.6-3.8 million times annually in the United States (21). It is recommended that evaluation of SRC include a multifaceted approach consisting of symptom assessment, neurocognitive evaluation, balance testing and other various measures (2,23). The Sport Concussion Assessment Tool 5 (SCAT5) combines this multifaceted approach into a single assessment, which can be used in conjunction with other evaluation measures. Modifications to the SCAT5 were introduced in 2017, following the Fifth International

Consensus Conference on Concussion in Sport (11). Like its preceding version, the SCAT5 includes Maddocks Questions for Memory Assessment, the Glascow Coma Scale (GSC), a symptom evaluation, the Standardized Assessment of Concussion (SAC) and the modified Balance Error Scoring System (mBESS) (11). Notable additions to the SCAT5 include an immediate or on-field assessment, a cervical spine assessment, a 10-word list for the immediate memory and delayed recall components of SAC with a minimum of five minutes between tasks, a neurological screening, and a minimal total completion time of 10 minutes (11).

Due to SRC's individualized presentation, injury evaluation often utilizes baseline assessments to serve as an individualized reference. Likewise, the SCAT is typically conducted prior to an athletic season to later serve as a personalized reference (26). When individualized results are unavailable, age, sex, and sport type (i.e., contact, non-contact) normative data are often used (26). Normative SCAT data has been previously reported for both males and females at the youth, (32) high school (18) and collegiate (33) level; however, with the recent modifications, specifically in the immediate and delayed word list, an update to these reference values is warranted.

Previous research has reported that SCAT results may be influenced by factors such as student-athlete sex, (5,13,32) health diagnoses (4,17) (concussion history, Attention-Deficit/Hyperactivity Disorder (ADD/ADHD), depression/anxiety), and sport type (contact, non-contact). Specifically, researchers have identified females as reporting greater concussive symptoms at baseline and following a SRC (5,13,32). In addition, when evaluating SAC and mBESS scores, females scored significantly better than their male counterparts (5,18,33). Like these reported sex differences, student-athletes with a prior history of concussion have also been found to report more symptoms at baseline and after subsequent SRCs (4,17). Student-athletes with two or more previous concussions have also been found to perform worse on a paper and pencil cognitive task compared to those with one or no previous injury (6). There is also evidence supporting SCAT differences in student-athletes with ADD/ADHD and depression/anxiety when compared to those without these diagnoses (5,26). Specifically, student-athletes with ADD/ADHD performed significantly worse on previous versions of the SCAT, as well as reported more symptoms at baseline than their non-diagnosed controls (5). Despite this previous research, mixed findings exist suggesting student-athlete sex, (33) health diagnoses, (16) and sport type (19) do not influence SCAT performance. Due to these inconsistent findings, it is unclear if these factors actually influence baseline measures. Therefore, the purpose of the current study was to report baseline values for the SCAT5 in a sample of National Collegiate Athletic Association (NCAA) Division I collegiate student-athletes. A secondary purpose was to evaluate if student-athlete sex, health diagnoses, or sport type influenced baseline SCAT5 performance in NCAA Division I collegiate student-athletes. It is hypothesized that student-athletes with ADD/ADHD, depression/anxiety, or that are females will report higher baseline symptoms and perform worse on the SCAT5 than their counterparts.

METHODS

Participants

A convenience sample of 462 Division I student-athletes between the ages of 18-24, from a Midwest University were included in the study. Student-athletes were excluded from the study if they currently had a diagnosed concussion, or any lower extremity injuries that may impact the balance portion of the assessment. Participants sport type was also classified as either contact or non-contact based on previously published classifications (28). This research was carried out fully in accordance to the ethical standards of the International Journal of Exercise Science (24).

Protocol

This study was approved by the university's Institutional Review Board, prior to enrolment, informed consent was also obtained. Student-athletes were administered the SCAT5 in a quiet environment by a trained research assistant. A total of 11 research assistants previously trained in how to conduct the SCAT5, completed data collection and took no less than 10 minutes per student-athlete to complete the assessment.

Sport Concussion Assessment Tool (SCAT5): The SCAT5 includes an immediate/on-field assessment, office/off-field assessment, student-athlete background, Glasgow Coma Scale, self-reported symptom evaluation, cognitive and neurological screening, and a balance measure.

Student-Athlete Background: Student-athletes are asked to self-report several key pieces of information about themselves and their past/current health diagnoses. Specifically, this includes student-athlete sex, age, academic year, and sport. Student-athletes are also asked to self-report previous or current medical diagnoses which include previous concussion, ADD/ADHD, and depression/anxiety.

Symptom Evaluation: Student-athletes self-report 22 concussion symptoms on a 7-point Likert scale (0 (none) to 6 (severe)). Student-athletes complete the baseline symptom evaluation based on how they "typically" feel. Student-athletes receive a total symptom score out of 22 along with a symptom severity score out of 132.

Cognitive Screening Test: The cognitive screening section includes the SAC. Orientation consists of various questions (i.e. what is the date today?) in which participants receive a point for every correct answer. Then, student-athletes are presented the 10-item immediate memory list, three separate times, and are asked to recite them back in any order. The concentration section consists of the digit backwards test and saying the months of the year in reverse order. During the digit backwards test, student-athletes are given a string of numbers and asked to repeat them backwards. The digit backwards test starts with a string of 3 numbers (i.e., 4-9-3) and increases up to 6 numbers (i.e., 8-4-1-3-5-7). This test is stopped after two consecutive incorrect answers or correctly repeating all strings backwards. The final section of the SAC is delayed recall, which asks student-athletes to repeat the original words from the immediate memory test. A total SAC score is calculated by adding each component (orientation, immediate memory, concentration and delayed recall) of the SAC together and has a max of 50. The original version of the SAC has

a test-retest reliability of 0.64 and a validity consisting of orientation (r= .36), immediate memory (r= .61), concentration (r= .68), and delayed recall (r= .52) (22). It should be noted that validity and reliability measures do not exist for the 10-word recall list.

Modified Balance Error Scoring System (mBESS): The mBESS consists of three stances; double-leg stance, single-leg stance on their non-dominant leg, and tandem stance in a heel-to-toe pattern (14,29). Student-athletes are instructed to stand quietly for 20 seconds with their eyes closed and hands on their hips. A trained researcher counts errors that includes: opening eyes, lifting hand(s) off hips, stepping, stumbling, falling, moving hips into more than 30^{o} of abduction, lifting the forefoot or heel, or remaining out of the test position for more than five seconds. If a same error is performed more than once during a single stance the student-athlete receives a point for each time the error occurs. If the student-athlete performs multiple errors at a given time, one error is recorded. Each stance is scored individually, and each error performed by the student-athlete results in a point. Higher scores on the mBESS represent worse balance performance. The mBESS test has significant correlations with the force-platform sway measures, and intra-tester reliability coefficients from .80 to .89 (15).

Statistical Analysis

Data were analyzed using descriptive and inferential statistics. Descriptive statistics included frequencies, means, standards deviations, medians, and inter-quartile ranges for the individual SCAT5 components. A Shapiro-Wilks test was first employed to determine normality for each component (p = <.001 - .004). After concluding that all data was not normally distributed, separate Mann-Whitney *U* tests were conducted for sex, health history, and sport type comparisons. These comparisons included symptom total, symptom severity, orientation, immediate and delayed recall, concentration, total SAC score, individual mBESS components, and overall mBESS score. No covariates were used for any analyses. The p-value was set a priori at .05.

RESULTS

A total of 462 healthy, collegiate student-athletes [212 females (19.96±1.24 years old); 250 males (19.42±1.36 years old)] completed the SCAT5 prior to their 2017-18, 2018-19, or 2019-20 athletic seasons. Student-athletes represented 17 of the 20 sports available at the university, with a majority participating in football (n= 102, 22.1%), see Table 1 for additional sport information. Most of the student-athletes included were collegiate freshmen (n= 229) with juniors (n= 89), sophomores (n= 78), seniors (n= 60) and graduate students (n= 6) less represented. Of the included student-athletes, 22.1% (n= 102) self-reported having sustained at least one previously diagnosed concussion. Thirty-five (7.6%) student-athletes reported being diagnosed with ADD/ADHD, while 29 (6.3%) reported having depression/anxiety. Less than 3% of student-athletes had a diagnosed learning disability/dyslexia (n= 11, 2.38%), while 21 (4.6%) reported being diagnosed with a headache disorder or migraines.

Table 1. Participants per Sport (N=462).

Sport	N (%)	Sport Type
Football	102 (22.1)	Contact
Wrestling	41 (8.9)	Contact
Women's Swimming	40 (8.7)	Noncontact
Women's Crew	38 (8.2)	Noncontact
Men's Swimming	33 (7.1)	Noncontact
Women's Ice Hockey	28 (6.1)	Contact
Women's Track and Field	28 (6.1)	Noncontact
Men's Track and Field	26 (5.6)	Noncontact
Baseball	21 (4.5)	Noncontact
Women's Basketball	20 (4.3)	Contact
Women's Soccer	19 (4.1)	Contact
Softball	17 (3.7)	Noncontact
Women's Tennis	12 (2.6)	Noncontact
Women's Gymnastics	11 (2.4)	Contact
Men's Golf	11 (2.4)	Noncontact
Men's Tennis	9 (1.9)	Noncontact
Men's Soccer	6 (1.3)	Contact
Total	462 (100)	

Table 2. Sport Concussion Assessment Tool 5 Group Means (N=462).

Component	**Max Score Possible**	**Mean (SD)**	**Median [IQR]**
Symptom Number	22.00	1.96 (3.37)	0.00 [3.00]
Symptom Severity	132.00	3.43 (7.63)	0.00 [4.00]
SAC Total	50.00	35.14 (5.23)	35.00 [8.00]
Orientation	5.00	4.96 (0.20)	5.00 [0.00]
Immediate Memory	30.00	20.18 (3.40)	20.00 [4.00]
Concentration	5.00	3.60 (1.14)	4.00 [2.00]
Delayed Recall	10.00	6.41 (1.94)	6.00 [3.00]
mBESS Total Errors	30.00	4.27 (3.81)	3.00 [5.00]
Double leg Stance	10.00	0.00 (0.00)	0.00 [0.00]
Single leg Stance	10.00	3.08 (2.86)	2.00 [4.00]
Tandem Leg Stance	10.00	1.19 (2.05)	0.00 [1.00]

At baseline, student-athletes reported an average of 1.96±3.37 symptoms, with a symptom severity of 3.43±7.63. The most commonly reported symptoms at were fatigue/low energy (n= 118, 25.5%), trouble falling asleep (n= 78, 16.9%), and difficulty concentrating (n= 71, 15.4%). Student-athletes also averaged a total SAC score of 35.14±5.23 out of 50. When examining the sub-components of the SAC, the average score for orientation was 4.96±0.20 with 95.7% (n= 442) of student-athletes recording the maximum score. During the three individual trials of the 10-word list, student-athletes accurately recited 5.27±1.34, 6.93±1.39, and 7.98±1.41 words, respectfully. In total, student-athletes averaged scores of 20.18±3.40 out of 30 for immediate

memory and 6.41±1.94 out of 10 for delayed recall. Only one student-athlete was able to correctly recite all 30 words for immediate memory. Whereas, 4.3% (n= 20) recited all 10 words for the delayed recall section. For the concentration section, student-athletes recorded an average total score of 3.60±1.14 out of 5, with 124 (26.8%) participants receiving a perfect score. All student-athletes completed the mBESS with no student-athletes recording errors for the double-leg stance. Student-athletes averaged 3.08±2.86 and 1.19±2.05 errors for the single-leg stance and tandem stance, respectively. Approximately 15% of participants (n= 70, 15.2%) performed the mBESS without an error for any stance. Group means for the SCAT5 are presented in Table 2.

At baseline, males and females yielded similar results for every component of the SCAT5. Symptom reporting remained consistent between males and females with regards to symptom total (males= 1.92±3.29, females = 2.00±3.47; *p*= .68), and symptom severity (males= 3.14±6.65, females= 3.77±8.65; *p*= .71). The most commonly endorsed symptoms for females were fatigue/low energy (n= 56, 26.4%) and trouble falling asleep (n= 40, 18.9%); whereas, males commonly endorsed fatigue/low energy (n= 62, 24.8%) and difficulty concentrating (n= 40, 16.0%). Similarly, there were no sex differences identified for overall SAC score, SAC component scores, or mBESS. A breakdown of SCAT5 performance by males and females can be found in Table 3.

Table 3. Sport Concussion Assessment Tool-5 Results by Sex (N=462).

	Males		Females			
Component	**Mean(SD)**	**Median[IQR]**	**Mean(SD)**	**Median[IQR]**	***U***	***p***
Symptom Number	1.92 (3.29)	0.50 [3.00]	2.00 (3.47)	0.00 [3.00]	25951.00	.68
Symptom severity	3.14 (6.65)	0.50 [3.00]	3.77 (8.65)	0.00 [4.00]	26008.50	.71
SAC Total	34.72 (5.31)	35.00 [7.00]	35.64 (5.10)	35.00 [7.00]	24444.00	.15
Orientation	4.95 (0.22)	5.00 [0.00]	4.97 (0.18)	5.00 [0.00]	25997.00	.32
Immediate Memory	19.88 (3.43)	20.00 [5.00]	20.53 (3.35)	21.00 [5.00]	23982.00	.08
Concentration	3.63 (1.20)	4.00 [2.00]	3.56 (1.07)	4.00 [1.00]	25001.50	.28
Delayed Recall	6.26 (1.94)	6.00 [3.00]	6.58 (1.94)	7.00 [3.00]	23846.00	.06
mBESS Total Errors	4.35 (3.99)	3.00 [6.00]	4.19 (3.89)	3.00 [5.00]	25974.50	.71
Double Leg Stance	0.00 (0.00)	0.00 [0.00]	0.00 (0.00)	0.00 [0.00]	26500.00	1.00
Single Leg Stance	3.11 (2.97)	2.00 [4.00]	3.06 (2.74)	2.00 [4.00]	26120.50	.79
Tandem Leg Stance	1.24 (2.06)	1.00 [1.00]	1.13 (2.04)	0.00 [2.00]	24519.50	.13

Of the student-athletes included, 35 (65% male) and 29 (62% female) reported being diagnosed with ADD/ADHD and depression/anxiety, respectively. Due to the small number of student-athletes reporting these diagnoses, each participant was matched to a non-diagnosed control with the same sex, year in school, and sport. Those who self-reported being diagnosed with ADD/ADHD reported more total symptoms (p= .01) and had a higher symptom severity (p= .01) than their non-diagnosed controls. The only other significant SCAT5 differences were for single leg mBESS (p= .01) and overall mBESS scores (p= .01), with healthy controls performing

Table 4. Sport Concussion Assessment Tool-5 Results by Health Diagnoses (N=462).

	Diagnosed		Not Diagnosed			
Component	**Mean(SD)**	**Median[IQR]**	**Mean(SD)**	**Median[IQR]**	***U***	***p***
Symptom Number						
Prior Concussion	2.47 (3.85)	1.00 [3.00]	1.81 (3.21)	0.00 [2.00]	16645.50	.12
ADD/ADHD	3.94 (4.88)	2.00 [4.00]	1.79 (3.17)	0.00 [2.00]	361.00	**.01***
Depression/Anxiety	3.90 (4.01)	3.00 [5.00]	1.83 (3.30)	0.00 [2.00]	243.00	**.01***
Symptom severity						
Prior Concussion	4.98 (10.19)	1.00 [5.00]	2.99 (6.68)	0.00 [3.00]	16326.50	.07
ADD/ADHD	8.14 (14.08)	4.00 [7.00]	3.04 (6.73)	0.00 [3.00]	348.00	**.01***
Depression/Anxiety	7.97 (11.80)	4.00 [11.00]	3.12 (7.18)	0.00 [3.00]	252.50	**.01***
SAC Total						
Prior Concussion	36.14 (5.01)	36.00 [6.00]	34.86 (5.25)	35.00 [8.00]	15570.50	**.02***
ADD/ADHD	33.83 (5.55)	34.00 [7.00]	35.25 (5.20)	35.00 [8.00]	562.00	.55
Depression/Anxiety	35.62 (5.53)	35.00 [8.00]	35.11 (5.22)	35.00 [8.00]	411.50	.89
Orientation						
Prior Concussion	4.96 (0.20)	5.00 [0.00]	4.96 (0.21)	5.00 [0.00]	18264.00	.82
ADD/ADHD	4.97 (0.17)	5.00 [0.00]	4.96 (0.21)	5.00 [0.00]	577.50	.31
Depression/Anxiety	4.97 (0.19)	5.00 [0.00]	4.96 (0.21)	5.00 [0.00]	406.50	.56
Immediate Memory						
Prior Concussion	20.79 (3.37)	21.00 [4.00]	20.00 (3.40)	20.00 [4.00]	15799.00	**.03***
ADD/ADHD	19.31 (3.60)	20.00 [4.00]	20.25 (3.38)	20.00 [4.00]	558.50	.52
Depression/Anxiety	20.69 (3.21)	20.00 [4.00]	20.14 (3.42)	20.00 [4.00]	417.50	.96
Concentration						
Prior Concussion	3.89 (1.05)	4.00 [2.00]	3.58 (1.17)	4.00 [2.00]	17766.50	.61
ADD/ADHD	3.23 (1.24)	3.00 [1.00]	3.63 (1.13)	4.00 [2.00]	497.50	.16
Depression/Anxiety	3.55 (1.30)	4.00 [2.00]	3.60 (1.13)	4.00 [2.00]	414.50	.92
Delayed Recall						
Prior Concussion	6.71 (2.00)	7.00 [2.00]	6.32 (1.95)	6.00 [3.00]	16102.00	.06
ADD/ADHD	6.31 (2.03)	7.00 [3.00]	6.41 (1.94)	6.00 [3.00]	601.00	.89
Depression/Anxiety	6.41 (2.13)	6.00 [3.00]	6.41 (1.93)	6.00 [3.00]	389.50	.63
mBESS Total Errors						
Prior Concussion	3.69 (3.84)	3.00 [4.00]	4.44 (3.96)	3.00 [6.00]	16091.00	.06
ADD/ADHD	6.49 (5.28)	6.00 [8.00]	4.10 (3.76)	3.00 [5.00]	370.00	**.01***
Depression/Anxiety	4.90 (3.97)	5.00 [7.00]	4.24 (3.94)	3.00 [5.00]	385.00	.58
Double Leg Stance						
Prior Concussion	0.00 (0.00)	0.00 [0.00]	0.00 (0.00)	0.00 [0.00]	18360.00	1.00
ADD/ADHD	0.00 (0.00)	0.00 [0.00]	0.00 (0.00)	0.00 [0.00]	612.50	1.00
Depression/Anxiety	0.00 (0.00)	0.00 [0.00]	0.00 (0.00)	0.00 [0.00]	420.50	1.00
Single Leg Stance						
Prior Concussion	2.66 (2.76)	2.00 [4.00]	3.21 (2.88)	2.00 [4.00]	16191.00	.07
ADD/ADHD	4.43 (3.44)	4.00 [5.00]	2.97 (2.78)	2.00 [4.00]	372.50	**.01***
Depression/Anxiety	3.07 (2.89)	2.00 [6.00]	3.09 (2.86)	2.00 [4.00]	406.00	.82
Tandem Leg Stance						
Prior Concussion	1.02 (1.64)	0.00 [1.00]	1.24 (2.15)	0.00 [2.00]	17917.50	.69
ADD/ADHD	2.06 (2.98)	1.00 [2.00]	1.12 (1.94)	0.00 [1.00]	457.00	.52
Depression/Anxiety	1.83 (2.16)	1.00 [3.00]	1.15 (2.04)	0.00 [1.00]	309.00	.07

*Significance at $p < .05$

better than those with an ADD/ADHD diagnosis. Student-athletes with a history of depression/anxiety were also matched to healthy non-diagnosed controls and reported significantly higher baseline symptoms (total: p= .01; severity: p= .01) than their counterparts. No other differences were found between those with a history of depression/anxiety diagnosis and health controls. A total of 102 (50% male) student-athletes reported being diagnosed with a prior concussion. Due to the larger proportion of student-athletes reporting a previous concussion, the entire sample was used for comparison. Concussion history had no influence on baseline symptom reporting (total: p= .12; severity: p= .07). All previous diagnoses also had little-to-no influence on SAC performance. Average SCAT5 results for student-athletes with a previous history of concussion, ADD/ADHD, and depression/anxiety are included in Table 4. Additionally, Table 4 includes average scores for all sampled participants who did not report each previous diagnosis.

Student-athletes were further categorized based on their sport type (contact, non-contact), with 227 (66% males) participating in contact sports, and 235 (43% males) participating in non-contact sports. Student-athletes participating in contact sports reported significantly more symptoms (2.24±3.82 vs 1.68±2.85; p= .03) and a higher symptom severity (4.19±9.54 vs 2.69±5.07; p= .03) than those participating in non-contact sports. Significant differences were also found for total SAC score, with non-contact student-athletes performing better than contact sport student-athletes (non-contact: 35.73±4.94, contact: 34.53±5.46; p= .04). Baseline SCAT5 results by contact and non-contact student-athletes are presented in Table 5.

Table 5. Sport Concussion Assessment Tool-5 Results by Sport Type (N=462).

	Contact		Non-Contact			
Component	**Mean(SD)**	**Median[IQR]**	**Mean(SD)**	**Median[IQR]**	***U***	***p***
Symptom Number	2.24 (3.82)	1.00 [3.00]	1.68 (2.85)	0.00 [3.00]	23834.50	**.03***
Symptom severity	4.19 (9.54)	1.00 [4.00]	2.69 (5.07)	0.00 [3.00]	23759.00	**.03***
SAC Total	34.53 (5.46)	35.00 [7.00]	35.73 (4.94)	36.00 [8.00]	23686.50	**.04***
Orientation	4.94 (0.23)	5.00 [0.00]	4.97 (0.17)	5.00 [0.00]	25939.50	.15
Immediate Memory	19.85 (3.55)	20.00 [4.00]	20.49 (3.24)	21.00 [4.00]	24430.50	.12
Concentration	3.57 (1.20)	4.00 [2.00]	3.63 (1.08)	4.00 [2.00]	26292.00	.78
Delayed Recall	6.17 (2.05)	6.00 [3.00]	6.64 (1.81)	7.00 [3.00]	23296.50	**.02***
mBESS Total Errors	4.15 (4.11)	3.00 [6.00]	4.40 (3.78)	3.00 [4.00]	24503.50	.13
Double Leg Stance	0.00 (0.00)	0.00 [0.00]	0.00 (0.00)	0.00 [0.00]	26672.50	1.00
Single Leg Stance	2.91 (3.01)	2.00 [5.00]	3.26 (2.71)	3.00 [4.00]	23521.00	**.03***
Tandem Leg Stance	1.25 (2.11)	1.00 [1.00]	1.14 (1.99)	0.00 [2.00]	25181.50	.26

*Significance at $p < .05$

DISCUSSION

The current study examined baseline SCAT5 performance in healthy, NCAA Division I collegiate student-athletes, and further compared these results by sex, health diagnoses, and sport type (contact, non-contact). In total, collegiate student-athletes reported approximately 2

baseline symptoms yielding an overall severity just over 3. Unsurprising, these totals are relatively low, likely due to the sample being healthy and free of SRC. However, this does indicate that student-athletes may report symptoms when in an otherwise "healthy" state (free of ongoing concussion) during pre-season baseline testing. This study is not the only study to identify the presence of these baseline symptoms, Katz et al. (19) found in their assessment of 15,681 NCAA student-athletes, that collegiate student-athletes endorsed an average of 3 symptoms, with an overall severity score of 5. Like previous research, this study also found comparable results for the orientation and concentration components of the SAC, however this is again unsurprising as these components are unchanged from previous SCAT editions (11). The immediate memory and delayed recall sections of the SCAT5 experienced the greatest update, moving to a 10-word list from the previously employed 5-word list.

Previous research using the 5-word immediate memory list found that 52% of student-athletes were able to record a perfect score during baseline testing (31). Furthermore, even after sustaining a SRC, student-athletes were still able to average an immediate memory score of 13 out of 15 (20). The SCAT5 attempts to address this potential ceiling effect by providing an optional 10-word list. This study found that when completing the 10-word list, student-athletes averaged an overall score of 20 out of 30. In addition, student-athletes correctly identified approximately 5, 7, and 8 words for trial 1, 2, and 3, respectively. It should be noted that most of these scores are higher than the max score for a single immediate memory trial on previous SCAT editions. Therefore, to prevent the ceiling effect of the immediate memory list, and to get a more accurate baseline representation, healthcare professionals should aim to utilize the optional 10-word immediate memory list over the traditional 5-word list when administering the SCAT5 in NCAA student-athletes.

Previous research has reported significant differences between males and females for several baseline and post-concussion outcome measures (5,8,31). Specifically, Brown et al. (3) reported that females were 43% more likely to report greater total symptoms at baseline when compared to males. However, conflicting results exist suggesting that males and females report similar levels of symptoms during pre-season baseline testing (33). Similarly, the current study found no differences between males and females for baseline symptom reporting. Additionally, no differences were found for any component of the SAC, including the new 10-word immediate memory and delayed recall list. These findings contrast with Shehata et al. (30) who reported that 60% of females received a perfect score for immediate memory compared to just 30% of males. It is possible that the increased difficulty of the 10-word list and the lack of perfect scores contributed to these similarities.

Student-athletes with a prior history of SRC have previously been found to report more symptoms at baseline and following another SRC than those without a previous history (9,27). Bruce et al. (4) found that student-athletes with two or more prior concussions reported significantly more symptoms at baseline than those with one or no previous injury. Similarly, researchers also found an increase in baseline symptom reporting with every additional SRC diagnosis (17). Despite these findings, an ample amount of research evidence refutes these claims (5,10,16). The current study identified that those who sustained a prior concussion scored

significantly higher on immediate memory and overall SAC scores, possibly due to these student-athletes being previously exposed to the SAC.

The current study found that student-athletes who self-report being diagnosed with ADD/ADHD or depression/anxiety reported twice as many baseline symptoms. Additionally, these student-athletes reported a symptom severity twice as high as those without the diagnosis. This is rather concerning considering the high prevalence of ADD/ADHD(1) and depression/anxiety among student-athletes (25). Specifically, previous research has found that nearly 15% of collegiate student-athletes meet criteria for clinical depression/anxiety (25). Similar to the current study, previous research has also identified student-athletes with these conditions as reporting more symptoms at baseline (7,12) and following SRC diagnosis (8,26). Participants in the current study were not asked about current medications, therefore, it is a possibility that taking medication to help manage these conditions may have influenced baseline symptom reporting. Healthcare professionals may need to consider more in-depth baseline concussion screening approaches for these individuals. Identifying those with significant baseline symptomologies may warrant further medical attention.

Student-athletes who participated in contact sports were found to report more baseline symptoms than non-contact student-athletes. Similarly, contact student-athletes reported a symptom severity nearly double that of non-contact student-athletes. These differences are in contrast with those presented by Katz et al. (19) who found slightly lower symptom scores in contact student-athletes when compared to limited and non-contact student-athletes. However, direct comparison between their findings and those of the current study are challenging, due to their inclusion of a limited-contact group. Limited-contact sports are sports where contact with other athletes is often inadvertent rather than intentional (i.e., basketball). The current study chose to not include a limited-contact group due to the ambiguous nature of determining which sports meet the criteria to be considered limited-contact. Contact sports have received increased media attention, due to their purposed influence on late-life cognition and neurological changes (34). However, the mechanisms behind these purposed differences are still unclear. Research is still needed to explore this purposed connection and identify if contact sports actually yield negative health outcomes.

This study is not without limitations. A major limitation is the relatively small sample size, which included student-athletes from a single Midwestern University. Of these participants, a large number were freshman and participated in football, making the data less generalizable to other ages and sports. Furthermore, when categorizing the sample based on co-morbid health diagnoses, groups of student-athletes with ADD/ADHD and depression/anxiety were small. Student-athletes were responsible for self-reporting these health diagnoses, thus there is potential for recall bias. Despite these limitations, the current study presents SCAT5 results in an organized fashion that is easy to interpret. These results also include scores for the 10-word immediate memory list, a component understudied by researchers. In addition, the results obtained were from researchers using the same testing directions in an attempt to maintain high levels of consistency. Future research should include a larger, more diverse sample from multiple institutions in different geographical locations. Significant research is also needed

evaluating post-concussion performance on the SCAT5 10-word immediate memory and delayed recall list. Finally, as a multifaceted assessment is recommended in SRC management, researchers should also investigate the utility of the SCAT5 with other SRC assessment tools.

The current study provides baseline reference values for the SCAT5 in Division I collegiate student-athletes. Additionally, this information is further categorized by sex, health diagnoses, and sport type (contact, non-contact) to better help clinicians utilize the most specific reference values possible for their student-athletes. Furthermore, student-athletes with ADD/ADHD or depression/anxiety and those who participate in contact sports were found to report more baseline symptoms than their counterparts. However, few other SCAT5 differences were found between the included student-athletes. The values presented in this study include results from the optional 10-word immediate memory list, which is a new component to the SCAT protocol. Due to this updated component, previously published reference values may not best reflect the most up to date version of the SCAT. Therefore, clinicians should aim to use reference values that represent the version of the SCAT they currently use.

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