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Baseline Evaluation of Concussion-Like Symptoms and Modifying Factors in Collegiate Club-Sport Athletes

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Context: Collegiate club-sport athletes participate in a variety of competitive sports and have been understudied in the concussion literature. Baseline performance measures are warranted to better understand assessment and management.

Objective: To quantify normative values and the effects of modifying factors sex, concussion history, diagnosed attention disabilities (attention-deficit/hyperactivity disorder [ADHD]), and sport type on baseline symptom evaluation among collegiate club-sport athletes.

Design: Cross-sectional study.

Setting: Retrospective chart review.

Patients or Other Participants: A total of 1034 collegiate club-sport athletes (N = 649 males, 62.7%) from 29 sports at a single institution.

Main Outcome Measure(s): Chart reviews were conducted for club-sport athletes who completed athlete background and symptom information on the Sport Concussion Assessment Tool—5th edition as a baseline concussion assessment during a single academic year. Demographics (eg, age, sex, sport), background medical information (eg, concussion history, ADHD), and symptom evaluation, consisting of individual 22-item symptom reports, the total number of symptoms, symptom severity scores, and symptom factors (eg, physical, cognitive, insomnia, and emotional), were analyzed.

Results: On baseline symptom reporting, 68% of club-sport athletes were asymptomatic, with mild symptoms described by 3% to 12% and moderate or severe symptoms by ≤4%. Modifier groups differed with a higher total number of symptoms and symptom severity in females ($P < .001$), individuals reporting a history of concussion ($P < .001$), and those with ADHD (total number $P = .04$, symptom severity $P = .02$). Similar significant findings were noted for females and the history of concussion group on all 4 symptom factors; however, those in collision or contact sports also indicated greater cognitive ($P = .03$) and insomnia ($P = .02$) factors. Those with ADHD endorsed more cognitive ($P < .001$) factors.

Conclusions: Normative symptoms for a collegiate club-sport sample revealed approximately 70% were asymptomatic. Higher total number of symptoms and symptom severity were demonstrated by females and those with a history of concussion. Cognitive-specific symptoms were greater in those diagnosed with ADHD and those who participated in collision or contact sports.

Key Words: mild traumatic brain injury, head injury examination, baseline assessment, sex differences

Key Points

- Approximately 70% of collegiate club-sport athletes were asymptomatic at baseline on the Sport Concussion Assessment Tool—5th edition symptom evaluation.
- Sex differences existed in collegiate club-sport athletes, with females endorsing a greater number of symptoms and higher severity scores.
- Additional modifiers, including a history of concussion and attention-deficit/hyperactivity disorder, led to more severe symptoms at baseline.
- Club-sport athletes who participated in collision or contact club sports reported greater cognitive and insomnia symptom factors.

Collegiate club-sport athletics programs feature a variety of competitive sports for college students who wish to engage in athletics separate from National Collegiate Athletic Association (NCAA)–sanctioned programs and sports teams. To date, the majority of the literature available on collegiate club-sport athletes has encompassed concussion reporting (indicating that 40% failed to report a concussion[1]), as well as injury epidemiology (revealing higher injury rates than among collegiate athletes[2]), and an increased risk of head injury in those playing a different club sport than their high school sport.[3] Considering that collegiate club sports, including ice hockey, men's and women's lacrosse, and men's and women's soccer, carry high injury rates of concussion[4] and that 86% of club-sport athletes were unsure if they had access to an athletic trainer,[1] understanding baseline and normative injury evaluation metrics can be pivotal for the clinical evaluation when these athletes seek medical care.

The current consensus on concussion[5] recommends the use of the Sport Concussion Assessment Tool (SCAT) for concussion assessment and management. Normative values for collegiate athletes have been published using the 5th edition (SCAT5), including the baseline number of symptoms and severity scores,[6] as well as individual item and symptom factors for both male and female collegiate athletes,[7,8] but no researchers have looked strictly at collegiate club-sport athletes. Symptom factors help to clarify specific categories and types of symptoms that athletes report,

enabling clinicians to better understand the appropriate rehabilitation and referral,[9] if needed. When providing normative values for male and female athletes, it is worth considering the effect of sex on symptom reporting, as high school[10] and collegiate[11] female athletes endorsed more symptoms than their male counterparts at baseline. Other pertinent medical background information, such as concussion history, learning disabilities, attention disorders (attention-deficit/hyperactivity disorder [ADHD]), and migraines, have been recognized as risk factors[12] and modifiers[13,14] in the baseline concussion assessment. On the SCAT5, in collegiate athletes, a concussion history[15] has been linked with roughly 1.5 times more symptoms and severity.[7] Similar findings were noted for intercollegiate and club-sport athletes with a history of concussion as well as those with ADHD.[16] Sport type is another factor: a greater number and severity of symptoms was seen on the SCAT5 among collegiate contact-sport athletes,[7] whereas the Concussion Assessment, Research and Education (CARE) Consortium demonstrated opposing results, with lower scores in the contact-sport group.[6] These results were also present for collision- and contact (C/C)-sport athletes in high school[17] and college.[18,19]

The purpose of our study was to establish normative values for baseline symptom evaluation in a sample of collegiate club-sport athletes and to examine the effects of modifiers, consisting of sex, sport type, concussion history, and diagnosed ADHD. We hypothesized that female athletes, individuals with a concussion history, and those with ADHD would report more symptoms and greater severity, whereas C/C-sport athletes would perform similarly to noncontact athletes.

METHODS

Participants

Institutional review board approval was granted with exempt status for the retrospective chart review. Baseline concussion data were analyzed for 1034 collegiate club-sport athletes (mean age = 19.83 ± 1.5 years) in the 2019–2020 academic year. All baseline testing occurred in fall 2019.

Measures

We conducted a retrospective chart review for club-sport athletes' reporting on the Athlete Background and Symptom Evaluation of the SCAT5. The Cognitive Screening, Neurological Screening, and Delayed Recall sections were not completed due to a lack of time and access to an athletic trainer for individual baseline testing and therefore were not included in the analyses. All participants completed the Athlete Background and Symptom Evaluation in a distraction-free environment, while in a rested state, before the start of the academic year.

Athlete background measures consisted of age; sport or team, which was then categorized dichotomously as either C/C or non-C/C based on the risk of colliding with or contacting an opposing player, playing surface, or object during practice and competition (Table 1); and concussion history, consisting of the number of past diagnosed concussions and, if applicable, when the most recent concussion occurred and the length of recovery in days. Athletes then responded either *yes* or *no* to each modifying and risk factor for concussion assessment and injury: (1) hospitalized for a head injury; (2) diagnosed or treated for a headache disorder or migraines; (3) diagnosed with a learning disability or dyslexia; (4) diagnosed with attention-deficit disorder (ADD) or ADHD; and (5) diagnosed with depression, anxiety, or other psychiatric disorder. Club-sport athletes completed the baseline symptom evaluation by rating their symptoms according to how they typically felt, per the SCAT5 instructions. They rated their symptoms for 22 items on a 7-point Likert scale, consisting of *none* (0), *mild* (1–2), *moderate* (3–4), or *severe* (5–6). The number of symptoms was tallied to produce the total number of symptoms variable (out of 22). The severity of all symptoms was also tallied to produce a symptom severity score (out of 132). Further, using previously published baseline symptom-factor structures,[8] we categorized individual symptoms into 1 of 4 factors: physical (out of 54; 9 symptoms), cognitive (out of 24; 3 symptoms), insomnia (out of 12; 2 symptoms), or emotional (out of 24; 3 symptoms). Two variables, *feeling slowed down* and *don't feel right*, were ungrouped and not included in the factor analyses. The breakdown of individual symptom items by factor is available in Table 2.

Table 1. Sport Type and Sport Categorization[a]

Sport Type		Sex, No. (%)	
Sport	No. (%)	Males	Females
Noncollision or noncontact	425 (41.1)	271 (63.8)	154 (36.2)
Badminton	11 (1.1)	6 (54.5)	5 (45.5)
Ballroom dancing	22 (2.1)	8 (36.4)	14 (63.6)
Bowling—men's	10 (1.0)	NA	NA
Clay shooting	24 (2.3)	19 (79.2)	5 (20.8)
Crew	28 (2.7)	22 (78.6)	6 (21.4)
Eventing—women's	15 (1.5)	NA	NA
Fishing—men's	43 (4.2)	NA	NA
Golf	27 (2.6)	26 (96.3)	1 (3.7)
Kayaking	30 (2.9)	23 (76.7)	7 (23.3)
Swimming	61 (5.9)	29 (47.5)	32 (52.5)
Table tennis	20 (1.9)	19 (95.0)	1 (5.0)
Tennis	68 (6.6)	40 (58.8)	28 (41.2)
Triathlon	43 (4.2)	25 (58.1)	18 (41.9)
Volleyball—women's	23 (2.2)	NA	NA
Contact or collision	609 (58.9)	378 (62.0)	231 (38.0)
Baseball—men's	35 (3.4)	NA	NA
Boxing	122 (11.8)	85 (69.7)	37 (30.3)
Field hockey	19 (1.8)	1 (5.3)	18 (94.7)
Gymnastics—women's	12 (1.2)	NA	NA
Ice hockey	32 (3.1)	3 (9.4)	29 (90.6)
Lacrosse—men's	55 (5.3)	NA	NA
Lacrosse—women's	36 (3.5)	NA	NA
Rugby—men's	29 (2.8)	NA	NA
Rugby—women's	41 (4.0)	NA	NA
Soccer—men's	26 (2.5)	NA	NA
Soccer—women's	36 (3.5)	NA	NA
Ultimate Frisbee—men's	88 (8.5)	NA	NA
Ultimate Frisbee—women's	29 (2.8)	NA	NA
Water polo	21 (2.0)	15 (71.4)	6 (28.6)
Water skiing	28 (2.7)	15 (53.6)	13 (46.4)

Abbreviation: NA, not available.

[a] Unless labeled as men's or women's, all sports were coeducational.

Statistical Analysis

A Cronbach α reliability analysis was conducted to determine the internal consistency of the individual 22-item

Table 2. Individual Symptom Items by Baseline Symptom Factor

Physical
Headache
"Pressure in head"
Neck pain
Nausea or vomiting
Dizziness
Balance problems
Sensitivity to light
Sensitivity to noise
Fatigue or low energy
Cognitive
Feeling like "in a fog"
Difficulty concentrating
Difficulty remembering
Confusion
Insomnia
Drowsiness
Trouble falling asleep
Emotional
More emotional
Irritability
Sadness
Nervous or anxious
Ungrouped[a]
Blurred vision
Feeling slowed down
"Don't feel right"

[a] Ungrouped symptoms were not included in the factor analyses.

Table 3. Athlete Background and Medical Information Demographics

Characteristic	No. (%)
Sex	
Male	649 (62.8)
Female	385 (37.2)
Age, y	
17–19	500 (48.3)
20–22	479 (46.3)
23+	55 (5.4)
Concussion history	
None	936 (90.5)
Prior concussions	98 (9.5)
1	51 (52.1)
2	31 (31.6)
3+	16 (16.3)
Hospitalization for a head injury	
No	970 (93.8)
Yes	64 (6.2)
Diagnosed or treated for headache disorder or migraines	
No	995 (96.2)
Yes	39 (3.8)
Diagnosed with a learning disability	
No	1004 (97.1)
Yes	30 (2.9)
Diagnosed attention-deficit or attention-deficit/hyperactivity disorder	
No	943 (91.2)
Yes	91 (8.8)
Diagnosed with depression, anxiety, or psychiatric disorder	
No	967 (93.5)
Yes	67 (6.5)

symptom report on the SCAT5. General descriptive (ie, means, SDs, frequencies) and inferential statistics were used to summarize the demographic information, medical background, and symptom evaluation. A 1-way analysis of variance was calculated to establish if age differed between males and females. A series of χ^2 tests for association were computed to identify any differences in medical background reporting (eg, sex and concussion history). To understand normative reference values, we determined means ± SDs and frequency distributions for symptom ratings (ie, asymptomatic, mild, moderate, or severe) for the total number of symptoms and severity scores and symptom factors. Shapiro-Wilk tests were conducted to assess the normality of the symptom evaluation. Due to nonparametric data in symptom reporting, we performed Mann-Whitney *U* tests to evaluate differences by sex, sport type, concussion history, and diagnosed ADD or ADHD in the total number of symptoms, symptom severity, and symptom factors. Separate analyses of symptom factors enabled us to control for type 1 error and correct for multiple comparisons. To better reproduce normative values for clinical use, mean symptom scores are provided, in addition to medians for the nonparametric data, for the modifying factor symptom reporting. An α level of .05 was used for all analyses.

RESULTS

Participants consisted of 649 (63%) male and 385 female athletes between the ages of 17 and 26 years. Of those with a history of concussion, 58 (59.2%) were male and 40 (40.8%), female. Regarding medical information, 64 (6.2%) reported having been hospitalized for a head injury, and 91 (8.8%) were diagnosed with ADD or ADHD. A total of 62 (68.1%) of those with ADHD were male. A full breakdown of athlete background and medical information demographics is presented in Table 3.

Reliability and Normative Values

Cronbach α analyses revealed high internal consistency for the 22 items on the SCAT5 among collegiate club-sport athletes ($\alpha = .920$). Internal consistency decreased when we examined α by individual symptom factors: physical ($\alpha = .828$), cognitive ($\alpha = .783$), insomnia ($\alpha = .585$), and emotional ($\alpha = .743$). Normative mean scores and the breakdown by symptom rating are shown in Table 4. The reported symptom averages ranged from (the lowest) nausea or vomiting (0.05/6) and dizziness, balance problems, and confusion (0.06/6) to (the highest) trouble falling asleep (0.25/6), difficulty concentrating (0.26/6), and feeling nervous or anxious (0.31/6). Mean scores and prevalences of mild, moderate, and severe scoring are also located in Table 4. A total of 68% reported no symptoms across the entire 22-item scale; the average was 1.69/22 symptoms, with a severity score of 3.02/132. For normative symptom factors, the prevalence of asymptomatic reporting was lowest in the physical and highest in the insomnia symptoms. All median scoring for the sample and groups was 0.00 for all individual symptoms, the total number of symptoms, severity scores, and symptom factors.

Group Differences Among Modifiers

Mann-Whitney *U* tests revealed group differences in total scoring and symptom factors among modifiers. Regarding

Table 4. Normative Symptom Evaluation

Symptom Evaluation Item	Mean ± SD	95% CI	Symptom Severity, No. (%)			
			Asymptomatic	Mild (1–2)	Moderate (3–4)	Severe (5–6)
Individual symptom item (out of 6 each)						
Physical factor	1.10 ± 2.9	0.92, 1.28	774 (74.9)	NA	NA	NA
Headache	0.23 ± 0.7	0.19, 0.27	901 (87.1)	104 (10.1)	27 (2.6)	2 (0.2)
"Pressure in head"	0.13 ± 0.5	0.09, 0.16	952 (92.1)	70 (6.7)	11 (1.1)	1 (0.1)
Neck pain	0.14 ± 0.5	0.11, 0.17	943 (91.2)	79 (7.6)	10 (1.0)	2 (0.2)
Nausea or vomiting	0.05 ± 0.3	0.03, 0.07	998 (96.5)	33 (3.2)	3 (0.3)	0 (0.0)
Dizziness	0.06 ± 0.3	0.04, 0.08	995 (96.2)	35 (3.4)	1 (0.3)	1 (0.1)
Balance problems	0.06 ± 0.3	0.04, 0.08	990 (95.7)	40 (3.9)	2 (0.2)	2 (0.2)
Sensitivity to light	0.12 ± 0.5	0.09, 0.15	964 (93.2)	55 (5.3)	15 (1.5)	0 (0.0)
Sensitivity to noise	0.08 ± 0.4	0.05, 0.10	984 (95.2)	44 (4.2)	5 (0.5)	1 (0.1)
Fatigue or low energy	0.24 ± 0.6	0.20, 0.28	884 (85.5)	125 (12.1)	25 (2.4)	0 (0.0)
Cognitive factor	0.61 ± 1.9	0.49, 0.72	846 (81.8)	NA	NA	NA
Feeling like "in a fog"	0.09 ± 0.4	0.07, 0.12	976 (94.4)	46 (4.4)	11 (1.1)	1 (0.1)
Difficulty concentrating	0.26 ± 0.7	0.21, 0.30	898 (86.8)	102 (9.9)	29 (2.8)	5 (0.5)
Difficulty remembering	0.20 ± 0.7	0.15, 0.24	927 (89.7)	80 (7.7)	21 (2.0)	6 (0.6)
Confusion	0.06 ± 0.4	0.03, 0.08	1004 (97.1)	20 (1.9)	9 (0.9)	1 (0.1)
Insomnia factor	0.38 ± 1.1	0.31, 0.44	879 (85.0)	NA	NA	NA
Drowsiness	0.12 ± 0.5	0.09, 0.15	960 (92.8)	61 (5.9)	12 (1.2)	1 (0.1)
Trouble falling asleep	0.25 ± 0.8	0.20, 0.30	911 (88.1)	81 (7.8)	39 (3.8)	3 (0.3)
Emotional factor	0.68 ± 1.9	0.56, 0.80	843 (81.5)	NA	NA	NA
More emotional	0.11 ± 0.5	0.08, 0.14	968 (93.6)	57 (5.5)	6 (0.6)	3 (0.3)
Irritability	0.13 ± 0.5	0.10, 0.17	954 (92.3)	66 (6.3)	10 (1.0)	4 (0.4)
Sadness	0.13 ± 0.5	0.09, 0.16	953 (92.2)	67 (6.5)	12 (1.1)	2 (0.2)
Nervous or anxious	0.31 ± 0.8	0.26, 0.37	878 (84.9)	107 (10.4)	43 (4.1)	6 (0.6)
Ungrouped						
Blurred vision	0.07 ± 0.4	0.05, 0.10	993 (96.0)	31 (3.1)	8 (0.8)	1 (0.1)
Feeling slowed down	0.08 ± 0.4	0.05, 0.10	984 (95.2)	44 (4.2)	6 (0.6)	0 (0.0)
"Don't feel right"	0.11 ± 0.5	0.08, 0.14	973 (94.1)	47 (4.6)	13 (1.3)	1 (0.1)
Total number of symptoms (out of 22)	1.69 ± 3.5	1.47, 1.91	703 (68.0)	NA	NA	NA
Symptom severity score (out of 132)	3.02 ± 7.4	2.57, 3.47	703 (68.0)	NA	NA	NA

Abbreviation: NA, not applicable.

sex, females reported more symptoms ($U = 107\,588.5$, $P < .001$) and higher severity scores ($U = 107\,578.0$, $P < .001$) than males. Those with a history of concussion described more symptoms ($U = 33\,927.5$, $P < .001$) and higher severity scores ($U = 22\,752.0$, $P < .001$) than those without, whereas those diagnosed with ADHD similarly indicated more symptoms ($U = 38\,402.5$, $P = .046$) and higher severity scores ($U = 37\,970.0$, $P = .028$) than those without a diagnosis. No differences were observed between the C/C and non-C/C groups for the total number of symptoms ($U = 124\,015.5$, $P = .168$) or severity ($U = 123\,964.0$, $P = .164$).

More physical symptoms were noted in females ($U = 110\,216.5$, $P < .001$) and those with a history of concussion ($U = 36\,630.5$, $P < .001$). Cognitive symptoms were noted in all modifiers, with higher scores in the female ($U = 11\,792.0$, $P = .012$), concussion history ($U = 39\,078.0$, $P < .001$), ADHD ($U = 34\,847.0$, $P < .001$), and C/C ($U = 122\,854.5$, $P = .039$) groups. Similar findings existed for the insomnia factor, with higher scores in the female ($U = 119\,039.0$, $P = .041$), concussion history ($U = 39\,715.5$, $P < .001$), and C/C ($U = 122\,888.0$, $P = .026$) groups. Lastly, only females ($U = 108\,076.5$, $P < .001$) and those with a history of concussion ($U = 39\,416.5$, $P < .001$) displayed higher emotional scores (see Table 5).

DISCUSSION

In this study, we attempted to quantify baseline symptom reporting in a large sample of collegiate club-sport athletes. During a retrospective chart review of baseline SCAT5 symptom reporting, approximately 70% of the athletes indicated they were asymptomatic. A breakdown of scoring by severity (ie, mild, moderate, severe) on the 22-item symptom checklist showed that 2% to 12% described mild symptoms; upward of 4%, moderate symptoms; and 0.6%, severe symptoms. The mean scores for our sample were consistent with but slightly lower than the normative values of Katz et al[6] from the CARE Consortium as well as Asken et al[1] in collegiate athletes, for both the total number of symptoms (1.69 versus 2.7 versus 2.4, respectively) and symptom severity (3.02 versus 4.9 versus 4.4, respectively). When we stratified our results by sex, the mean scores were similar to those from the CARE Consortium[6] and collegiate norms,[7,8] with females reporting a larger number of symptoms (2.18 versus 3.3 versus 2.9, respectively) and greater symptom severity (3.82 versus 5.9 versus 5.6, respectively) than males (number of symptoms: 1.4 versus 2.3 versus 2.0, respectively; severity: 2.55 versus 4.1 versus 3.2, respectively). Previous researchers[8] determined that the most common symptoms endorsed by collegiate athletes at baseline were fatigue, drowsiness, and headache. The most common symptoms in our sample were nervousness, fatigue, difficulty concentrating, and headache, further validating this baseline symptom reporting in collegiate athletes. We used the symptom-factor categorization implemented by Asken et al,[8] who identified only the number of collegiate athletes reporting at least a mild symptom score (ie, $\geq 1/6$) by factor. We aimed to provide

Table 5. Total Symptoms, Severity Scores, and Factors by Modifying Factor, Mean ± SD

	Sex		Prior Concussion		Attention-Deficit/ Hyperactivity Disorder		Sport Type	
Measure	Male	Female	No	Yes	No	Yes	Noncontact or -collision	Contact or Collision
Total number of symptoms[a,b,c]	1.40 ± 3.3	2.18 ± 3.8	1.53 ± 3.3	3.28 ± 4.8	1.63 ± 3.5	2.30 ± 3.9	1.61 ± 3.5	1.75 ± 3.5
Symptom severity score[a,b,c]	2.55 ± 7.1	3.82 ± 7.8	2.73 ± 6.9	5.78 ± 10.6	2.89 ± 7.3	4.34 ± 8.2	2.91 ± 7.2	3.10 ± 7.5
Physical factor[a,b]	0.92 ± 2.9	1.40 ± 2.9	0.99 ± 2.7	2.20 ± 4.1	1.09 ± 2.9	1.20 ± 2.6	1.13 ± 3.0	1.08 ± 2.8
Cognitive factor[a,b,c,d]	0.54 ± 1.8	0.71 ± 1.9	0.55 ± 1.7	1.16 ± 2.7	0.54 ± 1.8	1.32 ± 2.4	0.59 ± 1.9	0.62 ± 1.8
Insomnia factor[a,b,d]	0.35 ± 1.0	0.42 ± 1.1	0.35 ± 1.0	0.66 ± 1.5	0.36 ± 1.1	0.52 ± 1.2	0.28 ± 0.8	0.44 ± 1.2
Emotional factor[a,b]	0.51 ± 1.6	0.98 ± 2.2	0.64 ± 1.8	1.05 ± 2.1	0.65 ± 1.8	0.98 ± 2.4	0.67 ± 1.8	0.69 ± 1.9

[a] $P < .05$ between groups for sex.

[b] $P < .05$ between groups for prior concussion.

[c] $P < .05$ between groups for attention-deficit/hyperactivity disorder.

[d] $P < .05$ between groups for sport type.

prevalence by category (ie, mild, moderate, and severe). In addition, we supplied the number of asymptomatic individuals by factor, which equals the number who reported nonzero symptoms. Identical results were evident in the ≥1 symptom prevalence for the emotional (18.5% versus 18.6%) and cognitive (18.2% versus 21.0%) factors, but rates were lower for the physical (25.1% versus 46.1%) and insomnia (15.0% versus 30.5%) factors.

When comparing sex, we noted that collegiate club-sport females endorsed higher baseline numbers of symptoms, severity scores, and symptom-factor scores than males. These differences were consistent with those of Covassin et al,[11] who also demonstrated differences in the symptom severity scores using the Post-Concussion Symptom Scale (PCSS) in collegiate athletes. Although they did not address symptom factors, individual item differences revealed higher scores in females for headache, nausea, fatigue, and sensitivity to light and noise (physical factors); as well as difficulty concentrating (cognitive factor); drowsiness and sleeping more or less than usual (insomnia factor); and feeling more emotional, irritability, sadness, and nervousness (emotional factor), furthering validating our symptom-factor differences by sex at baseline.

We documented group differences in concussion history for all symptom variables (total number of symptoms, severity scores, and symptom factors), with more symptoms indicated by those who reported a prior concussion than those who did not. Kaye et al[16] noted similar results with more symptom severity endorsement on the PCSS for intercollegiate and collegiate club-sport athletes. This suggests that concussion history may lead to residual symptoms, even in cognitive factors, despite a lack of neurocognitive differences at baseline.[20] Concussion history was also associated with increased symptom severity in collegiate athletes independent of modifying factors such as emotional distress and sleep quality.[15]

Interestingly, the concussion history group displayed higher mean scores for the total number of symptoms and severity scores than any other modifier, including sex, sport type, and ADHD. Of the 98 individuals who described a history of ≥1 previous concussions, 59.1% were males, limiting the potential contribution of female sex to more symptoms and factors. Differences were noted in the concussion history and ADHD groups: 16 individuals had both a concussion history and ADHD, whereas 82 had a concussion history but no ADHD, and 75 had ADHD but no concussion history. Participants diagnosed with ADHD experienced a greater number of symptoms and more severity and cognitive-only factors. These findings agree with the outcomes of Elbin et al,[21] who observed a greater number of symptoms using the PCSS in a sample of collegiate and high school athletes diagnosed with ADHD when compared with a healthy control group. Petit et al[7] recorded similar results in collegiate athletes but with higher severity scores (8.47/132). Our cognitive-factor analysis clarified specific symptoms (fogginess, difficulty concentrating and remembering, and confusion) that combined to produce a higher factor score. These are explained by common characteristics of learning and behavior in individuals with ADHD, including inattention, impulsivity, and hyperactivity,[22] as well as low tolerance for frustration and mood instability[23] and academic problems,[24] which may lead to confusion and lack of cognitive desire. Of the 91 individuals with diagnosed ADHD, 62 (68%) were male, limiting the potential for sex to influence higher scores in this group.

Individuals in C/C club sports recounted a greater number of cognitive and insomnia symptom factors. The cognitive symptoms consisted of fogginess, difficulty concentrating and remembering, and confusion, whereas the insomnia symptoms were sleep related: drowsiness and trouble falling asleep. Though no differences were seen between athletes in C/C and non-C/C sports, mean scores were higher for the C/C athletes (1.75 symptoms and 3.10 severity versus 1.61 symptoms and 2.91 severity, respectively). Petit et al[7] also identified a larger number of symptoms and greater severity in contact sports than noncontact. These results contradict previous literature[18,19] in which authors described lower symptom scores in contact-sport than noncontact-sport athletes.[17] According to the CARE Consortium,[6] a greater number of symptoms (3.6) and more severity (6.5) occurred in the noncontact group than the limited-contact (2.8 symptoms and 5.1 severity) and contact (2.4 symptoms and 4.2 severity) athletes. Despite our use of a combined C/C category, all of the overlapping sports with the CARE Consortium were categorized similarly, with bowling, golf, rifle or clay shooting, rowing or crew, swimming, and tennis being labeled as noncontact. Contact sports consisted of field hockey, ice hockey, lacrosse, soccer, and water polo, while limited-contact sports were baseball, cross-country, gymnastics, track and field or triathlon, and volleyball.[6] The only sport in

our study that was not categorized similarly was volleyball, which we classified as non-C/C due to the net dividing players and opponents along with a lack of equipment and decreased risk of colliding one's head with an opposing player or surface. It may be that the C/C sport athletes indicated more insomnia symptoms due to a lack of recovery from the greater physical demands of playing. This may have led to poor or fewer hours of sleep, which has been known to increase baseline symptoms in high school athletes for all symptom factors, including cognitive-somatic symptoms.[25] Additionally, the athletes in the C/C group may be more likely to travel for away competitions and tournaments (eg, field hockey, lacrosse, rugby); this can result in more of a challenge balancing academic and athletic scheduling than in the non-C/C group (eg, badminton, ballroom dancing, table tennis), which may, in turn, affect sleep and cognition. However, these possibilities are merely speculative, have not been established in the literature, and remain largely unexplored.

This study was not without limitations. First, it was a retrospective review of baseline concussion symptom records using the SCAT5 symptom evaluation in club-sport athletes. Different symptom scales may result in different findings at baseline. We included a wide variety of sports, but other universities may host club sports at the intercollegiate or NCAA level. For example, in the Southeastern Conference, field hockey, ice hockey, and men's soccer are not NCAA–sanctioned sports as they are in the Atlantic Coast Conference and Big Ten Conference. Future research is needed to further quantify the baseline assessment, such as the remaining items of the SCAT5 and other tools, including balance and vestibular or ocular motor screening. Investigators should also explore these tools, including symptom evaluations, to understand postinjury status and the change from baseline performance, along with recovery interval measures (eg, 1-week postinjury, at return to sport).

In conclusion, approximately 70% of collegiate club-sport athletes reported being asymptomatic. A higher total number of symptoms and greater severity scores were noted by females and those with a history of concussion. Cognitive-specific symptoms were greater in those diagnosed with ADHD and those who participated in C/C sports. Additional examination is needed to confirm these findings postinjury and during clinical recovery. Special consideration may be warranted for females and individuals with diagnosed modifiers as well as those in C/C sports.

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