Journal of Athletic Training 2023;58(10):895–901
doi: 10.4085/1062-6050-0554.22

www.natajournals.org

Original Research

Self-Reported Mental Health Measures of Incoming Collegiate Student-Athletes With a History of COVID-19

Melissa N. Anderson, PhD*; Caitlin A. Gallo, BS*; Scott W. Passalugo, BS*; Jake M. Nimeh, BS†; Thomas A. Buckley, EdD, ATC*

*Department of Kinesiology and Applied Physiology and †Department of Biological Sciences, University of Delaware, Newark. Dr Anderson is now with the Ohio Musculoskeletal and Neurological Institute and the College of Health Sciences and Professions, Ohio University, Athens

Background: People with a history of COVID-19 may experience persistent neuropsychological disruptions such as lower satisfaction with life, depression, and anxiety. Although student-athletes are at low risk for severe COVID-19 complications, the effect of COVID-19 on mental health has not been elucidated.

Objective: To compare patient-reported mental health outcomes for incoming collegiate athletes with (COVID+) or without (COVID−) a history of COVID-19.

Design: Case-control study.

Setting: Laboratory.

Patients or Other Participants: A total of 178 student-athletes, consisting of 79 in the COVID+ group (44.3%; age = 18.90 ± 0.16 years) and 99 in the COVID− group (55.6%; age = 18.95 ± 0.16 years).

Main Outcome Measure(s): Participants completed the Satisfaction With Life Scale (SWLS), the Hospital Anxiety and Depression Scale (HADS), and the State-Trait Anxiety Inventory (STAI). Unadjusted 1-way analyses of variance were conducted across all patient-reported outcomes. Analyses of covariance were calculated to determine the interaction of COVID-19 group, sex, and race and ethnicity on outcomes. Post hoc Bonferroni testing was performed to identify specific differences between groups. A χ^2 analysis was computed to compare the number of athletes in each group who met the standard clinical cut points.

Results: We observed a between-groups difference for HADS depression ($P = .047$), whereby athletes in the COVID+ group had higher ratings (2.86 ± 0.26). We found group differences for the SWLS ($P = .02$), HADS anxiety ($P = .003$), and STAI state anxiety ($P = .01$) such that all scores were higher for the COVID+ group in the adjusted model. Post hoc testing revealed that female student-athletes in the COVID+ group had worse HADS anxiety ($P = .01$) and STAI trait anxiety ($P = .002$) scores than individuals in all other groups. We did not demonstrate differences between groups in the percentage of responses below established diagnostic thresholds.

Conclusions: Incoming collegiate student-athletes who reported a previous COVID-19 diagnosis displayed higher depression scores, suggesting that clinicians may need to provide appropriate identification and referral for mental health conditions. However, we were encouraged that most participants, regardless of a history of COVID-19 diagnosis, had mental health scores that did not exceed established diagnostic threshold values.

Key Words: patient-reported outcome measures, psychiatric status rating scales, life satisfaction, coronavirus

Key Points

- Differences in mental health for student-athletes with and those without a history of COVID-19 were below the established clinical cut points for satisfaction with life, anxiety, and depression.
- Female student-athletes reported worse anxiety than male student-athletes, regardless of their COVID-19 history.

According to the World Health Organization, as of October 2022, >617 million cases of COVID-19 had been diagnosed globally.[1] The most common physiological signs and symptoms are fever, respiratory problems, headache, diarrhea, and loss of taste or smell.[2] Furthermore, >75% of patients with COVID-19 reported cognitive difficulties with episodic memory, attention, and concentration, even when their cases were mild.[3] However, researchers[4–8] have indicated that one-third of people with a history of COVID-19 may experience persistent neuropsychological disruptions (ie, long COVID), with major depressive and anxiety disorders, posttraumatic stress disorder, obsessive-compulsive disorder, and insomnia being the most frequently noted, even among individuals with mild cases who were not hospitalized. Whereas authors[8,9] have documented negative mental health changes after COVID-19 recovery, investigation of the perceived low risk for virus-related complications, such as long COVID, among the intercollegiate student-athlete population is lacking.

Physical activity is a well-established protective and treatment approach for mental health. Habitual physical activity protects against the development of new depression or anxiety symptoms by releasing endorphins, increasing confidence, improving sleep quality, and facilitating healthy coping.[10] Interestingly, collegiate athletes were found to have a higher rate of mental health disorders than the general collegiate student population (38% of women, 22% of men).[11] Rates and severity of COVID-19 are lower in athletes than in nonathletes, yet substantial numbers of youth through collegiate athletes likely have experienced COVID-19. Athletic trainers and other health

care providers must be aware of the potential COVID-19–related additive risk so they can ensure appropriate treatment as these athletes move forward in their careers and encounter sport- or life-related mental health challenges.

Many mental health disturbances reported after COVID-19, including decreased satisfaction with life, anxiety, and depression, were acute and gradually disappeared or returned to baseline levels[5]; however, depression remained prevalent for up to 1-year postrecovery in about 12% (range = 7%–21%) of patients.[8] In the general population, depression is the most common psychiatric disorder, with approximately 15% experiencing at least 1 lifetime episode. The diagnosis of depression is based primarily on clinical symptoms such as sadness, apathy, hopelessness, and irritability and is often supported by the results on reliable and valid questionnaires.[12] Furthermore, depression is related to chronic, low-grade inflammation, with emerging evidence suggesting that it may be an immune response.[12] The COVID-19 infection causes systemic inflammation,[5,13] which may play a key role in the development of depression-like symptoms.[8] Thus, the inflammation from a COVID-19 infection may be related to depression and the associated feelings of sadness, hopelessness, and loss of interest (eg, in activities of daily living, sports), several of the hallmarks of depression noted in the general population.

Whereas the acute pandemic component of COVID-19 is declining, millions of youth athletes who have recovered from it will become collegiate student-athletes and may have an elevated risk of mental health disorders. Therefore, the primary aim of our study was to compare patient-reported mental health outcomes for incoming collegiate athletes with (COVID+) and those without (COVID−) a history of COVID-19 diagnosis. We hypothesized that satisfaction with life would be lower and levels of anxiety and depression would be higher for athletes in the COVID+ group.

METHODS

Participants

As part of a larger concussion research project, we enrolled 178 student-athletes of 324 participants (54.9%) who self-selected into this component by completing the COVID-19 question and all associated mental health measures. Included were incoming freshmen or transfer varsity student-athletes or cheerleaders. To achieve ecological validity of student-athletes, we used no exclusion criteria. All participants provided written and oral informed consent, and the study was approved by the University of Delaware Institutional Review Board. A total of 79 athletes with a history of COVID-19 (COVID+; n = 79, 44.4%; age = 18.90 ± 0.16 years) and 99 athletes without a history of COVID-19 (COVID−; n = 99, 55.6%; age = 18.95 ± 0.16 years) were included in our analyses. We observed no differences between groups for a previous diagnosis of psychiatric disorder, anxiety, or depression ($P > .05$). Complete demographic and health history information are presented in Table 1.

Instrumentation

Participants completed 3 commonly used mental health screening questionnaires.

The Satisfaction With Life Scale. The Satisfaction With Life Scale (SWLS) measures subjective well-being (college student sample: Cronbach $\alpha = 0.82$).[14] It consists of 5 questions scored on a 7-point Likert scale (1 = *strongly disagree*, 7 = *strongly agree*). Scores range from 5 (*extremely dissatisfied*) to 35 (*highly satisfied*), with a score <20 considered dissatisfaction with one's life.[14]

The Hospital Anxiety and Depression Scale. The Hospital Anxiety and Depression Scale (HADS) is a valid and reliable instrument (adult sample: Cronbach α range = .68–.93) for detecting states of anxiety and depression with subscales measuring the severity of emotional distress and has been used in collegiate student-athletes.[15] The survey consists of 7 questions for anxiety and 7 for depression that are scored separately. Subscores for anxiety and depression are categorized as *normal* (0 to 7), *borderline abnormal* (8 to 10), or *abnormal* (11 to 21).

The State-Trait Anxiety Inventory. The State-Trait Anxiety Inventory (STAI) consists of 40 questions separated into 2 forms (state and trait) scored on a 4-point Likert scale, with responses ranging from 1 (*not at all*) to 4 (*very much so*) for state anxiety and 1 (*almost never*) to 4 (*almost always*) for trait anxiety (range = 20–80). As suggested by previous researchers,[16] we used a cutoff of 40 to evaluate the presence or absence of state and trait anxiety. The STAI has demonstrated good internal consistency (Cronbach α = .90) and test-retest reliability ($r = 0.70$, $P < .001$). We analyzed both state and trait anxiety total scores.

Procedures

All surveys were completed via convenience sampling during the athletes' preseason concussion baseline testing session. Testing occurred individually in a dedicated laboratory space under quiet conditions, and participants were informed that their results would not be shared with the coaching staff or teammates. The COVID-19 history question was part of a larger set of questionnaires on the overall medical history approved by our institutional review board for a separate branch of the study from the required baseline testing. Therefore, completion of these additional assessments was optional, and athletes were informed that they were not required to take part in the study. The total time to complete the entire battery (Qualtrics) was approximately 30 minutes.

Statistical Analysis

Descriptive statistics were calculated to describe the sample demographic and outcome measures. To test our hypotheses, we compared the groups (COVID+ and COVID−) in a series of unadjusted models (model 1) across all patient-reported outcomes (SWSL, HADS anxiety, HADS depression, and state and trait anxiety) using 1-way analyses of variance. Effect sizes were calculated using the Cohen *d* and interpreted as *small* ($d = 0.20$), *moderate* ($d = 0.50$), or *large* ($d = 0.80$).[17] To control for potential contributors to model 1, we assessed the groups in model 2 using a 1-way analysis of covariance adjusted for the covariates of sex and race and ethnicity. Both sex and race and ethnicity were independently associated with mental health disorders[18,19]; thus, their inclusion in our model was essential. Both models are presented because model 1 is more clinically meaningful for athletic trainers. Furthermore, a 2-way analysis of covariance was computed to determine the interaction of COVID-19 group and sex in patient-reported mental health outcomes. Subsequent post hoc Bonferroni testing was performed to identify specific differences between

Version of Record at: https://doi.org/10.4085/1062-6050-0554.22

Table 1. Participant Characteristics

Variable	Group, No. (%)		*P* Value
	COVID+ (n = 79)	COVID− (n = 99)	
Sex			.83
Male	35 (44.3)	49 (49.5)	
Female	44 (55.7)	50 (50.5)	
Race and ethnicity[a]			
Asian	1 (1.3)	8 (8.1)	.02[b]
Black	11 (13.9)	10 (10.1)	.61
Hispanic	8 (10.1)	9 (9.1)	.97
Non-Hispanic	71 (89.9)	90 (90.9)	.82
White	70 (88.6)	76 (76.8)	.90
Psychiatric history			
Anxiety	2 (2.5)	3 (3.0)	.19
Attention-deficit/hyperactivity disorder	8 (10.1)	4 (4.0)	.09
Depression	3 (3.8)	5 (5.1)	.71
Learning disorder	4 (5.1)	1 (1.0)	.07
Psychiatric disorder	3 (3.8)	5 (5.1)	.71
None	61 (77.2)	83 (83.8)	.89
Sport[c]			
Baseball	5 (6.3)	8 (8.1)	.66
Basketball	6 (7.6)	1 (1.0)	.02[b]
Cheerleading	2 (2.5)	2 (2.0)	.82
Cross-country	1 (1.3)	4 (4.0)	.26
Field hockey	5 (6.3)	2 (2.0)	.14
Football	10 (12.7)	8 (8.1)	.31
Golf	0 (0.0)	4 (4.0)	.25
Lacrosse	5 (6.3)	11 (11.1)	.27
Rowing	11 (13.9)	21 (21.2)	.21
Soccer	10 (12.7)	9 (9.1)	.42
Softball	3 (3.8)	3 (3.0)	.78
Swimming/diving	7 (8.9)	16 (16.2)	.15
Tennis	10 (12.7)	5 (5.1)	.07
Track and field	4 (5.1)	4 (4.0)	.74
Volleyball	4 (5.1)	1 (1.0)	.10

Abbreviations: COVID+, history of COVID-19; COVID−, no history of COVID-19.

[a] Participants could choose >1 race and ethnicity or not respond.

[b] Indicates a difference ($P < .05$).

[c] Participants could choose >1 sport.

groups. Finally, we used χ^2 analyses to compare the number of athletes who met the standard clinical cut points for both groups. All analyses were conducted using JMP (version 16.0; JMP Statistical Discovery LLC), and the α level was set a priori at .05.

RESULTS

Patient-Reported Outcomes

Model 1 (Unadjusted). Means, SDs, and 95% CIs for each mental health patient-reported outcome (ie, SWLS, HADS anxiety, HADS depression, STAI) are provided in Table 2. In the unadjusted model, we observed a difference between groups for HADS depression ($F_{1,176} = 2.83$, $P = .047$), whereby athletes in the COVID+ group had higher depression ratings (2.86 ± 0.26) than those in the COVID− group (2.04 ± 0.25), with a large effect size (Cohen $d = 3.21$). No other models were different (Table 2). Individual responses are shown in the Figure.

Models 2 and 3 (Adjusted). After including sex and race and ethnicity as covariates, we found a group difference for the SWLS ($F_{1,176} = 2.27$, $P = .02$, Cohen $d = 0.47$), HADS anxiety ($F_{1,173} = 5.88$, $P = .003$, Cohen $d = 5.26$), and STAI state anxiety ($F_{1,171} = 2.36$, $P = .01$, Cohen $d = 0.21$) such that satisfaction with life, HADS anxiety, and state anxiety scores were higher for the COVID+ group. No group differences were found for the HADS depression or STAI trait anxiety scores in model 2.

Model 3 yielded group interaction effects for the HADS anxiety ($F_{1,173} = 13.76$, $P = .003$) and STAI trait anxiety ratings ($F_{1,171} = 6.74$, $P = .03$; Table 3). Post hoc testing revealed that female athletes in the COVID+ group had worse HADS anxiety ($P = .01$) and STAI trait anxiety ($P = .002$) ratings than all other athletes.

Proportion of Abnormal Scores by Group

We observed no differences between groups for the percentage of respondents who were classified as *abnormal* for any of the outcome measures (Table 4).

DISCUSSION

Given the possible deleterious effect of a positive COVID-19 diagnosis on mental health, we described and compared patient-reported measures among incoming intercollegiate athletes who did and those who did not report having had

Version of Record at: https://doi.org/10.4085/1062-6050-0554.22

Table 2. Unadjusted Model Comparisons in Mental Health Surveys Between COVID+ and COVID− Groups

Scale	Group, Mean ± SD (95% CI)		*P* Value	Cohen *d* Effect Size	Observed Power
	COVID+	COVID−			
Satisfaction With Life Scale	28.41 ± 0.59 (27.44, 29.37)	29.38 ± 1.16 (26.89, 29.38)	.73	1.05	0.06
Hospital Anxiety and Depression Scale					
Anxiety	2.13 ± 2.29 (1.62, 2.63)	2.27 ± 2.29 (1.81, 2.74)	.66	0.06	0.07
Depression	2.86 ± 0.26 (2.32, 3.39)	2.04 ± 0.25 (1.75, 2.76)	.047[a]	3.21	0.39
State-Trait Anxiety Inventory					
State anxiety	30.07 ± 11.71 (27.53, 32.61)	29.38 ± 10.91 (27.15, 31.61)	.69	0.06	0.06
Trait anxiety	30.37 ± 11.48 (27.87, 32.86)	29.84 ± 11.35 (27.51, 27.52)	.62	0.05	0.06

Abbreviations: COVID+, history of COVID-19; COVID−, no history of COVID-19.

[a] Indicates a difference ($P < .05$).

a COVID-19 diagnosis. We addressed this question using both unadjusted, clinically relevant models and adjusted models. Overall, athletes in the COVID+ group reported higher depression ratings than the athletes in the COVID− group. In addition, sex was a covariate linked to decreased life satisfaction, heightened depression, and increased anxiety in female compared with male student-athletes. Our findings suggest that the COVID-19 pandemic may result in persistent adverse effects on the mental well-being of otherwise healthy young adults. Thus, prioritizing athletes' mental health support is crucial for schools. High-resource schools likely have access to a team of sports psychologists working closely with the athletic

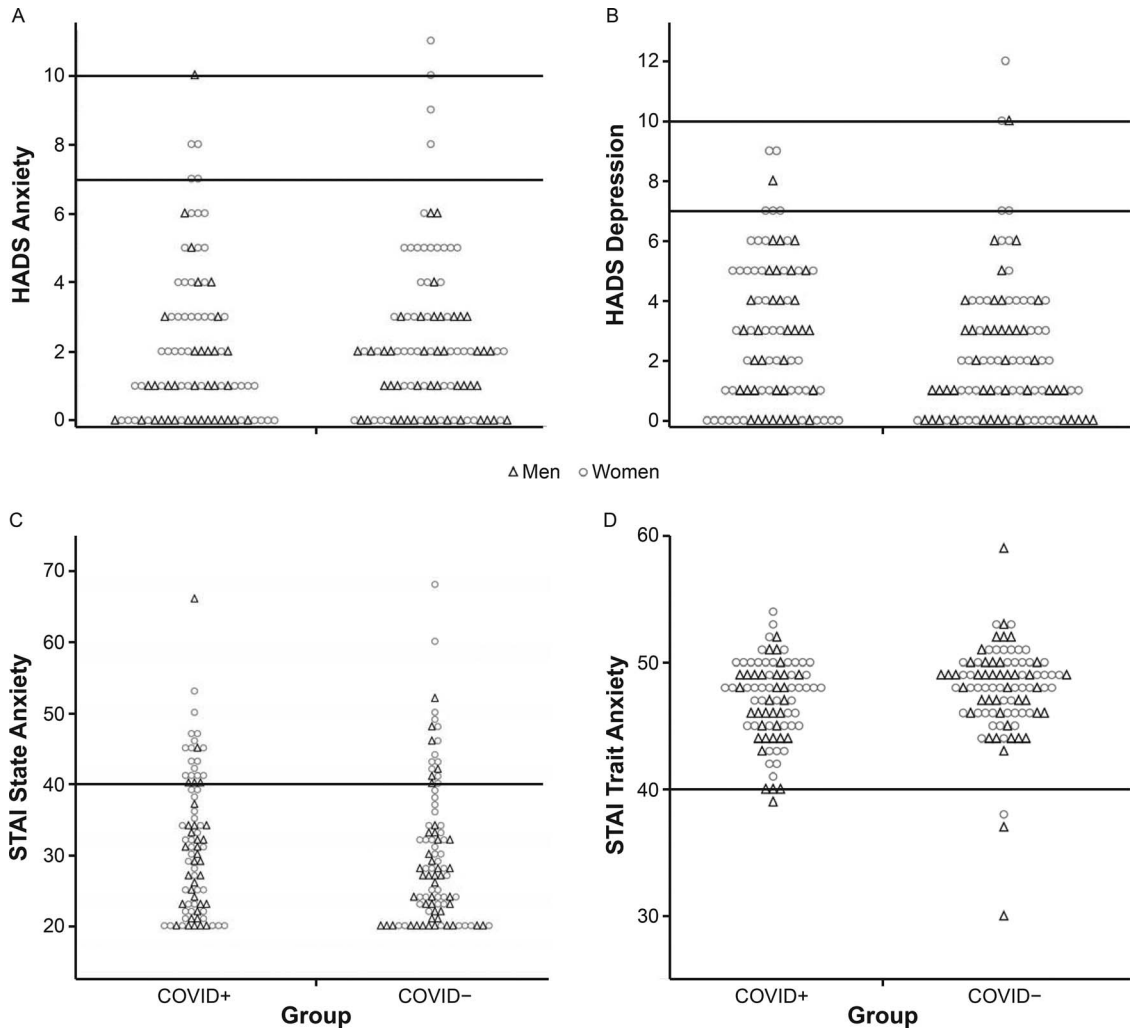

Figure. Individual data points for A, Hospital Anxiety and Depression Scale (HADS) anxiety, B, HADS depression, C, State-Trait Anxiety Inventory (STAI) state anxiety, and, D, STAI trait anxiety. Solid horizontal lines indicate clinical cutoff points for A and B, normal (below the lower line), borderline abnormal (between the lines), and abnormal (above the upper line) and C and D, average (below the line) and above average (above the line). Percentages above normal for groups with (COVID+; n = 75) or without (COVID−; n = 96) a history of COVID-19 were 96.2% and 94.9% for HADS anxiety, 94.4% and 95.6% for HADS depression, 78.2% and 80.1% for STAI state anxiety, and 82.3% and 84.9% for STAI trait anxiety, respectively.

Version of Record at: https://doi.org/10.4085/1062-6050-0554.22

Table 3. Adjusted Model for COVID-19 History and Sex

Scale	Sex	Group, Mean ± SD (95% CI)		*P* Value
		COVID+	COVID−	
Satisfaction With Life Scale	Male	29.8 ± 3.4 (25.6, 31.0)	29.1 ± 5.6 (27.4, 30.8)	.09
	Female	27.3 ± 4.6 (26.1, 28.8)	27.3 ± 6.4 (23.5, 29.1)	
Hospital Anxiety and Depression Scale				
Anxiety	Male	1.5 ± 2.2 (0.8, 2.3)	1.5 ± 1.5 (1.1, 2.0)	.003[a]
	Female	2.6 ± 2.3 (1.9, 3.2)	2.3 ± 2.2 (2.2, 3.7)	
Depression	Male	2.6 ± 2.2 (1.9, 3.4)	1.9 ± 2.1 (1.3, 2.6)	.18
	Female	3.0 ± 2.6 (2.3, 3.8)	2.59 ± 2.54 (0.80, 3.28)	
State-Trait Anxiety Inventory				
State anxiety	Male	28.0 ± 11.6 (24.0, 31.9)	26.7 ± 9.3 (23.9, 29.6)	.79
	Female	31.6 ± 11.7 (28.2, 34.9)	31.7 ± 11.8 (28.3, 35.1)	
Trait anxiety	Male	27.8 ± 10.3 (24.3, 31.3)	26.8 ± 8.9 (28.9, 36.1)	.03[a]
	Female	32.2 ± 12.1 (28.8, 35.7)	32.5 ± 12.6 (28.9, 36.1)	

Abbreviations: COVID+, history of COVID-19; COVID−, no history of COVID-19.

[a] Indicates a difference ($P < .05$).

department, whereas schools with limited resources may need to forge relationships with student health services to ensure that athletes receive the necessary mental health care.

Anxiety and depression frequently occur together but reflect different sequelae. Depression is often linked to past events in which something or someone valued is lost and perceived as challenging or impossible to regain.[12] Furthermore, major life events (eg, a pandemic) and other personal problems such as social isolation are believed to increase depressed feelings.[20] Depression was higher in the COVID+ group, which may be a psychological manifestation of not only the isolation and time lost from participation associated with the pandemic but also the systemic inflammation caused by COVID-19.[13] Conversely, anxiety reflects uncertainty about a potential future crisis.[18] Interestingly, anxiety scores did not differ between the groups. By the summer of 2021, vaccines for COVID-19 had become available, which could have contributed to a more positive outlook moving forward. Student-athletes appeared to remain optimistic about their future, as demonstrated by the low anxiety ratings on the HADS.

Although we demonstrated higher depression scores with a large effect size (Cohen $d = 3.21$) for the COVID+ group, most participants (94.5%) were still considered normal and nearly 4 points below the *mild depression* classification criterion.[21] Therefore, these statistical differences likely have limited clinical meaningfulness; however, athletic trainers should be aware that these individuals could have an increased risk of clinical depression if another event (eg, concussion or anterior cruciate ligament injury) occurs. Nearly all participants in both groups (COVID+ = 96.4%, COVID− = 95.7%) were within the normal anxiety range. As the prevalence of mental health concerns continues to increase globally,[22] the authors of a large study focused on physical activity as a protective mediator of anxiety and depression.[23] Involvement in sports mediates the presentation of psychological disorders and may serve as an effective treatment approach.[24] In addition, organized sports engagement (eg, being on a team, including in individual sports such as tennis) was associated with a decreased risk of developing anxiety and depression compared with physical activity alone.[10] Hence, continuing to be physically active and being on a team may explain why our sample, regardless of COVID-19 history, had scores below the clinical thresholds for anxiety and depression. However, because we do not have data specific to summer 2020 or earlier, we do not know if mental health declined when sport participation was temporarily cancelled.

Table 4. Chi-Square Analysis of Proportions of Clinical Cutoff Scores by Group

Measure	Group, No.		χ^2 Value	*P* Value
	COVID+	COVID−		
Hospital Anxiety and Depression Scale				
Anxiety	79	94	1.298	.52
Depression	79	94	1.607	.45
State-Trait Anxiety Inventory				
State anxiety	75	96	0.901	.34
Trait anxiety	75	96	0.029	.87

Abbreviations: COVID+, history of COVID-19; COVID−, no history of COVID-19.

Anxiety is further subdivided into state and trait anxiety, with *state anxiety* defined as a more transient reaction to an adverse situation and *trait anxiety* defined as a more stable personality attribute that affects long-term thought processes.[25] More than 83% of student-athletes in both groups had state or trait anxiety scores below the clinical cutoffs. This result aligns closely with prepandemic anxiety levels, when 30% of female and 25% of male student-athletes self-reported anxiety.[18] This lack of group differences indicates that COVID-19 may not have resulted in lasting, meaningful changes in either state or trait anxiety. Still, we did observe differences in HADS and trait anxiety scores between male and female student-athletes such that female student-athletes had higher (worse) levels. This finding is similar to most of the literature, with researchers[18] consistently documenting more anxiety in women than men. Therefore, critical demographic characteristics such as sex may affect the mental health response of student-athletes after COVID-19 recovery and should be considered by the evaluating sports medicine professionals.

Satisfaction with life refers to a cognitive judgmental process in which individuals assess their quality of life according to criteria they deem important.[14] It requires people to compare their current circumstances with what they believe is the standard. The COVID-19 pandemic likely influenced this factor across the general population. Our incoming student-athletes had higher SWLS scores (approximately 28.9) than previously reported for typical college students (approximately 23.5[14]; Tables 2 and 3); however, these scores were

lower than the SWLS scores of athletes before COVID-19 (range = 29.2–29.5) in a Concussion Assessment, Research and Education Consortium study.[26] We did observe a large effect size that was not different ($P = .73$; Cohen $d = 1.05$) but no clinically meaningful difference (difference between scores <1) between groups. Starting their college experience and joining a university sport team is an exciting period for student-athletes. The higher-than-average SWLS scores for college students in our study may reflect this optimism for the future, yet these scores were still lower than those before COVID-19. Involvement in sports and greater team cohesion have been associated with better SWLS scores in athletes.[27] Furthermore, postconcussion musculoskeletal injury rates in intercollegiate student-athletes were lower in those with higher SWLS scores.[28] Future authors should examine how SWLS evolves over an individual's collegiate athletics career.

Our work had limitations. All mental health conditions were self-reported by the participants, which is an inherent limitation of questionnaire-based research. We could not account for illness severity (eg, symptom magnitude and days to recover) in athletes who had COVID-19. Furthermore, our investigation was limited to a single mid-Atlantic university, and surveys were administered only to new, incoming student-athletes; however, this represents a large ecologically valid patient sample. We reported low power (range = 0.06–0.39) for our unadjusted model, but the sample size of 178 participants was sufficient. Finally, future researchers should evaluate both pathophysiological and psychosocial contributions to post–COVID-19 mental health challenges in student-athletes and, more importantly, treatment strategies focused on the specific demands of this unique population.

CONCLUSIONS

Incoming collegiate student-athletes who reported a previous COVID-19 diagnosis displayed higher depression scores, suggesting that clinicians may need to provide appropriate identification and referral for mental health concerns. Nonetheless, it was encouraging that most participants had mental health scores that did not exceed established threshold values. Thus, although the pandemic resulted in a global emotional upheaval, this change may be transient in healthy young adults. Female athletes may have a higher risk for mental health challenges, and athletic trainers should continue to incorporate mental health specialists in the treatment of student-athletes.

REFERENCES

1. WHO coronavirus (COVID-19) dashboard. World Health Organization. Accessed July 24, 2023. https://covid19.who.int
2. Grant MC, Geoghegan L, Arbyn M, et al. The prevalence of symptoms in 24 410 adults infected by the novel coronavirus (SARS-CoV-2; COVID-19): a systematic review and meta-analysis of 148 studies from 9 countries. *PLoS One*. 2020;15(6):e0234765. doi:10.1371/journal.pone.0234765
3. Ritchie K, Chan D. The emergence of cognitive COVID. *World Psychiatry*. 2021;20(1):52–53. doi:10.1002/wps.20837
4. Kumar A, Nayar KR. COVID 19 and its mental health consequences. *J Ment Health*. 2021;30(1):1–2. doi:10.1080/09638237.2020.1757052
5. Mazza MG, Palladini M, De Lorenzo R, et al; COVID-19 BioB Outpatient Clinic Study Group. Persistent psychopathology and neurocognitive impairment in COVID-19 survivors: effect of inflammatory biomarkers at three-month follow-up. *Brain Behav Immun*. 2021;94:138–147. doi:10.1016/j.bbi.2021.02.021
6. Taquet M, Lucianno S, Geddes JR, Harrison PJ. Bidirectional associations between COVID-19 and psychiatric disorder: retrospective cohort studies of 62 354 COVID-19 cases in the USA. *Lancet Psychiatry*. 2021;8(2):130–140. doi:10.1016/S2215-0366(20)30462-4
7. Crunfli F, Carregari VC, Veras FP, et al. SARS-CoV-2 infects brain astrocytes of COVID-19 patients and impairs neuronal viability. *Research Square*. Preprint posted online November 13, 2020. doi:10.21203/rs.3.rs-104944/v1
8. Premraj L, Kannapadi NV, Briggs J, et al. Mid and long-term neurological and neuropsychiatric manifestations of post-COVID-19 syndrome: a meta-analysis. *J Neurol Sci*. 2022;434:120162. doi:10.1016/j.jns.2022.120162
9. Lorkiewicz P, Waszkiewicz N. Biomarkers of post-COVID depression. *J Clin Med*. 2021;10(18):4142. doi:10.3390/jcm10184142
10. Elbe AM, Lyhne SN, Madsen EE, Krustrup P. Is regular physical activity a key to mental health? Commentary on "Association between physical exercise and mental health in 1.2 million individuals in the USA between 2011 and 2015: a cross-sectional study," by Chekroud et al, published in *Lancet Psychiatry*. *J Sport Health Sci*. 2019;8(1):6–7. doi:10.1016/j.jshs.2018.11.005
11. Weigand S, Cohen J, Merenstein D. Susceptibility for depression in current and retired student athletes. *Sports Health*. 2013;5(3):263–266. doi:10.1177/1941738113480464.
12. Berk M, Williams LJ, Jacka FN, et al. So depression is an inflammatory disease, but where does the inflammation come from? *BMC Med*. 2013;11:200. doi:10.1186/1741-7015-11-200
13. Lyra E, Silva NM, Barros-Aragão FGQ, De Felice FG, Ferreira ST. Inflammation at the crossroads of COVID-19, cognitive deficits and depression. *Neuropharmacology*. 2022;209:109023. doi:10.1016/j.neuropharm.2022.109023
14. Diener E, Emmons RA, Larsen RJ, Griffin S. The Satisfaction With Life Scale. *J Pers Assess*. 1985;49(1):71–75. doi:10.1207/s15327752jpa4901_13
15. Katz BP, Kudela M, Harezlak J, et al; CARE Consortium Investigators. Baseline performance of NCAA athletes on a concussion assessment battery: a report from the CARE Consortium. *Sports Med*. 2018;48(8):1971–1985. doi:10.1007/s40279-018-0875-7
16. Hart R, McMahon CA. Mood state and psychological adjustment to pregnancy. *Arch Womens Ment Health*. 2006;9(6):329–337. doi:10.1007/s00737-006-0141-0
17. Cohen J. Statistical power analysis. *Curr Dir Psychol Sci*. 1992;1(3):98–101. doi:10.1111/1467-8721.ep10768783
18. Bandelow B, Michaelis S. Epidemiology of anxiety disorders in the 21st century. *Dialogues Clin Neurosci*. 2015;17(3):327–335. doi:10.31887/DCNS.2015.17.3/bbandelow
19. Bailey RK, Mokonogho J, Kumar A. Racial and ethnic differences in depression: current perspectives. *Neuropsychiatr Dis Treat*. 2019;15:603–609. doi:10.2147/NDT.S128584
20. Deng J, Zhou F, Hou W, et al. The prevalence of depression, anxiety, and sleep disturbances in COVID-19 patients: a meta-analysis. *Ann N Y Acad Sci*. 2021;1486(1):90–111. doi:10.1111/nyas.14506
21. Breeman S, Cotton S, Fielding S, Jones GT. Normative data for the Hospital Anxiety and Depression Scale. *Qual Life Res*. 2015;24(2):391–398. doi:10.1007/s11136-014-0763-z
22. Roehrig C. Mental disorders top the list of the most costly conditions in the United States: $201 billion. *Health Aff (Millwood)*. 2016;35(6):1130–1135. doi:10.1377/hlthaff.2015.1659
23. Chekroud SR, Gueorguieva R, Zheutlin AB, et al. Association between physical exercise and mental health in 1.2 million individuals in the USA between 2011 and 2015: a cross-sectional study. *Lancet Psychiatry*. 2018;5(9):739–746. doi:10.1016/S2215-0366(18)30227-X
24. Penedo FJ, Dahn JR. Exercise and well-being: a review of mental and physical health benefits associated with physical activity. *Curr Opin Psychiatry*. 2005;18(2):189–193. doi:10.1097/00001504-200503000-00013

25. Spielberger CD, Gorsuch RL, Lushene R, Vagg PR, Jacobs GA. *Manual for the State-Trait Anxiety Inventory*. Consulting Psychologists Press; 1983. Found at https://psycnet.apa.org/doiLanding?doi=10.1037%2Ft06496-000
26. Broglio SP, Katz BP, Zhao S, McCrea M, McAllister T; CARE Consortium Investigators. Test-retest reliability and interpretation of common concussion assessment tools: findings from the NCAA-DoD CARE Consortium. *Sports Med*. 2018;48(5):1255–1268. doi:10.1007/s40279-017-0813-0
27. Hung Chen L, Kee YH, Chen MY. Why grateful adolescent athletes are more satisfied with their life: the mediating role of perceived team cohesion. *Soc Indic Res*. 2015;124:463–476. doi:10.1007/s11205-014-0798-0. Found at https://link.springer.com/article/10.1007/s11205-014-0798-0
28. Buckley TA, Bryk KN, Enrique AL, Kaminski TW, Hunzinger KJ, Oldham JR. Clinical mental health measures and prediction of post-concussion musculoskeletal injury. *J Athl Train.* 2023;58(5):401–407. doi:10.4085/1062-6050-0595.21

Address correspondence to Melissa N. Anderson, PhD, School of Applied Health Sciences and Wellness, College of Health Sciences and Professions, Grover Center, 53 Richland Avenue, Athens, OH 45701. Address email to m.anderson@ohio.edu.