Journal of Athletic Training 2023;58(9):775–780
doi: 10.4085/1062-6050-0536.22

www.natajournals.org

Original Research

Changes in State and Trait Anxiety Throughout Concussion Recovery in High School– and College–Aged Individuals

Tracey Covassin, PhD, ATC*; Aaron J. Zynda, PhD*; Megan C. Loftin, MS*; Alyssa M. Pollard-McGrandy, MS, ATC*; Allie J. Tracey, BS, BA*; Christopher P. Tomczyk, MS, ATC†

*Department of Kinesiology, Michigan State University, East Lansing; †Department of Kinesiology, Albion College, MI

Context: Researchers have indicated that individuals may experience anxiety symptoms after concussion. A potential mechanism for these presentations is shifts in anxiety throughout recovery.

Objective: To examine the levels of state and trait anxiety in individuals after concussion throughout recovery compared with the levels in individuals serving as uninjured matched control participants.

Design: Prospective cohort study.

Setting: University laboratory.

Patients or Other Participants: Seventy-eight high school- and college-aged individuals (concussion group = 39, age = 18.4 ± 2.3 years; matched control group = 39, age = 18.4 ± 2.3 years) were enrolled.

Main Outcome Measure(s): The State-Trait Anxiety Inventory was administered within 72 hours of injury (day 0: first test session), 5 days (±1 day) after the first test session (day 5), and at the time of full medical clearance (+2 days). Separate 2 × 3 repeated-measures analyses of variance were used to investigate differences in state and trait anxiety for each group throughout recovery.

Results: State and trait anxiety were higher in the concussion group than in the control group at day 0, day 5, and full medical clearance. For state anxiety, we observed a group × time interaction ($F_{2,150} = 10.45$, $P < .001$, $\eta_p^2 = 0.12$). For trait anxiety, we did not note an interaction ($F_{1.74,150} = 1.5$, $P = .22$, $\eta_p^2 = 0.02$) but did find main effects for time ($F_{1.74,150} = 25.7$, $P < .001$, $\eta_p^2 = 0.3$) and group ($F_{1,75} = 7.23$, $P = .01$, $\eta_p^2 = 0.09$).

Conclusions: Participants with concussion experienced higher levels of state anxiety throughout recovery than matched control individuals. Although trait anxiety was higher in the concussion group and decreased over time, no interaction was seen, demonstrating that concussion may not affect this aspect of personality. Postinjury anxiety may result from increased state anxiety, and clinicians should screen for and manage these symptoms throughout recovery.

Key Words: postinjury anxiety, individualized treatment, concussion assessments, concussion symptoms

Key Points

- State and trait anxiety were higher in individuals postconcussion than in uninjured matched control participants.
- State, not trait, anxiety levels fluctuated across recovery, indicating that individuals who sustained a concussion were experiencing heightened anxiety symptoms throughout the entire recovery process compared with uninjured matched control participants.
- Measuring the types of anxiety at baseline and specifically state anxiety at postconcussion assessments will allow for individualized treatment and rehabilitation protocols (ie, mental health services) and may minimize the burden of anxiety on recovery.

Between 1.6 and 3.8 million sport- and recreation-related traumatic brain injuries occur annually in the United States,[1] with concussions constituting 75% of all traumatic brain injury–related diagnoses. In addition, sport-related concussions account for 8.9% and 5.8% of all high school and collegiate athletic injuries, respectively.[2] Concussion is a heterogeneous injury that results in a variety of physical symptoms (eg, headache and dizziness), affective symptoms (eg, anxiety and depression), cognitive impairments (eg, memory problems), and sleep impairments.[3] Researchers[4] and clinicians have used clinical profiles to assess and manage concussions. These clinical profiles are vestibular and ocular impairment, posttraumatic migraine, anxiety and mood disturbances, and cognitive impairment, along with cervical and sleep disturbances as modifiers. Investigators[4] have suggested that 24% of patients with concussion experience anxiety and mood clinical profiles. Furthermore, clinicians often find it difficult to disentangle postconcussion symptoms and anxiety symptoms (eg, nervousness and irritability)[5] because of the overlapping nature of these conditions. Despite this challenge, most authors have focused on associations of preexisting anxiety with increased symptoms[6,7] and prolonged recovery.[8–10] However, characterizing postinjury anxiety in individuals with a diagnosed concussion and assessing whether

fluctuations in anxiety occur throughout the recovery process are important.

Recently, researchers[11] determined that 13% of patients with concussion exhibited clinical levels of postinjury anxiety. These postinjury anxiety symptoms may be attributed to increased stress, lack of team involvement, lack of social support, or uncertainty about recovery time.[12] Postinjury anxiety has been an area of focus because it is an indicator of prolonged recovery. Schilling et al[13] found that youth (aged 12–18 years) who exhibited anxiety symptoms had a prolonged recovery (>28 days postinjury). Other investigators[14] noted elevated levels of anxiety at return to play (28 days) in collegiate athletes. Yet a major limitation of these studies was the measurement of postinjury anxiety at only 1 time point. In addition, Singh et al[15] suggested that collegiate football players had no increase in anxiety symptoms at 1 month after concussion. This examination was limited to football players, did not involve measurement of anxiety after individuals were fully cleared to play, and lacked an evaluation of specific aspects of anxiety.

Anxiety has been categorized into 2 distinct factors: state and trait anxiety. *State anxiety* is a transient emotional response to a situation that can result in feelings of apprehension and tension.[16] *Trait anxiety* is a stable aspect of personality that represents a predisposition to assessing a situation as threatening and influences whether an anxiety response is initiated.[16] Wood et al[17] explored state and trait anxiety in adults (mean age = 40 years) who presented at a concussion clinic 2 weeks postinjury and did not find elevated state or trait anxiety scores versus those of a healthy control group. Among collegiate athletes, Yang et al[18] observed that athletes with concussion who experienced depression symptoms at baseline were 3.4 times more likely to report increased state anxiety than athletes with concussion who did not describe anxiety or depression at baseline. However, the authors did not address postconcussion state or trait anxiety across recovery. Turner et al[19] identified elevated levels of state anxiety at the start of the stepwise concussion progression and at return to play. More specifically, 73% of collegiate athletes with concussion had scores above the state anxiety threshold that decreased slightly to 60% at return to play.[19] The researchers commented that state anxiety was normal among competitive athletes and that the results might represent a typical response for this population.[19,20]

A more complete understanding and assessment of state and trait anxiety may help to improve our existing knowledge of postinjury anxiety. Fluctuations in state anxiety across recovery may have implications for how a clinician chooses to assess and treat an individual. Furthermore, although trait anxiety is considered part of one's stable personality, whether this remains true after an event such as a concussion is unknown. In addition, no current studies have assessed both state and trait anxiety after a concussion in high school and collegiate populations or compared these populations with an uninjured matched control group to determine whether elevated levels of state anxiety are a typical response for competitive athletes. Therefore, the purpose of our study was to examine the levels of state and trait anxiety in patients with concussion throughout recovery compared with those in uninjured matched control participants. We hypothesized that patients with concussion would have higher levels of state anxiety than uninjured matched control participants overall and at each time point. We also hypothesized that the level of trait anxiety would remain stable for both groups.

METHODS

Study Design and Participants

We used a prospective cohort study with a case-control, repeated-measures design to characterize anxiety throughout recovery. A total of 78 participants were enrolled; 39 high school– and college–aged patients with concussion (25 males and 14 females; age = 18.4 ± 2.3 years) in the mid-Michigan area were matched to 39 uninjured control individuals (25 males and 14 females; age = 18.4 ± 2.3 years) on sex, age, and, when possible, contact sport (n = 62). Inclusion criteria were no history of a neurologic disease (eg, epilepsy), age between 14 and 24 years, and written informed assent and consent, as appropriate, from the participant and a parent or guardian. Exclusion criteria were no testing within 72 hours of injury, a visible abnormality on computed tomography scan, loss of consciousness for ≥20 minutes, or hospital admission for >24 hours due to the head injury or collateral injuries. Recruits were excluded from the uninjured matched control group if they had a concussion within the past year. This study received approval from the University of Michigan Institutional Review Board.

Operational Definitions

Concussion. *Concussion* was defined as an altered mental status due to a direct or indirect blow to the head, face, or body that resulted in a variety of clinical signs and symptoms.[3] All participants with suspected concussions were assessed by physicians using the following criteria: (1) the presence of ≥1 on-field signs (eg, loss of consciousness, amnesia, disorientation or confusion, balance difficulty), (2) symptoms (eg, headache, nausea, dizziness), (3) any impairment on sideline assessment (eg, Sport Concussion Assessment Tool), or (4) a combination of these.

Full Medical Clearance. *Full medical clearance* (FMC) was defined as the time when the physician cleared the participant for full unrestricted activity. To achieve FMC, participants with concussion had to report no symptoms, have normal vestibular assessment, complete all 5 stages of the Concussion in Sport[3] return-to-play stepwise protocol, and be examined and cleared by a physician. Individuals with concussion were in the stepwise progression for 5 days. If symptoms returned at any stage of the protocol, they remained in that stage until they were symptom free.

Instrumentation

State-Trait Anxiety Inventory. Anxiety was measured using the State-Trait Anxiety Inventory Form Y (STAI), a self-reported 40-item questionnaire that consists of separate measures for state anxiety and trait anxiety (20 items each).[16] The state anxiety scale focuses on the present moment, with items representing the emotional state of the participant at the time of administration. State anxiety is rated on a scale from 1 to 4, with 1 indicating *not at all* and 4 indicating *very much so*. In contrast, the trait anxiety scale asks how people feel generally, with items representing their ongoing emotional state. It is rated on a scale from 1 to 4, with 1 indicating *almost never* and 4 indicating *almost always*. Scores on both scales

range from 20 to 80, with higher scores reflecting greater levels of anxiety. The STAI classifies high levels of state anxiety as scores >38 and trait anxiety as scores >52.[21] The STAI has been shown to have good test-retest reliability for trait anxiety (intraclass correlation coefficient = 0.84) with internal consistency ranging from a Cronbach α of .86 to .92 for a normative sample.[22] Internal consistency for state anxiety ranged from a Cronbach α of .83 to .94 in a sample of high school and college students.[22] The STAI also has very good concurrent and factorial validity, ranging from a Cronbach α of .70 to .85.[22]

Procedures

Patients with a concussion were recruited via an established network of athletic trainers and health clinics at nearby universities, colleges, and high schools. Clinicians in these networks contacted the study team when a patient received a concussion diagnosis, and trained research coordinators (A.J.Z. and C.P.T.) travelled to the school to enroll the patient and administer the study procedures. Uninjured matched control participants were recruited through patients with concussion and recruitment flyers.

Participants with a diagnosed concussion were tested within 72 hours of injury (day 0: first test session), 5 days (±1 day) from the first test session (day 5), and at the time of FMC (+2 days). Uninjured matched control individuals were tested following the same schedule as their matched participant with concussion. On day 0, we collected demographic and medical history and concussion characteristics (for the concussion group only) and administered the STAI. For the subsequent visits (day 5), FMC participants completed the STAI. All data were collected using pen and paper and were transcribed into an Excel (version 2016; Microsoft Corp) spreadsheet by a study coordinator (C.P.T.).

Statistical Analysis

Descriptive statistics were calculated for the demographic and medical history variables in the concussion and control groups. Independent-samples *t* tests were used to compare continuous demographic characteristics, and the χ^2 test was used to compare categorical variables between groups. Separate 2 × 3 repeated-measures analyses of variance were computed to investigate changes in state and trait anxiety for each group throughout recovery. Within-subject variables were time (day 0, day 5, and FMC), and between-subjects variables were group (concussion and uninjured matched control). Estimates of the effect size for each repeated-measures analysis of variance were determined as partial η^2 (η_p^2). Greenhouse-Geisser ε corrections were applied when the assumption of sphericity was violated. Interactions were further explored via independent-samples *t* tests as post hoc testing at each time point. For the post hoc *t* tests, we estimated Cohen *d* effect sizes, which we interpreted as *small* ($d = 0.2$), *medium* ($d = 0.5$), or *large* ($d = 0.8$).[23] We set the α level a priori at .05. All statistical analyses were completed using SPSS (version 27; IBM Corp).

RESULTS

Demographic Characteristics and Medical History

No differences in demographic characteristics and medical history were found between groups (Table 1). Of note, 5 (12.8%) participants in the concussion group and 2 (5.1%) participants in the uninjured matched control group reported a history of depression or anxiety ($P = .23$). The average time from concussion to day 0 was 2.2 ± 0.8 days, to day 5 was 5.5 ± 1.0 days, and to FMC was 11.6 ± 14.4 days. On average, participants in the control group were enrolled within 7.02 ± 39 days of the participants in the concussion group to whom they were matched. Furthermore, we observed no differences in the timing of visits and, subsequently, the timing of STAI assessments between groups (Table 2).

Table 1. Participant Characteristics

Variable	Concussion Group (n = 39)[a]	Control Group (n = 39)[a]	χ^2 Value t_{76}	χ^2 Value *P*
Age, y	18.36 ± 2.29	18.38 ± 2.30	−0.05	.96
Sex			0.00	>.99
Male	25 (64.1)	25 (64.1)		
Female	14 (35.9)	14 (35.9)		
Level			0.22	.64
College	24 (61.5)	24 (61.5)		
High school	15 (38.5)	15 (38.5)		
Sport			14.19	.65
Basketball	2 (5.1)	2 (5.1)		
Football	16 (41.0)	15 (38.5)		
No sport	2 (5.1)	5 (12.8)		
Rugby	2 (5.1)	3 (7.7)		
Soccer	3 (7.7)	3 (7.7)		
Tennis	1 (2.6)	3 (7.7)		
Other	13 (33.3)	8 (20.5)		
Previous concussion			5.07	.17
Yes	13 (33.3)	8 (20.5)		
No	16 (41.0)	19 (48.7)		
Not reported	10 (25.6)	12 (30.8)		
Headaches or migraines			0.72	.40
Yes	4 (10.3)	2 (5.1)		
No	34 (87.2)	36 (92.3)		
Not reported	1 (2.6)	1 (2.6)		
Learning disorder			3.12	.08
Yes	0 (0.0)	3 (7.7)		
No	38 (97.4)	35 (89.7)		
Not reported	1 (2.6)	1 (2.6)		
Attention-deficit or hyperactivity disorder			1.12	.29
Yes	3 (7.7)	1 (2.6)		
No	31 (79.5)	34 (87.2)		
Not reported	5 (12.8)	4 (10.3)		
Depression or anxiety			1.42	.23
Yes	5 (12.8)	2 (5.1)		
No	33 (84.6)	36 (92.3)		
Not reported	1 (2.6)	1 (2.6)		

[a] Values are mean ± SD or No. (%). Percentages were rounded and may not total 100%.

State Anxiety

We observed a group × time interaction ($F_{2,150} = 10.45$, $P < .001$, $\eta_p^2 = 0.12$), indicating that the change in state anxiety scores over time differed by group membership. The post hoc analysis revealed that the concussion group reported a higher level of state anxiety than the control group at each

Table 2. Time Between Visits and State-Trait Anxiety Inventory Assessments in the Concussion and Matched Control Groups

Time	Concussion Group (n = 39)[a]	Control Group (n = 39)[a]	t_{76} Value	*P* Value	Cohen *d* Effect Size
Date of injury to day 0[b]	2.2 ± 0.8	NA	NA	NA	NA
Day 0 to 5[c]	5.5 ± 1.0	5.8 ± 1.1	−1.42	.16	−0.3
Day 5 to full medical clearance	11.6 ± 14.4	13.4 ± 14.8	−0.53	.59	−0.1

Abbreviation: NA, not applicable.

[a] Values are mean ± SD.

[b] Day 0 indicates within 72 h of injury.

[c] Day 5 indicates 5 days (±1 day) postenrollment.

time (Table 3). In both groups, state anxiety was highest on day 0 and decreased across time. On day 0, 56.4% (n = 22) of the concussion and 10.3% (n = 4) of the uninjured matched control group had scores above the clinical cutoff of 38 for a high level of state anxiety. On day 5, 38.5% (n = 15) of the concussion and 12.8% (n = 5) of the control group had scores >38. At FMC, 20.5% (n = 8) of the concussion and 7.7% (n = 3) of the uninjured matched control group had scores >38.

Trait Anxiety

No group × time interaction was found ($F_{1.74,150} = 1.5$, $P = .22$, $\eta_p^2 = 0.02$), although main effects for time ($F_{1.74,150} = 25.7$, $P < .001$, $\eta_p^2 = 0.3$) and group ($F_{1,75} = 7.23$, $P = .01$, $\eta_p^2 = 0.09$) were seen. At each time, the concussion group reported more trait anxiety than the control group (Table 4). In both groups, trait anxiety was highest on day 0 and decreased across time. On day 0, 15.4% (n = 6) of the concussion and 2.6% (n = 1) of the control group had scores above the clinical cutoff of 52 for a high level of trait anxiety. On day 5, 12.8% (n = 5) of the concussion and 2.6% (n = 1) of the control group had scores >52. At FMC, 10.3% (n = 4) of the concussion and 2.6% (n = 1) of the control group had scores >52.

DISCUSSION

We examined the levels of state and trait anxiety in high school– and college–aged individuals after concussion and compared them with those in uninjured matched control participants across recovery. Differences were present in state anxiety for patients with concussion on day 0 and day 5 and at FMC compared with the control group. More specifically, state anxiety was consistently higher in those with a concussion throughout recovery despite diminishing levels over time in both groups. This interaction was not observed for trait anxiety, although individuals with concussion demonstrated higher levels of trait anxiety overall. Therefore, health care professionals should be aware that individuals with concussion may be more susceptible to anxiety after injury, which could negatively influence recovery outcomes.

State Anxiety Throughout Recovery

Previous researchers[14,19] have suggested that anxiety symptoms increase after concussion and that measuring state anxiety affords clinicians the opportunity to efficiently assess these emotional responses. The STAI classifies a high level of state anxiety as a score >38, which can indicate a current anxiety response.[22] On day 0, 56.4% of the concussion group had scores above the clinical cutoff for a high level of state anxiety; however, by FMC, only 20.5% of the concussion group had scores above this clinical cutoff. The results suggest that individuals with concussion were at the greatest risk for increased anxiety symptoms during the days immediately after injury but still had a greater emotional response at all 3 times than their uninjured counterparts.

Heightened state anxiety during the acute phase of injury may be attributed to the uncertainty and confusion participants had surrounding the concussive incident and the potential for further harm.[21,24,25] This possibility is further supported by a systematic review of student-athletes in which the investigators[24] identified the most common barriers to reporting concussion symptoms as fears of losing current or future playing time and letting their team down. In addition, Anderson et al[25] reported that athletes with more fear of reinjury after a concussion had more affective symptoms than those with less fear of reinjury. These fears could induce feelings of apprehension and tension when individuals are removed from normal activities and begin concussion treatment. However, we did not examine the fear of reinjury, and it should be considered for future research.

The concussion group had higher levels of state anxiety throughout recovery than the control group. These results are similar to those of Turner et al,[19] who also reported elevated levels of state anxiety at both the start of the stepwise concussion protocol and return to play in collegiate athletes. The persistence of state anxiety throughout recovery may represent the patients' anxiety about how the concussion might affect everyday life, such as not knowing what to expect during recovery or concern that their symptoms would not improve.[21] Even though the level of state anxiety at FMC

Table 3. State Anxiety Scores on the State-Trait Anxiety Inventory in the Concussion and Matched Control Groups Over Time

Time	Concussion Group (n = 39)[a]	Control Group (n = 39)[a]	t_{76} Value	*P* Value[b]	Cohen *d* Effect Size
Date of injury to day 0[c]	41.5 ± 11.4	28.1 ± 7.4	6.19	<.001	1.40
Day 0 to 5[d]	35.6 ± 13.3	27.2 ± 8.7	3.36	.001	0.76
Day 5 to full medical clearance	31.4 ± 9.9	26.3 ± 7.8	2.47	.02	0.56

[a] Values are mean ± SD.

[b] Post hoc tests compared state anxiety scores between groups at each time ($P < .05$).

[c] Day 0 indicates within 72 h of injury.

[d] Day 5 indicates 5 days (±1 day) postenrollment.

Table 4. Trait Anxiety Scores on the State-Trait Anxiety Inventory in the Concussion and Matched Control Groups Over Time, Mean ± SD

Time[a]	Concussion Group (n = 39)	Control Group (n = 39)
Date of injury to day 0[a]	39.3 ± 11.4	32.5 ± 8.9
Day 0 to 5[b]	37.6 ± 11.9	30.8 ± 9.2
Day 5 to full medical clearance	35.2 ± 12.5	29.8 ± 8.8

[a] Day 0 indicates within 72 h of injury.

[b] Day 5 indicates 5 days (±1 day) postenrollment.

for the concussion group did not exceed the cutoff score, it could still indicate these individuals were anxious when they were expected to resume normal activities.[19] Earlier authors[26] suggested that these individuals may be at risk for subsequent injury or other consequential health outcomes. Finally, we observed a decline in state anxiety for the control group that could be attributed to external factors not captured in this study (eg, attenuation effect, life events, academic responsibilities).[27]

Trait Anxiety Throughout Recovery

Unlike state anxiety, which represents the current emotional state of individuals, trait anxiety represents the part of personality that influences the initiation of anxiety responses.[22] Therefore, it is considered a stable predisposition and may not be susceptible to dramatic change after injury. Our result of no interaction supported this notion, as did previous research[28] that demonstrated no differences in trait anxiety across concussion recovery. Nonetheless, main effects were present between groups and over time, suggesting that the concussion group may simply have had a higher predisposition to experiencing anxiety responses than their counterparts.

Furthermore, high levels of trait anxiety can be a potential indicator of future injury.[29] Concerning concussion, in a systematic review, Trinh et al[30] described a relationship between preexisting psychological factors (eg, life stressors, emotional states, Big Five personality traits) and the incidence and severity of sport-related concussion. Thus, the greater trait anxiety in the concussion group may have indicated that they were already more susceptible to injury and resulted in the higher state anxiety levels throughout recovery. Unfortunately, this cannot be explicitly determined because baseline trait anxiety levels were not collected, but future researchers should focus on the mediating interaction between trait anxiety level and concussion incidence. Overall, these findings add to the current understanding of postconcussion anxiety and its role in recovery.

Clinical Implications

The anxiety and mood clinical profile is the second most common single profile, representing 25% of patients with concussion.[4] We noted an increase in state anxiety during the acute phase of concussion for the concussion group compared with that in the control group. The STAI could be used as a clinical tool pre- and postconcussion to identify individuals who may be at risk (eg, history of psychiatric conditions, significant life stressors) or experiencing state anxiety responses throughout recovery due to their concussion. Although a baseline STAI was not administered in this study, understanding individuals' baseline emotional states is important for evaluating possible postconcussion changes in state anxiety or those with higher trait anxiety who may be at risk for prolonged recovery. Using the STAI could help identify individuals who may require a referral to appropriate licensed professionals (eg, sports psychologist, clinical psychologist) pre- or postconcussion. In addition, incorporating the STAI into assessment and management after a concussion could allow clinicians to provide specific targeted treatments for individuals with high state anxiety. Targeted treatments such as active rehabilitation programs,[31] psychotherapy,[32] and cognitive behavioral therapy[33] reduced anxiety symptoms postconcussion in pediatric and adult populations.

Limitations

This study had limitations. First, our sample consisted of high school– and college–aged individuals in the mid-Michigan area, yet their mean age was 18 years. Moreover, our participants were those who reported their concussion to a health care provider. We did not account for unreported concussions or individuals who declined to participate in the study. However, trained researchers worked with individuals at multiple visits, which can lead to greater comfort in the laboratory with the researchers and, thus, more likelihood of participating. Therefore, future investigations should include youth and older adults to permit generalizability. Second, as with all self-report surveys, participants may not have been honest in their answers on the STAI. Third, we did not conduct a baseline assessment of trait anxiety. A baseline assessment could confirm that no interaction existed between baseline and postconcussion anxiety, which could then show that trait anxiety remains stable over time. Fourth, participants with concussion could have typically experienced more anxiety (ie, trait) that translated into greater vulnerability to anxiety postinjury (ie, state). Similarly, we included individuals with a history of depression or anxiety, which might have contributed to anxiety postinjury (ie, state). Yet we observed no differences between groups for their history of anxiety or depression, so we did not remove these participants from the study. Finally, our sample size was small; future authors should replicate our work and demonstrate generalizability to other samples. Future researchers should also examine the effect of high trait anxiety on concussion incidence, determine if high levels of postconcussion state anxiety yield longer recovery times, and assess the influence of specific treatments on reducing state anxiety postinjury.

CONCLUSIONS

Individuals with concussion displayed higher levels of state anxiety throughout recovery than uninjured matched control participants. Although trait anxiety did not differ between individuals with a concussion and uninjured matched control participants, the former presented with higher levels, but they were not statistically different. Overall, our findings support current literature indicating that anxiety symptoms are common after concussion and should be considered during the assessment and treatment process.

REFERENCES

1. Langlois JA, Rutland-Brown W, Wald MM. The epidemiology and impact of traumatic brain injury: a brief overview. *J Head Trauma Rehabil*. 2006;21(5):275–278. doi:10.1097/00001199-200609000-00001
2. Gessel LM, Fields SK, Collins CL, Dick RW, Comstock R. Concussions among United States high school and collegiate athletes. *J Athl Train*. 2007;42(4):495–503.

3. McCrory P, Meeuwisse W, Dvorak J, et al. Consensus statement on concussion in sport—the 5th International Conference on Concussion in Sport held in Berlin, October 2016. *Br J Sports Med*. 2017;51(11):838–847. doi:10.1136/bjsports-2017-097699
4. Kontos AP, Sufrinko A, Sandel N, Emami K, Collins MW. Sport-related concussion clinical profiles: clinical characteristics, targeted treatments, and preliminary evidence. *Curr Sports Med Rep*. 2019;18(3):82–92. doi:10.1249/JSR.0000000000000573
5. American Psychiatric Association. Anxiety disorders. In: *Diagnostic and Statistical Manual of Mental Disorders*. 5th ed (DSM-5). American Psychiatric Association; 2013:591–643. https://dsm.psychiatryonline.org/doi/epdf/10.1176/appi.books.9780890425596
6. Iverson GL, Greenberg J, Cook NE. Anxiety is associated with diverse physical and cognitive symptoms in youth presenting to a multidisciplinary concussion clinic. *Front Neurol*. 2022;12:811462. doi:10.3389/fneur.2021.811462
7. Martin AK, Petersen AJ, Sesma HW, et al. Concussion symptomology and recovery in children and adolescents with pre-existing anxiety. *J Neurol Neurosurg Psychiatry*. 2020;91(10):1060–1066. doi:10.1136/jnnp-2020-323137
8. Zemek R, Barrowman N, Freedman SB, et al. Clinical risk score for persistent postconcussion symptoms among children with acute concussion in the ED. *JAMA*. 2016;315(10):1014–1025. doi:10.1001/jama.2016.1203
9. Corwin DJ, Zonfrillo MR, Master CL, et al. Characteristics of prolonged concussion recovery in a pediatric subspecialty referral population. *J Pediatr*. 2014;165(6):1207–1215. doi:10.1016/j.jpeds.2014.08.034
10. Morgan CD, Zuckerman SL, Lee YM, et al. Predictors of postconcussion syndrome after sports-related concussion in young athletes: a matched case-control study. *J Neurosurg Pediatr*. 2015;15(6):589–598. doi:10.3171/2014.10.PEDS14356
11. Gillie BL, Fazio-Sumrok V, Eagle SR, et al. Clinical predictors of post-injury anxiety in adolescent patients following concussion. *Appl Neuropsychol Child*. 2022;11(3):253–259. doi:10.1080/21622965.2020.1799790
12. Van Veldhoven L, Sander A, Struchen M, et al. Predictive ability of preinjury stressful life events and post-traumatic stress symptoms for outcomes following mild traumatic brain injury: analysis in a prospective emergency room sample. *J Neurol Neurosurg Psychiatry*. 2011;82(7):782–787. doi:10.1136/jnnp.2010.228254
13. Schilling S, Mansour A, Sullivan L, Ding K, Pommering T, Yang J. Symptom burden and profiles in concussed children with and without prolonged recovery. *Int J Environ Res Public Health*. 2020;17(1):351. doi:10.3390/ijerph17010351
14. Carlson JM, Kangas KJ, Susa TR, Fang L, Moore MT. Sport-related concussion is associated with elevated anxiety, but not attentional bias to threat. *Brain Inj*. 2020;34(3):363–368. doi:10.1080/02699052.2020.1723698
15. Singh R, Savitz J, Teague TK, et al. Mood symptoms correlate with kynurenine pathway metabolites following sports-related concussion. *J Neurol Neurosurg Psychiatry*. 2016;87(6):670–675. doi:10.1136/jnnp-2015-311369
16. Spielberger CD. Theory and research on anxiety. In: Spielberger CD, ed. *Anxiety and Behavior*. Elsevier Inc; 1966:3–20. doi:10.1016/C2013-0-12378-1
17. Wood RL, O'Hagan G, Williams C, McCabe M, Chadwick N. Anxiety sensitivity and alexithymia as mediators of postconcussion syndrome following mild traumatic brain injury. *J Head Trauma Rehabil*. 2014;29(1):E9–E17. doi:10.1097/HTR.0b013e31827eabba
18. Yang J, Peek-Asa C, Covassin T, Torner JC. Post-concussion symptoms of depression and anxiety in division I collegiate athletes. *Dev Neuropsychol*. 2015;40(1):18–23. doi:10.1080/87565641.2014.973499
19. Turner S, Langdon J, Shaver G, Graham V, Naugle K, Buckley T. Comparison of psychological response between concussion and musculoskeletal injury in collegiate athletes. *Sport Exerc Perform Psychol*. 2017;6(3):277–288. doi:10.1037/spy0000099
20. Gouttebarge V, Aoki H, Verhagen E, Kerkhoffs G. A 12-month prospective cohort study of symptoms of common mental disorders among European professional footballers. *Clin J Sport Med*. 2017;27(5):487–492. doi:10.1097/JSM.0000000000000388
21. Byrd MM, Kontos AP, Eagle SR, Zizzi S. Preliminary evidence for a relationship between anxiety, anger, and impulsivity in collegiate athletes with sport-related concussion. *J Clin Sport Psychol*. 2022;16(2):89–108. doi:10.1123/jcsp.2020-0003
22. Spielberger CD, Gorsuch RL, Lushene RE. *STAI Manual for the State-Trait Anxiety Inventory ("Self-Evaluation Questionnaire")*. Consulting Psychologists Press; 1970.
23. Cohen J. *Statistical Power Analysis for the Behavioral Sciences*. 2nd ed. Lawrence Erlbaum Associates; 1988.
24. Clark R, Stanfill AG. A systematic review of barriers and facilitators for concussion reporting behavior among student athletes. *J Trauma Nurs*. 2019;26(6):297–311. doi:10.1097/JTN.0000000000000468
25. Anderson MN, Womble MN, Mohler SA, et al. Preliminary study of fear of re-injury following sport-related concussion in high school athletes. *Dev Neuropsychol*. 2019;44(6):443–451. doi:10.1080/87565641.2019.1667995
26. Brooks MA, Peterson K, Biese K, Sanfilippo J, Heiderscheit BC, Bell DR. Concussion increases odds of sustaining a lower extremity musculoskeletal injury after return to play among collegiate athletes. *Am J Sports Med*. 2016;44(3):742–747. doi:10.1177/0363546515622387
27. Chida Y, Hamer M. Chronic psychosocial factors and acute physiological responses to laboratory-induced stress in healthy populations: a quantitative review of 30 years of investigations. *Psychol Bull*. 2008;134(6):829–885. doi:10.1037/a0013342
28. Schoenhuber R, Gentilini M. Anxiety and depression after mild head injury: a case control study. *J Neurol Neurosurg Psychiatry*. 1988;51(5):722–724. doi:10.1136/jnnp.51.5.722
29. Cagle JA, Overcash KB, Rowe DP, Needle AR. Trait anxiety as a risk factor for musculoskeletal injury in athletes: a critically appraised topic. *Int J Athl Ther Train*. 2017;22(3):26–31. doi:10.1123/ijatt.2016-0065
30. Trinh LN, Brown SM, Mulcahey MK. The influence of psychological factors on the incidence and severity of sports-related concussions: a systematic review. *Am J Sports Med*. 2020;48(6):1516–1525. doi:10.1177/0363546519882626
31. Hunt AW, Agnihotri S, Sack L, et al. Mood-related changes in children and adolescents with persistent concussion symptoms following a six-week active rehabilitation program. *Brain Inj*. 2020;34(8):1068–1073. doi:10.1080/02699052.2020.1776396
32. Dindo L, Johnson AL, Lang B, Rodrigues M, Martin L, Jorge R. Development and evaluation of an 1-day Acceptance and Commitment Therapy workshop for veterans with comorbid chronic pain, TBI, and psychological distress: outcomes from a pilot study. *Contemp Clin Trials*. 2020;90:105954. doi:10.1016/j.cct.2020.105954
33. Potter SD, Brown RG, Fleminger S. Randomised, waiting list controlled trial of cognitive-behavioural therapy for persistent postconcussional symptoms after predominantly mild-moderate traumatic brain injury. *J Neurol Neurosurg Psychiatry*. 2016;87(10):1075–1083. doi:10.1136/jnnp-2015-312838

Address correspondence to Aaron J. Zynda, PhD, Michigan State University, 308 W Circle Drive, East Lansing, MI 48823. Address email to zyndaaar@msu.edu.