


# Multicentre evaluation of anxiety and mood among collegiate student athletes with concussion

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## ABSTRACT

**Objectives** Mental health problems are a premorbid and postinjury concern among college student athletes. Clinical phenotypes of anxiety and mood disruption are prevalent following mild traumatic brain injury, including concussion, a common sports injury. This work examined whether concussed student athletes with a history of mental health problems and higher symptoms of anxiety and mood disruption at baseline were more likely to have higher postinjury reports of mood and anxiety as well as prolonged resolution of postconcussive symptoms to near-baseline measures.

**Methods** This was a retrospective cohort study of a multi-institutional database of standardised baseline and postinjury assessments among college student athletes. Anxiety/mood evaluation data among varsity college athletes from four institutions over 1 year were measured and compared at baseline and postconcussion recovery using descriptive statistics and multilevel/mixed-effects analysis.

**Results** Data from 2248 student athletes were analysed, with 40.6% reporting at least one symptom of anxiety and/or mood disruption at baseline. Of the 150 distinct concussions, 94.7% reported symptoms of anxiety/mood disruption during recovery (recovery time=0–96 days). Higher anxiety/mood scores at baseline were significantly associated with higher scores following concussion ( $p<0.001$ ). Recovery trajectories of anxiety/mood scores showed different patterns by sex and prolonged recovery.

**Conclusion** Symptoms of anxiety and mood disruption are common at *baseline* among college student athletes. These students are at higher risk for symptomatology following injury, representing a screening cohort that may benefit from early counselling. Almost all student athletes will experience symptoms of anxiety and/or mood disruption following concussion.

## INTRODUCTION

More than 6% of all injuries reported to the National Collegiate Athletic Organization (NCAA) in 2014 were mild traumatic brain injuries (mTBI).<sup>1 2</sup> The NCAA also reported that approximately 11 500 mTBIs occur each year, and 53% occur during competition.<sup>2 3</sup> mTBI, including concussion, is a

### WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Premorbid psychiatric history has been associated with risk of mTBI. Anxiety and mood disruption are prevalent concussion subtypes in the acute, sub-acute and chronic time periods following injury.

### WHAT THIS STUDY ADDS

⇒ Symptoms of anxiety and mood disruption are common among college student athletes at baseline and very commonly prevalent during concussion recovery.

### HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ This study's results support that anxiety and mood disruption both at baseline and following mTBI represent an opportunity for intervention to support well-being and recovery among college athletes.

disruption in the brain's normal functioning following head injury<sup>4</sup> and may be classified by five common presenting clinical profiles or subtype domains, including anxiety and mood disruption, vestibular impairment, cognitive impairment, headache or migraine and oculomotor impairment.<sup>4–6</sup> Eighty-five per cent of NCAA athletic trainers recognise anxiety disorders among their student athletes,<sup>7</sup> and the American College of Sports Medicine reports that approximately 30% of student athletes have anxiety.<sup>8</sup> Growing research indicates associations between sports-related injuries and the development and/or exacerbation of psychological symptoms and disorders.<sup>9–13</sup> Psychological responses following mTBI have not been as well examined as compared with psychological responses postorthopaedic injuries.<sup>14 15</sup>

In order to target treatment, there is a critical need to examine the prevalence and recovery trajectories of mood and anxiety symptoms following mTBI among collegiate athletes; a population that often also experiences significant changes in social supports

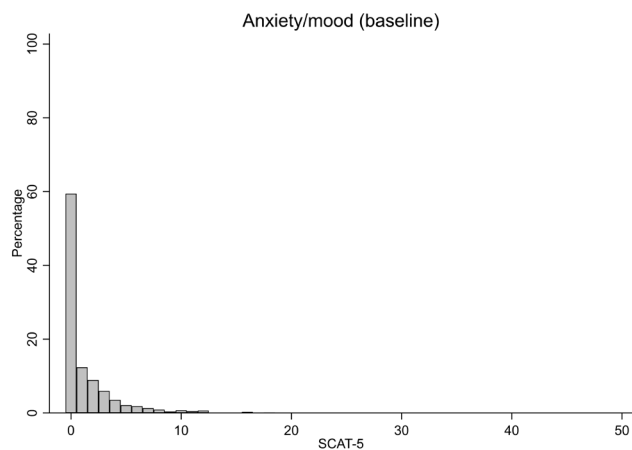


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**Figure 1** Distribution of anxiety/mood scores at baseline.

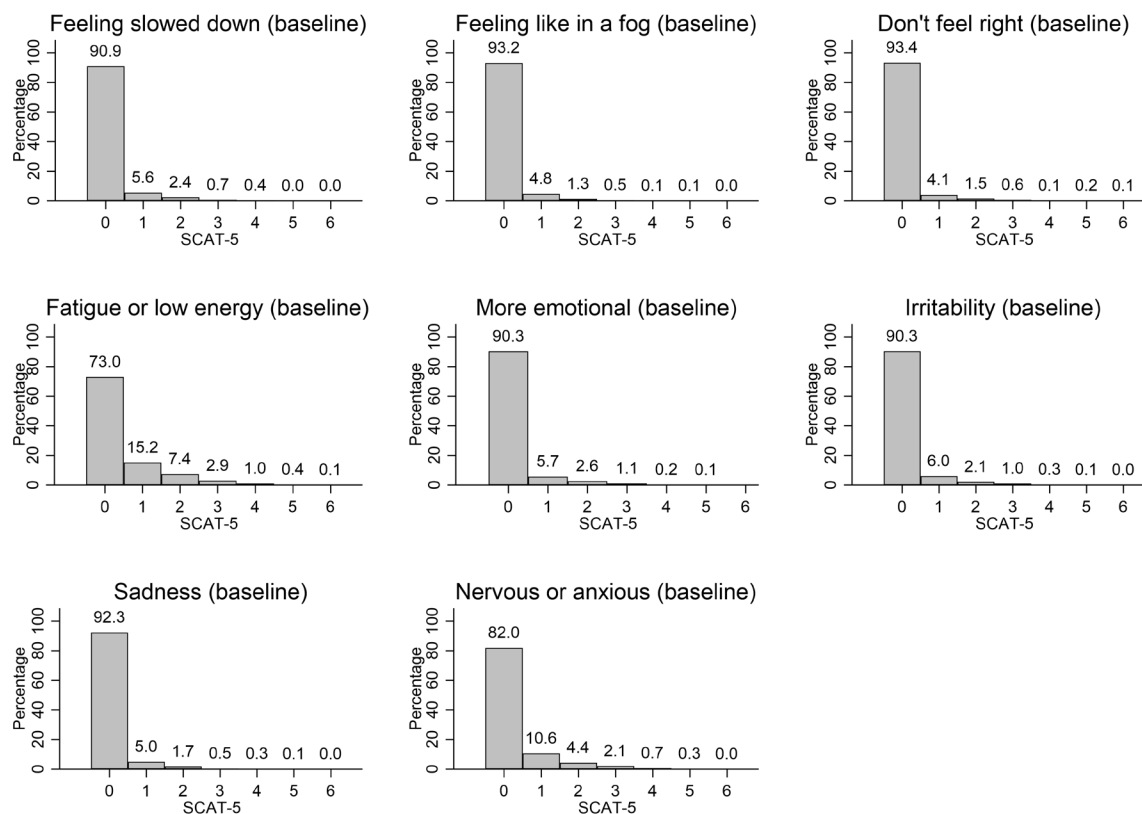
and environment in transitioning to college. More than 60% of collegiate athletes sustaining mTBI reported that their injury upset them, 46.7% were fearful and 25.0% were anxious.<sup>16</sup> While athletes may experience emotional upheavals during an acute period after any injury, it becomes maladaptive if these persist. Mild TBI symptoms affect daily functioning and may be similar to the effects of mood and anxiety disorders.<sup>17</sup> Current research suggests that risk factors for mood disruption following mTBI include mental health history and female sex,<sup>17 18</sup>

and that pre-morbid psychiatric conditions (eg, anxiety, bipolar disorder and depression)<sup>19</sup> are associated with a risk of prolonged recovery following mTBI.<sup>20</sup> Literature suggests that social support following injury influences the development of anxiety,<sup>14</sup> and higher levels of social support significantly predicted decreased postinjury anxiety.<sup>14</sup>

This work aimed to examine trends in symptom reports of anxiety and mood disruption at several institutions among college student athletes diagnosed with concussion through their recovery. We hypothesised that concussed student athletes with a history of mental health problems and higher symptoms related to anxiety and mood disruption at baseline would have higher postinjury reports of mood and anxiety symptoms and prolonged resolution of postconcussive symptoms.

## METHODS

This was a retrospective cohort study that examined reports from the Sports Concussion Assessment Tool 5 (SCAT-5),<sup>21</sup> compared with baseline reports, to identify associated preinjury risk factors, acute postinjury predictive measures and overall recovery trajectories defined as return-to-play date. SCAT-5 is a common, standardised tool used by healthcare professionals to evaluate mTBI.<sup>22 23</sup> Specifically, SCAT-5 symptoms surveyed that may reflect anxiety and mood disturbance were studied



**Figure 2** Distribution of scores for each symptom score scale at baseline.

**Table 1** Frequencies of concussion assessments after injury by time point

Timepoint	f (%)
Acute	183 (13.6)
Subacute	988 (73.7)
Asymptomatic	118 (8.8)
Return to play	52 (3.9)
Total	1341 (100.0)

and include ‘feeling slowed down’, ‘feeling like in a fog’, ‘don’t feel right’, ‘fatigue or low energy’, ‘more emotional’, ‘irritability’, ‘sadness’ and ‘nervous or anxious’.<sup>24</sup> Each symptom is rated on a Likert scale from 0 (no symptoms) to 6 (severe symptoms), and a composite anxiety/mood score was created, which ranged from 0 to 48.

### Participants

Participants included male and female college student athletes of any sport diagnosed with mTBI inclusive of concussion at four Pac-12 institutions from 1 July 2018, through 30 June 2019. All participants were screened at baseline with standardised assessments, and pre-existing general physical and mental health diagnoses were reviewed. Standardised postinjury assessments occurred at several time points following acute injury through

**Table 2** Demographics of injured athletes (N=150 distinct injuries from 140 unique athletes)

Variable	f (%)
Gender	
Male	86 (57.3)
Female	64 (42.7)
Sport	
Baseball	4 (2.7)
Basketball	12 (8.0)
Cross-country/track	4 (2.7)
Cheerleading	4 (2.7)
Football	58 (38.7)
Gymnastics	1 (0.7)
Lacrosse	10 (6.7)
Rowing	2 (1.3)
Skiing	6 (4.0)
Soccer	26 (17.3)
Softball	5 (3.3)
Swimming	7 (4.7)
Track and field	3 (2.0)
Unspecified	2 (1.3)
Volleyball	6 (4.0)
Age(mean (SD))	20.0 (1.4)

**Table 3** Descriptive measures of post-injury anxiety/mood scores by assessment time point

Time point	N	Anxiety/mood score (SCAT-5)		
		Mean (SD)	Median (IQR)	Min, Max
Acute	163	10.2 (9.4)	8 (15)	0, 41
Subacute	834	4.8 (7.4)	1 (6)	0, 39
Asymptomatic	114	0.5 (1.6)	0 (0)	0, 11
Return to play	51	0.3 (0.9)	0 (0)	0, 5

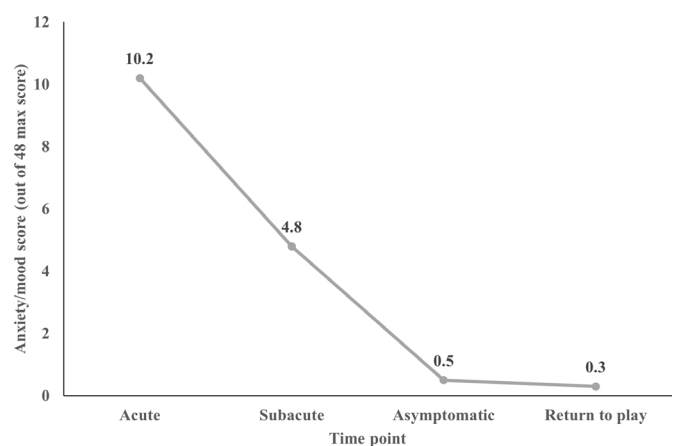
SCAT-5, Sports Concussion Assessment Tool 5.

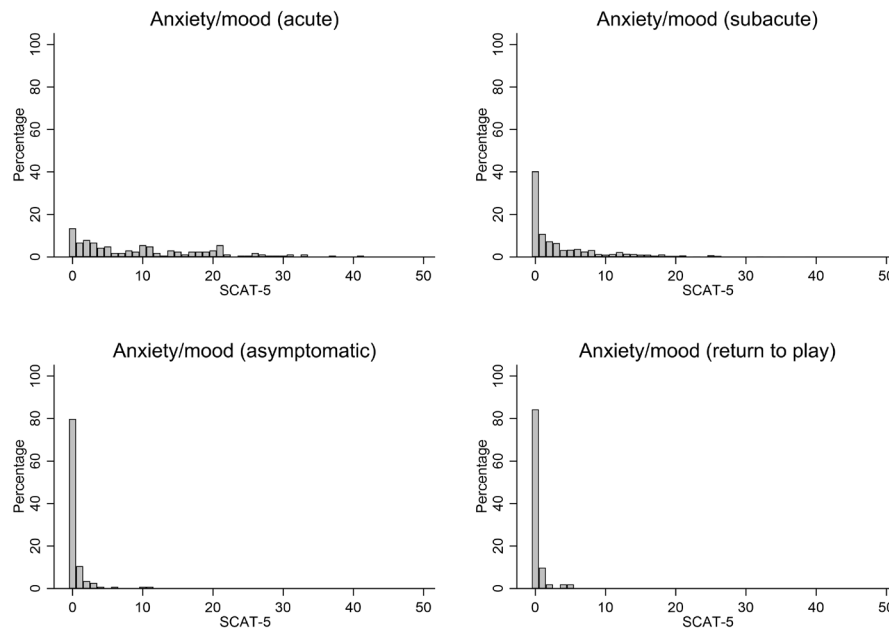
return to play. Assessments occurred at baseline, the sideline, within 3 days postinjury (defined as acute), daily thereafter (defined as subacute), on asymptomatic report and on return to play.

### Data analysis

Anxiety and mood symptom evaluation data measured at baseline were described using a histogram and summary statistics, including mean, standard deviation (SD), median, IQR, minimum value (min) and maximum value (max). This analysis was done for both anxiety/mood scores and those for each symptom. Furthermore, baseline anxiety/mood scores were compared by sex and self-reported history of diagnosed psychiatric condition and/or ADHD, using the Wilcoxon-Mann-Whitney rank-sum test because of the skewed distributions of these scores.

Symptom evaluation data after injury were analysed, using a histogram and descriptive statistics mentioned above, separately for each concussion assessment time point. In addition, demographics, including sex and sport, of injured student athletes were summarised with frequency and percentage. The proportions of symptomatology (anxiety/mood score >0) between the baseline data and injury data were compared using the two-sample test of proportions. Multilevel/mixed-effects analysis was performed to examine the recovery trajectory of anxiety/mood scores after injury while using sex, age, baseline


**Figure 3** Unadjusted mean anxiety/mood scores at post-injury by assessment time point.



**Figure 4** Distribution of anxiety/mood scores at post-injury by assessment time point. SCAT-5, Sports Concussion Assessment Tool 5.

anxiety/mood composite score and prolonged recovery (defined as recovery period to return to play of <14 days vs  $\geq 14$  days)<sup>25 26</sup> as covariates. Since only one injury case had a self-reported history of a diagnosed psychiatric condition, this variable was ultimately not included in the model. The model was built with two sets of two-way interactions (time $\times$ sex and time $\times$ prolonged recovery). Since both interaction terms were significant ( $p < 0.05$ ), a follow-up analysis, using simple contrasts with the Sidak correction, in order to better control the family-wise error rate with a slightly higher power than the Bonferroni correction,<sup>27</sup> was performed to examine the difference in anxiety/mood scores between the two adjacent assessment time points by sex and prolonged recovery. Furthermore, the slope of recovery trajectory between the two adjacent assessment time points was compared by sex and prolonged recovery status. The model's residuals were examined to ensure that the model met the regression assumptions. Missing data were excluded analysis by analysis. The institution's internal review board approved this deidentified database for the study.

## RESULTS

### Anxiety/mood scores at baseline

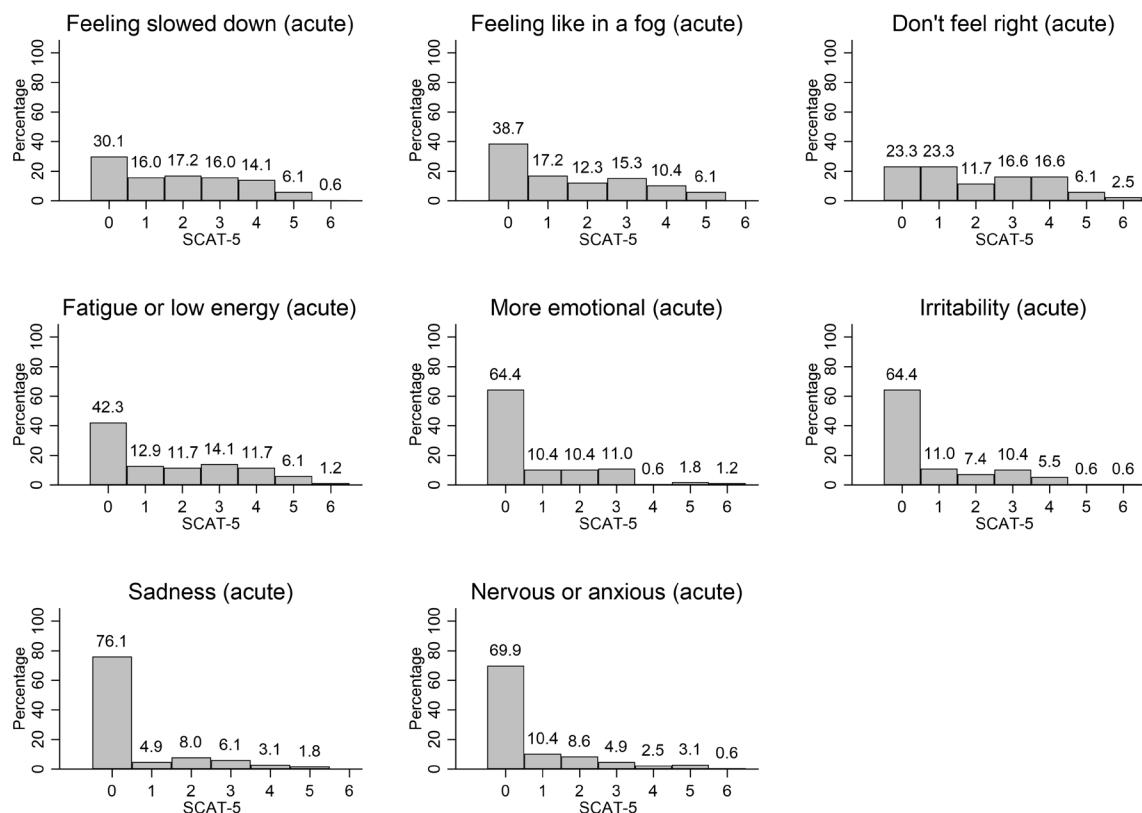
Symptom evaluation data at baseline from 2248 student athletes were included in the analysis (men:  $n=1321$  or 58.8%; 18–28 years of age). If student athletes had multiple baseline evaluations across the years, data from the first evaluation were used for the analysis. All baselines were included because stressors and mental health may change in a student athlete through their college course. The distribution of baseline anxiety/mood scores is

shown in [figure 1](#). The scores were positively skewed, with 59.4% of those ( $n=1336$ ) being zero and 40.6% ( $n=912$ ) of those reporting at least one symptom of anxiety and mood disruption (mean (SD)=1.5 (3.2); median (IQR)=0 (2); min, max=0, 41). Although there was a statistically significant difference in the anxiety/mood scores by sex (men: mean (SD)=1.3 (2.9), median (IQR)=0 (2); women: mean (SD)=1.9 (3.6), median (IQR)=0 (2);  $p < 0.001$ ), the size of the difference was not considered clinically significant in clinical practice. The baseline anxiety/mood scores were significantly higher in athletes with a history of psychiatric condition ( $n=29$ ) than those without it ( $n=1978$ ) (mean (SD)=3.4 (4.9) vs 1.6 (3.1); median (IQR)=1 (4) vs 0 (2);  $p=0.005$ ). The distribution of the scores for each symptom scale was similar to that of composite anxiety/mood scores ([figure 2](#)), showing a positive skewness for all distributions.

### Anxiety/mood scores following injury

One hundred and forty athletes sustained 150 mTBIs in the 2018–2019 academic year ( $n=131$  for one mTBI;  $n=8$  for two mTBIs;  $n=1$  for three mTBIs). After excluding 21 assessments whose time points were recorded as 'unmapped/unspecified', a total of 1341 assessments, including four distinct assessment time points ([table 1](#)), were analysed in this study. Demographics and clinical characteristics of the injured student athletes (out of 150 distinct mTBIs) are summarised in [table 2](#). Football players had the highest number of mTBIs ( $n=58$ ; 38.7%), followed by soccer players ( $n=26$ ; 17.3%).

Descriptive measures of postinjury anxiety/mood scores by assessment time point are summarised in



**Figure 5** Distribution of scores for each symptom score scale at the sideline. SCAT-5, Sports Concussion Assessment Tool 5.

table 3 and figure 3. Of the 150 distinct injuries, 141 (94.0%) reported anxiety/mood scores  $>0$  at some point after injury. There were 54 (36.0%) injured athletes with baseline anxiety/mood scores  $>0$  and 26 (17.3%) of those without baseline anxiety/mood scores. A mean anxiety/mood score was the highest at acute ( $\leq 3$  days postinjury) (mean (SD)=10.2 (9.4); median (IQR)=8 (15)) and was the lowest at the return to play (mean (SD)=0.3 (0.9); median (IQR)=0 (0)). The distribution of postinjury anxiety/mood scores was close to uniform acutely at acute but was positively skewed thereafter (figure 4). The individual symptom scale scores in the acute period showed uniform and positively skewed distributions, depending on the scale (figure 5). Close to half of the injuries ( $n=67$ ; 44.7%) resulted in a prolonged recovery (recovery period to return to play of  $\geq 14$  days), with recovery time ranging from 0 to 96 days. Of the 150 distinct injuries, 54.8% ( $n=68$ , excluding 26 cases with no baseline data) reported at least one symptom of anxiety and mood disruption at baseline. This finding contrasted all baseline data, which included only 40.6% of athletes reporting symptoms ( $p=0.002$ ). If those 26 student athletes with no baseline data were assumed to have the same percentage of having at least one symptom of anxiety and mood disruption at baseline (ie, 40.6% or 11 of 26 cases; 79 out of 150 injuries or 52.7% having at least

one symptom), the difference in the two proportions was still significant ( $p=0.004$ ).

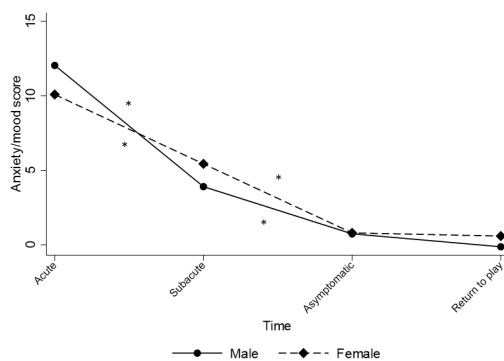
The results of the multilevel/mixed-effects analysis on the recovery trajectory of post-injury anxiety/mood scores are summarised in table 4. Simple contrasts with the Sidak correction demonstrated that anxiety/mood scores significantly decreased from acute to subacute periods (adjusted mean anxiety/mood scores: 12.0 to 3.9;  $p<0.001$ ) and from subacute to asymptomatic periods (adjusted mean anxiety/mood scores: 3.9 to 0.7;  $p<0.001$ ) in male student athletes (figure 6). Similarly, female student athletes also showed a significant decrease in anxiety/mood scores from acute to subacute (adjusted mean anxiety/mood scores: 10.1 to 5.4;  $p<0.001$ ) and from subacute to asymptomatic periods (adjusted mean anxiety/mood scores: 5.4 to 0.8;  $p<0.001$ ). Athletes with prolonged recovery showed a significant decrease in anxiety/mood scores from acute to subacute periods (adjusted mean anxiety/mood scores: 12.6 to 5.7;  $p<0.001$ ) and from subacute to asymptomatic (adjusted mean anxiety/mood scores: 5.7 to 1.0;  $p<0.001$ ), whereas such decline was observed from acute to subacute only (adjusted mean anxiety/mood scores: 9.4 to 2.5;  $p<0.001$ ) in athletes without prolonged recovery (figure 7). Higher baseline anxiety/mood scores were significantly associated with higher anxiety/



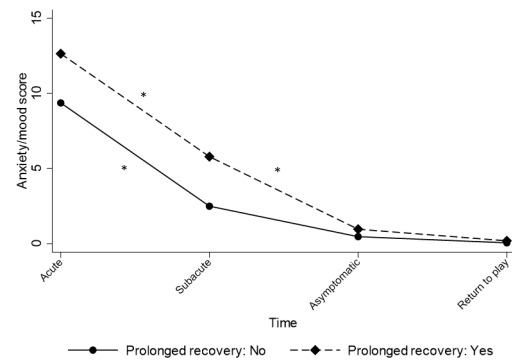
**Table 4** Multilevel/mixed-effects model on recovery trajectory of post-injury anxiety/mood scores

Predictor/covariate	$\beta$ (95% CI)	P
Time		
Acute (= reference)	–	
Subacute	–8.14 (–9.93 to 6.35)	<0.001
Asymptomatic	–9.63 (–11.90 to 7.36)	<0.001
Return to play	–10.28 (–13.45 to 7.11)	<0.001
Sex		
Male (= reference)	–	
Female	–1.95 (–4.38 to 0.47)	0.115
Age	–0.08 (–0.73 to 0.55)	0.793
Baseline anxiety/mood score	0.42 (0.20 to 0.64)	<0.001
Prolonged recovery		
No (= reference)	–	
Yes	3.27 (0.84 to 5.71)	0.008
Time×Gender	–	0.014
Time×Prolonged Recovery	–	0.033
Outcome variable=anxiety/mood score after injury (SCAT-5). SCAT-5, Sports Concussion Assessment Tool 5; B, beta coefficient.		

mood scores after injury ( $p<0.001$ ) over the recovery period. Specifically, one unit increase in the baseline anxiety/mood score was associated with a 0.4 increase in the score after injury. Even though the increase was relatively small, this change may be meaningful—an increase represents the presence of symptomatology that may benefit from clinical validation in the care setting, prognostication and intervention. A follow-up subanalysis with a point-biserial ( $r_{pb}$ ) correlation showed that athletes with higher baseline scores were significantly associated with prolonged recovery ( $r_{pb}=0.209$ ;  $p<0.001$ ). The slope of recovery trajectory in male athletes was significantly higher (ie, steeper slope) than that in female athletes from the acute to the subacute time point ( $p=0.004$ ). Meanwhile, there was no significant difference in the slope of recovery trajectory by prolonged recovery at any



**Figure 6** Recovery trajectory of post-injury anxiety/mood scores by sex, adjusted for age, baseline anxiety/mood score and prolonged recovery. \*Significant difference.



**Figure 7** Recovery trajectory of post-injury anxiety/mood scores by prolonged recovery, adjusted for age, baseline anxiety/mood score and sex. \*Significant difference.

adjacent assessment time-point interval ( $p>0.05$ ). The inspection of the model residuals showed that, although the outcome variable, anxiety/mood scores after injury, showed skewed distributions over the various assessment time points, as mentioned above, the standardised residuals were fairly normally distributed and were distributed over the predicted values without showing any particular pattern, indicating that the model met the regression assumptions.

## DISCUSSION

While most (close to 60%) college student athletes did not report any symptoms relevant to anxiety and mood disruption on baseline assessments,<sup>28</sup> almost all injured athletes (94.0%) did experience feelings of anxiety and mood disruption following concussion, which is higher than published reports of anxiety and depression following other sports injuries.<sup>29–31</sup> Furthermore, more than half (54.8%) of the athletes who sustained concussions had at least one symptom of anxiety and mood disruption at baseline. Symptoms of anxiety and mood disruption were self-reported within 3 days of initial injury, with a consistent downtrend over time. Notably, football players had the most diagnoses of concussion and were all men. The trajectory of symptom resolution by time point varied by sex to some extent. Specifically, male athletes showed a steeper decline in the anxiety/mood symptom scores from the acute to subacute period than female athletes, followed by a gradual decrease from daily subacute to asymptomatic in both groups. Concerning symptom resolution over time and in relation to prolonged recovery status (recovery period to return to play of <14 days vs  $\geq 14$  days),<sup>25 26</sup> student athletes with *prolonged recovery* showed significant, steep declines from acute to subacute and subacute to asymptomatic. Meanwhile, athletes without prolonged recovery showed more gradual decreases in anxiety/mood scores over the recovery period, with a significant decline only from the acute to subacute period. Athletes with higher baseline scores in this study were at increased risk of having more symptoms after injury. Furthermore, athletes with higher baseline scores were also at risk of prolonged recovery.

A strength of this work is its examination of more than 2000 baseline reports of anxiety and mood disruption symptoms with important findings; student athletes with a history of psychiatric disorder were more likely to report symptoms of anxiety and/or mood disruption. This screening cohort may represent an opportunity for further evaluation and pre-emptive counselling, which may include more in-depth discussion of symptoms and related conditions such as sleep disturbance and school stressors, referral for counselling, other school-based supports, referral for psychological evaluation and therapy. These student athletes are also more likely to have *higher* postinjury anxiety and mood disruption reports. They may benefit from earlier targeted therapies such as cognitive behavioural therapy and other forms of counselling. Previous research reports that premorbid conditions like attachment disorders, mental health problems and low resilience are related to increased post-concussive symptoms.<sup>32–34</sup>

Limitations to this work included missing data encountered with large, multicentre data. We addressed missingness using multilevel, mixed-effects modelling. Due to the few concussions diagnosed in several sports, we could not determine significant differences by individual sport. Because concussion care is personalised across the Pac-12, time points of assessment on asymptomatic and return to play varied by individual, and this work reported overall trajectories. College varsity athletes from four Pac-12 institutions were included in this study and, therefore, are not generalisable to other regions, paediatric populations, non-varsity athlete populations or postcollegiate populations. Furthermore, some athletes may sustain multiple concussions in a single season, although that number was low in this study's cohort. There may be unique characteristics associated with multiple concussions, warranting future research. Finally, the SCAT-5 is not a mental health assessment tool. However, it is widely used and describes symptoms relevant to anxiety and mood disruption that, in light of results from this study, may represent the first screening tool or prompt further validated mental health assessments.

In conclusion, symptoms of anxiety and mood disruption are prevalent following concussion among our multisite cohort of student athletes. Prognostication and validation of these feelings with positive messaging of symptom resolution with time, in association with appropriate social and counselling supports, are important components of clinical care.

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**Contributors** AL-B developed the study, conducted the literature search, design the data analysis and prepared the original draft. MT conducted the data analysis and prepared the sections of the original draft. RZ conducted the literature search and organised the data. ADB helped the data collection and analysis. DFA, KH, DJP, RR, SKP, and JG provided expert insight into the development of the study. All authors reviewed the draft manuscript and approved the final manuscript.

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