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Comparison of Psychological Response between Concussion and Musculoskeletal Injury in Collegiate Athletes

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Abstract

The psychological response to musculoskeletal injuries has been well documented, however, research on the psychological response to concussion is limited. The Profile of Mood States (POMS) and the State-Trait Anxiety Inventory (STAI) have recently been used to assess the psychological recovery of concussions. Although some studies indicate that psychological response is different for musculoskeletal injuries and concussion, there is currently not enough information to indicate this difference occurs at specific clinical milestones. The purpose of this study was to compare the psychological responses of student-athletes who have been diagnosed with a concussion to those of athletes diagnosed with musculoskeletal injuries with similar recovery duration. Fifteen collegiate athletes who sustained a musculoskeletal injury were recruited and matched with 15 previously collected concussion participants. The main outcome measures were the scores of POMS constructs: tension-anxiety, anger-hostility, fatigue-inertia, depression-dejection, vigor-activity, confusion-bewilderment, and total mood disturbance and STAI (state anxiety only). Two-way MANOVAs was run to determine the effects of group and time on POMS and STAI constructs. There were no significant interactions identified, but follow-up ANOVAs identified a main effect for time for most POMS subscales, with POMS scores improving over time in both groups. Analyses also revealed that tension-anxiety, vigor-activity and the STAI were not affected by time or group. The findings of this study, that both groups' psychological response to injury improves over time and at similar clinical milestones suggests reduction in sports and team related activities may play a substantial role in the psychological response to either concussion or musculoskeletal injury.

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Keywords

Profile of Mood States; State-Trait Anxiety Inventory; Concussion; Recovery

INTRODUCTION

The multifaceted assessment of sports-related concussion in collegiate student-athletes typically includes tests of balance, mental status screenings, cognition, and self-reported concussions related symptoms, however the assessment of psychological symptoms is limited (Buckley, Burdette, & Kelly, 2015; Kelly, Jordan, Joyner, Burdette, & Buckley, 2014). Anxiety and subclinical depression, depression not meeting the diagnostic criteria for a clinical disorder, are commonplace following concussion and may contribute to the decreased health-related quality of life for months post-injury (Covassin et al., 2014;Hutchison, Mainwaring, Comper, Richards, & Bisschop, 2009; Hutchison et al., 2016; Johnston et al., 2004; Kontos, Covassin, Elbin, & Parker, 2012; Kontos, Deitrick, & Reynolds, 2016; Mainwaring, Bisschop, Comper, Richards, & Hutchison, 2010; Mainwaring et al., 2004; Novak et al., 2016). Similarly, following orthopedic musculoskeletal (MSK) injuries, health care providers tend to focus their evaluation, treatment, and rehabilitation on the physical aspects of the injury and functional capacity of the individual with limited consideration for the potential presence or development of psychological symptoms (Covassin et al., 2014; Vincent, Horodyski, Vincent, Brisbane, & Sadasivan, 2015). These symptoms may adversely affect an individual's quality of life and, specific to collegiate student-athletes, may pose substantial risk to academic performance (Kontos et al., 2012; Vincent et al., 2015). Despite the high prevalence of both concussions and MSK injuries in the intercollegiate athletic population, there have been limited investigations comparing these responses.

Acutely post-concussion, increases in subclinical depression and total mood disturbance have been identified (Kontos et al., 2012). Specifically, elevated levels of depression, fatigue, confusion, and anger have been reported with the highest abnormalities occurring acutely post-concussion and general reductions towards age and gender appropriate levels over several weeks (Covassin et al., 2014; Hutchison et al., 2009; Kontos et al., 2012; Mainwaring, Hutchinson, Camper, & Richards, 2012; Mainwaring et al., 2010; Mainwaring et al., 2004). During the acute symptomatic period, concussed athletes demonstrated elevated levels of total mood disturbance and mood subscales compared to healthy athletes (Hutchison et al., 2016). Interestingly, following return to play (RTP) post-concussion, the individuals had lower mood disturbance (better) than the healthy athletes, which may reflect a return to "normalcy" in activities of daily living (ADLs; Hutchison et al., 2016). When comparing psychological response between MSK and concussion, Covassin et al. (2014) reported no differences in either the state or trait levels of anxiety; however, only one time point (within a week post-injury) was assessed and injury characteristics were not presented. Conversely, Mainwaring et al. (2010) observed higher levels of depression, which persisted longer following anterior cruciate ligament (ACL) injury whereas concussed individuals had short duration acute increases in total mood disturbance and depression. However, the psychological response to MSK injuries compared to concussion on specific milestones during similar time loss injuries is unknown.

These elevated levels of anxiety and depression may reflect a physiological and/or psychological response. Physiologically, the hippocampus, amygdala, and prefrontal cortex brain regions are associated with depression and anxiety and neuroimaging investigations have identified physiological alterations in these regions following a concussion (Chen, Johnston, Petrides, & Ptito, 2008; McAllister et al., 2014; Reger et al., 2012; Sheline, Wang, Gado, Csernansky, & Vannier, 1996; van der Horn, Liemburg, Aleman, Spikman, & van der Naalt, 2016). There is also an association between lower functional connectivity in the bilateral frontal and salience network with elevated depression scores following concussion (van der Horn et al., 2016). Similarly, post-concussion metabolic alterations in the kynurenine pathway correlates with elevated anxiety levels (Singh et al., 2016). However, this subclinical depression response could be an emotional response secondary to physical activity restrictions and removal from regular activity in competitive athletics. Thomas et al. (2015) described this as“situational depression” and several studies have suggested delayed symptom recovery following physical activity restrictions while hypothesizing that removal from regular activity (e.g., games and practices) prolonged recovery (Buckley, Munkasy, & Clouse, 2015; Thomas, Apps, Hoffmann, McCrea, & Hammeke, 2015). However, individuals with MSK injuries, who have not suffered brain trauma and requisite supraspinal physiological responses, do face physical activity restrictions (e.g., limited or no practices or games while recovering), which could result in similar psychological challenges. For both concussion and MSK injured student-athletes, frustration over uncertain recovery time, isolation from teammates and sports, and lack of social support may result in a negative emotional response post-injury (Kontos et al., 2016; Moreau, Langdon, & Buckley, 2014). If these psychological symptoms are incorrectly managed, individuals may develop clinical depression, anxiety, and even suicidal ideation and intent (Kontos et al., 2016). Thus, identification of individuals who are experiencing anxiety and subclinical depression is critically important in the management of sport-related concussion.

It is currently unknown if the psychological response to concussion is primarily physiological (e.g., altered neurological response) or emotional (e.g., altered ADL’s) in nature which could influence the medical treatment and physical rehabilitation of concussions. Several key determinants of psychological response to concussion require further investigation, specifically the interaction of time loss and clinical milestones during recovery between common sports related MSK injuries and concussions (Covassin et al., 2014; Hutchison et al., 2016; Udry, Gould, Bridges, & Tuffey, 1997). Therefore, the purpose of this study was to evaluate the psychological response to concussions and musculoskeletal injuries in collegiate student athletes with similar time loss injuries on specific post-injury milestones utilizing two commonly applied inventories, the Profile of Mood States and State-Trait Anxiety Inventory. This approach seeks to clarify the influence of sports-related time-loss injury on individual’s psychological response. We hypothesized there would be an increase in anxiety and negative mood state in both groups acutely post-injury (Hutchison et al., 2009,Mainwaring, Hutchinson, Camper, & Richards, 2012; Mainwaring et al., 2010; Mainwaring et al., 2004). Furthermore, we hypothesized that as specific recovery milestones are achieved (e.g., exercise initiation) there will be improved psychological response

(Hutchison et al., 2016). Finally, we hypothesized the concussed student-athletes will have residual elevations in anxiety and negative mood when compared to the MSK student-athletes.

METHODS

Participants

There were 30 participants enrolled in this study; 15 with medically diagnosed sports related concussions (CONC) and 15 with minor musculoskeletal (MSK) injuries over two academic years (Table 1). The participants were all members of National Collegiate Athletic Association (NCAA) Division I intercollegiate athletics program or cheerleading team. The inclusion criteria required CONC participants to be medically diagnosed by a physician with a sports-related concussion based on current consensus diagnostic guidelines (McCrory et al., 2013). After a CONC participant was consented and participated, matched MSK participants were recruited. The MSK group was prospectively matched based on the diagnosis of an acute lower extremity musculoskeletal injury, which was speculated to have a time-loss similar to the CONC participants. Specifically, the team athletic trainers notified a member of the research team of a potentially matched participant who then completed inventories in accordance with the procedures described below. This ecologically valid approach has limitations, such as low sample size, but is an appropriate method to collect prospective data through the recovery process. Participants were excluded if their injury resulted in not returning to play in the current competitive season, having a subsequent re-injury prior to full return, or injuries requiring surgical intervention. All participants provided written informed consent prior to participating as approved by the Institutional Review Board.

Instruments

Mood states—The Profile of Mood States (POMS) was used to assess the participants' mood states (Grove & Prapavessis, 1992). This valid and reliable measure utilizes a 5-point Likert scale: 0 (not at all), 1 (a little), 2 (moderately), 3 (quite a bit), or 4 (extremely). The inventory is divided into 6 subscales, which include: 1) Tension-Anxiety (e.g., “tense”, “uneasy”), 2) Anger-Hostility (e.g., “grouchy”, “annoyed”), 3) Fatigue-Inertia (e.g., “worn out”, “sluggish”), 4) Depression-Dejection (e.g., “sad”, “blue”), 5) Vigor-Activity (e.g., “lively”, “energetic”), and 6) Confusion-Bewilderment (e.g., “confused”, “unable to concentrate”) in which each word is individually rated. Subscales are scored by summing up the points for each word associated with that subscale. The depression-dejection subscale has 8 items associated with it, resulting in a total possible score 32. The tensions-anxiety subscale has six items, resulting a total possible score of 24. The anger-hostility subscale has seven items, resulting in a total possible score of 28. The fatigue-inertia subscale has five items, resulting in a total possible score of 20. The vigor-activity subscale has six items, resulting in a total possible score of 24. The confusion-bewilderment subscale has five items, resulting in a total possible score of 20.

The total mood disturbance (TMD) scoreis calculated by adding the subscale scores for tension-anxiety, anger-hostility, fatigue-inertia, depression-dejection, and confusion-bewilderment, and then subtracting the subscale score for vigor-activity. The score for TMD can range from −24 to 124, with a higher score indicating a higher mood disturbance. To be consistent with previous research, we added the constant of 100 to this score (Mainwaring et al., 2010). For the current study, the Cronbach's alpha for the POMS subscales were as follows: Tension-Anxiety, 0.81, Anger-Hostility, 0.88, Fatigue-Inertia, 0.83, Depression-Dejection, 0.86, Vigor-Activity, 0.89, and Confusion-Bewilderment, 0.71.

State anxiety—The State Trait Anxiety Inventory (STAI) is composed of two categories; for this study only the "state" portion was used (Abend, Dan, Maoz, Raz, & Bar-Haim, 2014; Spielberger, Gorsuch, & Lushene, 1970). In the STAI, "state" refers to the how the individual feels in the current moment. Participants were given a list of 20 statements, such as "I feel calm", "I feel upset", and "I am confused" and rated these statements on a Likert Scale: 1 (almost never), 2 (sometimes), 3 (often), or 4 (almost always). The STAI is calculated summing the scores for each item, with a total score for anxiety ranging from 20–80. A higher score on the state portion of the STAI indicates higher levels of state anxiety (Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983). The STAI has been shown to be a valid and reliable tool with this population (Abend et al., 2014).

Procedures

The participants were recruited through the host institutions' clinical athletic training staff based on inclusion and exclusion criteria and all participants who meet the criteria over two academic years were attempted to be recruited. Participants completed both the POMS and the STAI, in a private setting separate from the athletic training room, at three specific milestone time points: 1) Acute, 2) Day 1 of Exercise (Exercise), and 3) Return to Play day (RTP). Participants were given a written version of the POMS and STAI, with printed instructions and completed both instruments in 5 – 10 minutes. The instructions provided to participants were to rate how they felt "right now" for each word on the POMS and phrase on the STAI and were given assurances their responses would remain confidential. The researchers did not read statements aloud, but did answer questions if asked.

Operationally, Acute was defined as within 72 hours of the injury (Mainwaring et al., 2004), all CONC participants were still acutely symptomatic, and all participants were fully restricted from all athletic and team-related participation. For CONC participants, Exercise was determined when the individual initiated the graduated return to play protocol, was self-reported symptom free and had achieved baseline values on the Balance Error Scoring System, the Standard Assessment of Concussion, and a computerized neurocognitive test, in accordance with the 4th Consensus Statement on Concussion in Sport (4th CIS) (McCrory et al., 2013). The MSK participants were classified as Exercise when they were progressed to non-team related sport specific activities or cardiovascular exercise. Finally, RTP was determined by the day the participant was permitted full and unrestricted participant in team activities and participants completed the instruments shortly before the start of practice that day (McCrory et al., 2013). The host institution adhered closely to the 4th CIS recommendations for baseline testing, post-injury management, and the graduated return to play protocol (McCrory et al., 2013).

Statistical Analysis

Before conducting the analysis, data was checked for normality and homogeneity of variance, with several means comparisons failing to meet the assumption of homogeneity of variance. Transformations of the data were attempted, but did not improve the data. Furthermore, there is a lack of independence between POMS subscales and TMD. Therefore, a more conservative alpha level ($\alpha < .01$) was adopted for means comparisons.

The dependent variables of interest for the POMS were the six subscales and TMD while STAI has one outcome measure of interest, state anxiety. The independent variables were Group (CONC and MSK) and Time (Acute, Exercise, RTP). A 2 (Group) × 3 (Time) MANOVA was performed to compare the POMS subscales. To determine where differences occurred, individual ANOVAs were run. Where needed, simple contrasts were also run to determine differences in outcomes by time. For the STAI, a 2 (Group) × 3 (Time) ANOVA was run with simple contrasts to determine differences.

RESULTS

There was no difference between groups for duration from injury to Acute (CONC: 1.3 ± 0.5 and MSK: 1.6 ± 1.0 days; $F(1, 28) = 1.41$, $p=0.245$), Exercise (CONC: 7.1 ± 3.1 and MSK: 8.4 ± 4.9 days; $F(1, 29) = 0.81$, $p = 0.375$) or RTP (CONC: 14.1 ± 5.4 and MSK: 14.5 ± 8.4 days; $F(1, 28) = 0.05$, $p = 0.832$).

Profile of Mood States

The MANOVA for the POMS subscales was significant for group, Wilk's $\lambda = .75$, $F(6, 76) = 4.19$, $p = .001$, $\eta2 = .251$, and for time, Wilk's $\lambda = .60$, $F(6, 76) = 3.62$, $p < .001$, $\eta2 = .225$. Based on the alpha level adjustment, no significant interaction effects were seen in the MANOVA, Wilk's $\lambda = .74$, $F(6, 76) = 2.04$, $p = .024$, $\eta2 = .140$. Individual ANOVAs were run to determine where differences existed within each subscale and TMD.

Tension-Anxiety—There were no significant interactions, ($F (2, 86) = .05$, $p = .96$, $\eta2 = .001$) or main effects for group ($F (2, 86) = 6.32$, $p = .014$, $\eta2 = .073$) or time ($F (2, 86) = 4.53$, $p = .014$, $\eta2 = .102$) for the Tension-Anxiety subscale (Table 2).

Anger-Hostility—No significant interactions were found for the Anger-Hostility subscale, ($F (2, 86) = 2.02$, $p = .140$, $\eta2 = .049$). Similarly, no main effects for group were found, ($F (2, 86) = 5.75$, $p = .019$, $\eta2 = .067$). However, significant main effects for time were identified ($F (2, 86) = 7.25$, $p = .001$; $\eta2 = .15$), with simple contrasts showing differences in scores between Acute and Exercise ($p = .005$) as well as Acute and RTP ($p < .001$; Table 2).

Fatigue-Inertia—No significant interactions were found for the Fatigue-Inertia subscale ($F (2, 86) = 3.51$, $p = .035$, $\eta2 = .081$). No main effects for group were found, ($F (2, 86) = 2.81$, $p = .098$, $\eta2 = .034$), although significant main effects for time were identified ($F (2, 86) = 13.83$, $p < .001$; $\eta2 = .26$), with simple contrasts showing differences in scores between Acute and Exercise ($p < .001$) as well as Acute and RTP ($p < .001$; Table 2).

Depression-Dejection—No significant interactions were found for the Depression-Dejection subscale ($F (2, 86) = .92$, $p = .402$, $\eta 2 = .022$). In addition, no main effects for group were found, ($F (2, 86) = 4.87$, $p = .030$, $\eta 2 = .057$). However, significant main effects for time were identified for the subscale, ($F (2, 86) = 6.75$, $p = .002$; $\eta 2 = .14$). Simple contrasts showed differences in scores between Acute and Exercise ($p = .004$) as well as Acute and RTP ($p = .001$; Table 2).

Vigor-Activity—There was no interaction ($F (2, 86) = .02$, $p = .981$, $\eta 2 = .000$) or main effect by group ($F (2, 86) = 2.19$, $p = .143$, $\eta 2 = .027$) or time ($F (2, 86) = 2.69$, $p = .074$ $\eta 2 = .063$) for the vigor-activity subscale (Table 2).

Confusion-Bewilderment—No significant interactions were found for the Confusion-Bewilderment subscale ($F (2, 86) = 3.78$, $p = .027$, $\eta 2 = .086$). Similarly, no main effects for group were found, ($F (2, 86) = .90$, $p = .345$, $\eta 2 = .011$). However, significant main effects for time were identified, ($F (2, 86) = 16.13$, $p < .001$; $\eta 2 = .29$) and simple contrasts showed differences in scores between Acute and Exercise ($p < .001$) as well as Acute and RTP ($p < .001$; Table 2).

Total Mood Disturbance—No significant interactions were found for TMD ($F (2, 86) = .20$, $p = .819$, $\eta 2 = .005$). There were also no main effects observed for group, ($F (2, 86) = 1.22$, $p = .273$, $\eta 2 = .015$). However, significant main effects for time were identified, ($F (2, 86) = 13.49$, $p < .001$; $\eta 2 = .02$) and simple contrasts showed differences in scores between Acute and Exercise ($p < .001$) as well as Acute and RTP ($p < .001$; Table 2).

State Anxiety Inventory

There was no interaction ($F (2, 86) = 1.02$, $p = .386$, $\eta 2 = .027$) or main effect by group ($F (2, 86) = .66$, $p = .420$, $\eta 2 = .006$) or time ($F (2, 86) = 2.14$, $p = .099 \eta 2 = .054$) for the state anxiety subscale of the STAI (Table 2). In the acute phase post-injury, 73.3% (11/15) CONC and 66.7% (10/15) MSK participants exceed the threshold for state anxiety (score of 38 or higher). While both group means dropped to a subclinical levels (less than a score of 38) at the start of exercise (CONC: 35.3 ± 15.7 and MSK: 35.5 ± 11.4), over half of participants in each group (53.3%, 8/15) still scored higher than 38. At RTP, 60% of individuals (8/15 in both groups) reached the state anxiety threshold.

DISCUSSION

The understanding of psychological responses to injury, both MSK and CONC, are critically important for health care providers for both the medical management of injuries and the development of appropriate rehabilitation programs. The primary finding of this study was that a similar psychological response between CONC and MSK groups across milestones occurred during their time matched injury recovery process. The psychological response for both groups, based on the inventories used herein, generally demonstrated improvement across the milestones with the exception of the STAI which showed a non-significant increase from Exercise to RTP day and had more than 50% of participants clinically classified as “anxious” (state anxiety > 38). This finding differs from earlier studies, which suggested a difference in psychological responses; however, this study controlled for time loss and included only non-surgical injuries and thus likely represents an ecologically valid comparison group (Mainwaring et al., 2010). As we tightly matched time loss and rehabilitation duration, these findings of similar responses between groups suggest the psychological considerations of time lost from practice/games, social isolation, and withdrawal from their activities of daily living likely play a larger role than the physiological response to the concussion.

The POMS assesses the self-reported mood state with a collection of subscales and overall Total Mood Disturbance value. Herein, there were significant main effects for time, showing that mood states at the Acute time point were worse than either Exercise or RTP, for the Anger-Hostility, Fatigue-Inertia, and Depression-Dejection subscales as well as Total Mood Disturbance. These results suggest that both concussed athletes and those with similar time loss MSK injury demonstrate a gradual improvement in mood state throughout the recovery process (Hutchison et al., 2009; Hutchison et al., 2016; Mainwaring et al., 2010; Mainwaring et al., 2004). While there were no differences in the remaining subscales, the trends were consistent with gradual improvement over time. The subscale and TMD outcomes amongst these student-athletes were similar to previous concussion populations (Hutchison et al., 2016; Mainwaring et al., 2010; Mainwaring et al., 2004). This resolution of elevated mood disturbance over the first couple of weeks post-concussion is consistent with most previous findings suggesting the mood disturbance is transient, although Kontos (2012) did report elevated levels of depression, including a non-significant increase in the collegiate athletes, which persisted at least 2 weeks post-concussion (Hutchison et al., 2016; Mainwaring et al., 2010; Mainwaring et al., 2004). The mood resolution has been speculated to be related to symptom reduction, overall feelings of well-being associated with recovery, improved sleep quality, and the return to normal ADL's including sports participation in practices and games (Hutchison et al., 2016). As the MSK group was assessed across similar time frames, this supports the contention that the withdrawal from team athletic activity (e.g., practices and games) may be the primary influence on mood disturbance (Hutchison et al., 2016; Moreau et al., 2014). The MSK participants herein may have continued with off-field training as plausible (e.g., weight training, team video sessions, team meetings) which the CONC participants would have also been restricted from due to symptoms, yet the psychological responses were similar between groups. These findings are similar to Covassin (2014) who identified similar psychological response between concussion and orthopedic injuries within a week post-injury. Furthermore, qualitative study of student-athletes' experiences with concussion include reports of nervousness, tension, anxiety, and anger at suffering the concussion, which athletes often stated later resolved as they accepted the diagnosis and worked through the recovery process and progressed to RTP (Moreau et al., 2014). Similar findings have been observed among professional English soccer players as well (Williams, Langdon, McMillan, & Buckley, 2016).

The STAI evaluates apprehension, tension, nervousness, and worry at the time the test is taken (Spielberger et al., 1970). In a study specific to healthy student-athletes, Yang et al. (2007) found that college student-athletes'mean STAI score was 35.1 + 9.4 with significant increases for athletes with history of injury (36.3 ± 9.6), reported pain (36.0 ± 9.4), and symptoms of depression (44.4 ± 9.4). Even with these means and standard deviations in mind, a STAI score greater than 38 is postulated to indicate high state anxiety levels;

however, it is important to note that this does not mean that these individuals are reaching levels of clinically diagnosed anxiety (Spielberger et al., 1983). Antony, Orsillo, and Roemer (2001) reported that individuals with diagnosed anxiety tend to score between 47 and 61 on the STAI. Within the current study, 73.3% of participants exceed the threshold for state anxiety during the acute phase post-injury, regardless of type of injury. While both group means dropped to lower levels of state anxiety at the start of exercise, over half of participants in each group (53.3%) still scored higher than 38. Finally, there was a non-significant increase at RTP of group means exceeding 38, with the majority of individuals (53.3%) reaching the state anxiety threshold. The participants herein had higher state anxiety at all three time points than reported by Covassin et al. (2014) (CONC: 31.4 ± 10.1 and Ortho: 31.0 ± 10.2) who were assessed within one-week post-injury, a time that most closely mirrors the Exercise milestone. These results suggest that many injured student-athletes may have unresolved anxiety at the time of return to play; however, it is important to note that state anxiety is commonplace amongst competitive athletes and the results here may represent typical responses (Gouttebarge, Aoki, Verhagen, & Kerkhoffs, 2016).

The current concussion RTP protocol is based on "passing" balance and cognitive tests as well as self-reporting asymptomatic; however, lingering neurobiological deficits beyond RTP are routinely reported in the literature (Buckley, Oldham, & Caccese, 2016; McCrea, Prichep, Powell, Chabot, & Barr, 2010; McCrory et al., 2013). Typically, these deficits are assessed individually per task (e.g., identified cognitive deficits); however, the influence of psychological response on physical or cognitive outcomes has received limited consideration. Neurobiological supporting evidence potentially linking psychological outcomes with chronic post-concussion alterations include both altered frontal-alpha symmetry on EEG assessment and dorsolateral prefrontal cortex connectivity, which have been associated with the neural substrates underlying psycho-affective health (Chen et al., 2008; Moore, Sauve, & Ellemberg, 2016; van der Horn et al., 2016). Interestingly, postural control testing of gait termination, a functional task with dorsolateral prefrontal cortex supraspinal control, has identified deficits post-concussion which provides further potential evidence linking the systems (Buckley, Munkasy, Tapia-Lovler, & Wikstrom, 2013; Oldham, Munkasy, Evans, Wikstrom, & Buckley, 2016). An emerging area of concussion research suggests an elevated risk of post-concussion subsequent MSK injury in collegiate student-athletes (Brooks et al., 2016; Gilbert, Burdette, Joyner, Llewellyn, & Buckley, 2016; Lynall, Mauntel, Padua, & Mihalik, 2015) and both impaired postural control and residual psychological disturbances have been speculated as potential confounders or mechanisms.

For student-athletes demonstrating substantial or worsening psychological symptoms following a sports-related concussion, referral to an appropriate and experienced mental health provider is recommended as these individuals may benefit from psychotherapy or pharmacological treatment (Kontos et al., 2016). However, most athletes will respond to behavioral therapy approaches including regulated sleep schedule, proper nutrition and hydration, stress management techniques, and physical activity (Collins, Kontos, Reynolds, Murawski, & Fu, 2014; Kontos et al., 2016). Increasing physical activity, absent vestibular impairment, is essential for reducing anxiety and several recent studies have reported acutely reduced symptom duration for the physically active as compared to individuals with more restrictive and/or prolonged physical and cognitive rest (Buckley et al., 2015; Kontos et al., 2016; Thomas et al., 2015). Conversely, individuals with post-concussions syndrome and prolonged symptoms may benefit from either rest or physical activity and the principle of individualized treatment should be followed (Leddy, Hinds, Sirica, & Willer, 2016; Moser, Glatts, & Schatz, 2012). Beyond these sports medicine clinical interventions, evidence based psychological interventions including identifying social support, cognitive behavioral therapy, and goal setting can be implemented by psychologists to support student-athlete recovery (Wiese-Bjornstal, White, Russell, & Smith, 2015).

The majority of collegiate student-athletes recover from a concussion within 7 – 10 days and the participants herein were asymptomatic and achieved baseline on balance and cognitive testing 7.1 ± 3.1 days (range: 2 – 12 days) post-concussion (McCrory et al., 2013). While the loss of consciousness (20%) and posttraumatic amnesia (40%) rates were higher than typically reported, the acute presentation of symptoms as well as balance and cognitive symptoms were generally consistent with prior findings (McCrea et al., 2005; McCrea et al., 2003). This suggests the population herein represents a typically presenting collegiate student-athlete population; however, these findings may not translate to high school athletes or other ages or populations (e.g., military). An important limitation of this study is the sample size despite data collection occurring over a two-year window, many potential participants were removed most commonly due to missed testing time points due to travel related challenges, delayed diagnosis confirmation, or participant non-compliance. A further limitation was the lack of healthy baseline data for participants in both groups as pre-injury psychological risk factors including personality, trait anxiety, history of stressors, coping resources, and interventions may all influence psychological outcome following concussion. Unfortunately, we were unable to collect baseline values on these measures and future studies should incorporate both baseline and, preferably, annual assessment of student-athletes' psychological characteristics. However, post-injury mood disturbances are not predicted by pre-injury mood disturbance (Hutchison et al., 2009; Mainwaring et al., 2004). The use of an athletic population with acute MSK injury was an a-priori decision, however, no healthy control participants were used as the research question focused on differentiating psychological responses between concussions from MSK injuries. Finally, self-reported inventories are limited by patient honesty and the research team took multiple steps to reduce external stressors including completing all testing in a private research lab without teammates or coaches nearby and were repeatedly reminded that their individual results would be not shared.

The results of this study suggest that both concussion and MSK injured student-athletes experience mood disturbance and anxiety acutely following injury; however, these tend to resolve over the several weeks following the injury. The lack of differences between groups suggests that, as measured by the POMS and STAI, reduced ADLs (e.g., lost playing time from sports) may be contributing to the increased mood disturbance more than a physiological response to a concussion. The utilization of both recovery-specific milestones and closely matched time loss injuries elucidates a consideration in understanding the psychological response to concussion. A high percentage of individuals in both groups were classified as "anxious" at RTP, which should be of concern to sports medicine clinicians and likely warrants continued improvements in student-athlete mental health services (Neal et al., 2013).

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1

Demographic Information

		CON		MSK	
		N	%	N	%
Gender	Female	7	46.7	6	55.0
	Male	8	53.3	9	45.0
Year in School	Freshman	5	33.3	5	40.0
	Sophomore	6	40.0	4	20.0
	Junior	4	26.7	3	15.0
	Senior	0	0.0	3	25.0
Previous History of Concussion	0	5	33.3	11	75
	1	5	33.3	1	5
	2	4	26.7	2	15
	3	1	6.7	1	5
Loss of Consciousness	Yes	3	20%	--	--
	No	12	80%	--	--
Post-Traumatic Amnesia	Yes	3	20%	--	--
	No	12	80%	--	--
		Mean	**SD**	**Mean**	**SD**
Age		19.40	1.45	19.95	1.15
Height (cm)		172.63	12.46	179.57	9.72
Weight (kg)		78.42	20.02	84.73	20.89
RTP (days)		13.93	4.88	10.85	9.63

Table 2

Means, Standard Deviations, and ANOVA Comparisons

Mood State		CONC			MSK			Overall		Group × Time Interaction	Group	Time
		M	SD	95% CI	M	SD	95% CI	M	SD			
Tension-Anxiety										ns	ns	ns
	Acute	2.21	2.46	.80 – 3.63	3.53	4.60	.99 – 6.08	2.90	3.72			
	Exercise	.15	.56	−.18 – .49	1.86	2.85	.21 – 3.50	1.04	2.23			
	RTP	0.40	1.06	−.18 – .98	1.73	2.28	.47 – 3.00	1.07	1.87			
Anger-Hostility										ns	ns	.001
	Acute	1.43	2.50	−.02 – 2.87	4.60	6.14	1.20 – 8.00	3.07	4.94			
	Exercise	.23	.44	−.03 – .50	1.36	1.82	.30 – 2.41	.81	1.44			
	RTP	.20	.56	−.11 – .51	.40	.91	−.10 – .90	.30	.75			
Fatigue-Inertia										ns	ns	< .001
	Acute	5.14	4.02	2.82 – 7.46	4.00	3.09	2.29 – 5.71	4.55	3.55			
	Exercise	.23	.83	−.27 – .73	2.79	2.89	1.12 – 4.45	1.56	2.49			
	RTP	.40	.91	−.10 – .90	1.93	3.02	.33 – 3.53	1.17	2.25			
Depression-Dejection										ns	ns	.002
	Acute	1.64	3.05	−.12 – 3.41	4.00	5.36	1.03 – 6.97	2.86	4.49			
	Exercise	.00	.00	--	1.21	2.33	−.13 – 2.56	.63	1.76			
	RTP	.20	.56	−.11 – .51	.60	1.18	−.06 – 1.26	.40	.93			
Vigor-Activity										ns	ns	ns
	Acute	5.71	6.02	5.14 – 10.19	7.67	4.56	2.24 – 9.19	6.72	5.31			
	Exercise	7.23	7.33	2.80 – 11.66	8.86	4.64	6.18 – 11.54	8.07	6.02			
	RTP	9.20	7.64	4.97 – 13.43	11.47	5.79	8.26 – 14.67	10.33	6.76			
Confusion-Bewilderment										ns	ns	< .001
	Acute	3.29	2.37	1.92 – 4.65	1.60	2.56	.18 – 3.02	2.41	2.57			
	Exercise	.08	.28	−.09 – .24	.50	1.35	−.09 – .24	.30	.93			
	RTP	.27	.70	−.12 – .66	.53	.99	−.02 – 1.08	.40	.86			
Total Mood Disturbance										ns	ns	< .001
	Acute	108.00	15.48	99.06 – 116.94	110.07	20.38	98.78 – 121.35	109.07	17.89			

Mood State		CONC			MSK			Overall		Group × Time Interaction	Group	Time
		M	**SD**	**95% CI**	**M**	**SD**	**95% CI**	**M**	**SD**			
	Exercise	93.46	8.05	88.59 – 98.32	98.86	8.52	93.94 – 103.78	96.25	8.59			
	RTP	92.27	7.76	87.97 – 96.56	93.73	8.25	89.16 – 98.30	93.00	7.90			
State Anxiety										ns	ns	ns
	Acute	39.73	12.84	32.62 – 46.85	40.11	4.77	37.47 – 42.76	39.92	9.52			
	Exercise	35.33	15.66	26.66 – 44.01	35.53	11.39	29.22 – 41.84	35.43	13.46			
	RTP	39.45	8.66	32.95 – 42.92	40.12	16.37	20.87 – 39.00	39.79	13.60			