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DEPARTMENT OF PSYCHOLOGY

CORRELATION BETWEEN CONCUSSION HISTORY AND POST-CONCUSSION DEPRESSIVE SYMPTOMS IN COLLEGIATE ATHLETES

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ABSTRACT

Athletes are frequently subjected to mild traumatic brain injury (mTBI), also known as a concussion. The cognitive and emotional symptoms of these concussions can linger for months or even years after the injury. These effects may include exacerbation of symptoms of subsequent head injuries. The purpose of this study was to examine the depressive symptoms seen in athletes after multiple concussions as compared with athletes after sustaining their first concussion. Data were collected from the Penn State Sports Concussion Neuropsychology Program databases and analyzed using SPSS Statistics. The 312 athletes included in the study were divided into three groups based on concussion history (1: baseline; 2: post-concussion [0 previous mTBI]; 3: post-concussion [1+ previous mTBI]), and measures of depressive symptoms were compared between groups. Groups 2 and 3 both showed significantly higher depression scores (Beck Depression Inventory – Fast Screen: BDI-FS) than Group 1, but the difference between 2 and 3 was not statistically significant. Group 3 also showed a significantly lower examiner-observed affect rating than Group 1. All comparisons for Affective Word List bias and Post-Concussion Symptom Scale Affective scores were not found to be significant. Based on these results, only the affect rating showed a significant increase in depressive symptoms when comparing an athlete's first concussion to a subsequent concussion. However, relative to athletes with no prior concussions who were only examined at baseline, depression symptom reports were increased in athletes who had experienced a concussion regardless of concussion history. These findings suggest the possibility that experiencing a concussion increases the likelihood of depression symptoms in collegiate athletes.

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Introduction

As more research is conducted regarding traumatic brain injury (TBI), more attention is given to the millions of TBI patients seen annually in the United States. The CDC estimates that 1.3 million emergency room visits in the United States each year are due to a suspected TBI (Schatz & Moser 2011). Many of these incidents are the result of automobile accidents or falls, but a significant portion of these injuries are sports-related. Participation in sports, both competitive and non-competitive, is an integral part of life for many Americans, especially adolescents and young adults. As a result, an estimated 300,000 sports-related TBI, predominantly concussions, occur each year. This number was behind only motor vehicle accidents as the second-most common cause of TBI (Gessel, et al. 2007). Even less obvious contact sports such as soccer and basketball often lead to TBI in high school and collegiate athletes.

With player safety being a major concern in athletics, it comes as no surprise that major sports leagues are funding research into the effects of TBI and ways to prevent them. The National Collegiate Athletic Association (NCAA) and National Football League (NFL), in particular, have taken strides to further develop the understanding of sports-related TBI. Administration of the Immediate Post-Concussion Assessment and Cognitive Testing (IMPACT) battery has now become standard procedure in both professional and collegiate athletics. Current and former players have been studied to gain insight into all aspects of TBI, both short and long-term. For instance, cognitive deficits and depression were recently found to be more common in former NFL players than a matched healthy control group (Hart, et al. 2013). Researchers working with the NCAA found similar results in collegiate athletes who incurred a TBI during their careers (Guskiewicz, et al. 2003). These studies represent a snapshot of the current sports-

related TBI literature, to which more studies are constantly being added to build upon the volume and specificity of the data.

The most common sports-related TBI, as well as the focus of this study, is a mild TBI, also known as a concussion. Despite a plethora of research into concussions, there is still dispute regarding the exact definition of a concussion, with multiple definitions containing similar criteria being used. A recent consensus defined a concussion as "a complex pathophysiological process affecting the brain, induced by traumatic biomechanical forces…typically result[ing] in the rapid onset of short-lived impairment of neurologic function that resolves spontaneously" (McCrory, et al. 2009). Diagnosis of a concussion is based on evaluation of symptoms following an incident involving head impact or whiplash.

The significant effects of concussions have been well documented in the literature and cover a variety of categories including cognitive, behavioral/emotional, and physical impairments. While the effects differ from person to person in both type and duration, a common set of symptoms cover the majority of concussion patients. When these symptoms last for an extended duration (usually at least three months), post-concussion syndrome is often diagnosed, though diagnostic criteria vary.

Cognitive deficits are commonly evaluated during post-concussion treatment and assessment. Deficits are often seen in cognitive areas such as attention, memory, executive function, and reaction time (Arciniegas, et al., 2005). These deficits are most severe shortly after the injury and usually decrease over time as the patient recovers. Recovery from these cognitive deficits is seen as sign of recovery in mTBI patients. Emotional and behavioral impairments can be more difficult to quantify, but are still frequently seen after a concussion. Depression, which is the focus of this study, as well as anxiety disorders and personality changes can stem from and/or be exacerbated by a head injury. In addition to cognitive and behavioral symptoms, a TBI will often result in physical symptoms such as headaches, fatigue, and sensitivity to light or noise

(Riggio and Wong, 2009). Due to the individual differences among individuals suffering from a concussion, the set and severity of symptoms can differ greatly and is not strictly limited to the symptoms listed above. Mental and physical impairments can interact to affect their severity, further complicating the assessment of an individual's impairment (Beaupre, De Guise, & McKerral, 2012). Even a patient's perception of their injury can affect their symptoms (Whittaker, Kemp, and House, 2006).

While symptoms fade as a patient recovers, there can still be long-term effects that can linger long after an individual has been determined to have fully recovered from his or her injury. While most individuals fully recover from a mTBI within one to three months, impairments such as deficits in memory, concentration, and processing speed can remain significant for months or even years after injury (Levin, et al., 1987; Moser, Schatz, & Jordan, 2005). These effects can increase susceptibility to another concussion while also increasing both the severity of cognitive deficits and recovery time for subsequent concussions. Even high school athletes have been found to show evidence of the cumulative effects of concussions (Collins, et al., 2002). Neurocognitive impairments have also been found in athletes with a concussion history years after their playing careers have ended. Cognitive and behavioral impairments are more frequently found than physical symptoms in very-long-term studies, and these deficits are usually significantly less severe than deficits immediately post-injury (Brown, et al., 2011). Though they may be less severe, the various symptoms can still interact years after injury, affecting an individual's quality of life (Stalnacke, 2009).

If left untreated, these neurocognitive deficits can sometimes develop into a condition known as chronic traumatic encephalopathy (CTE). CTE, a progressive neurodegenerative disease, is closely linked to athletes who have suffered multiple closed head injuries. No definitive mechanism has been defined, but CTE often presents with cognitive and emotional disturbances that progress into deficits similar to those seen in Parkinson's disease. Although

research investigating the cause of CTE is still inconclusive, a history of mTBI has been shown to be a significant risk factor (Saulle & Greenwald, 2012). Brain imaging studies have shown evidence of chronic brain trauma in retired NFL players, most of whom have a history of concussions (Omalu, et al., 2010; Amen, et al., 2011).

Research of CTE has gained popularity in the public following the suicides of multiple former NFL players, with the most recent being former star linebacker Junior Seau in May 2012. With depression being a common emotional difficulty seen in CTE, it is important to look at the depressive symptoms that arise after concussions, as well. Post-TBI depression may arise any time after injury and has significant overlap with spontaneous depression in both brain morphometry and symptoms (Hudak, et al., 2011). As with mTBI, there is no definitive set of symptoms that encompass depression, and presentation of depression varies among individuals. Common features of depression include, but are not limited to, sadness, persistent negative thoughts, apathy, and a lack of energy (Guillamondegui, O., et al., 2011). In some cases, depression may also lead to suicide, making it a vital topic for research. The emergence of depressive symptoms after a concussion typically resolves over time, something that has been well documented (Schoenhuber & Gentilini, 1988; Bombardier, et al., 2010). Like other post-concussion symptoms, however, depression may last for years after the injury (Stalnacke, 2009).

Screening for depressive symptoms is an important part of the post-concussion evaluation. Research into the validity of techniques to screen for spontaneous depression has found them to also be valid for post-TBI depression (Cook, et al., 2011). The screening technique used for the present study is the Beck Depression Inventory Fast-Screen (BDI-FS), a shortened version of the widely-used Beck Depression Inventory (BDI) that has been found to strongly correlate with BDI scores of depression (Beck, et al., 1988; Neitzer, et al., 2012). Other, more indirect measures have also been found to correlate with depression and are used to supplement self-report screens such as the BDI-FS. A negative bias in an affective recall task, such as an

affective word list, has been shown to correlate with depression (Blaney, 1986). Certain post-concussion symptoms including fatigue, irritability, poor concentration, and sleep problems are also correlated with depression (Trahan, et al., 2001). Such measures, along with a perceived rating of an individual's affect, can be used to evaluate depressive symptoms.

While the incidence of depression after a TBI is established, there is less research regarding the effect of multiple concussions on the presentation of depressive symptoms. This study compared the depressive symptoms seen in collegiate athletes after sustaining their first concussion with the depressive symptoms seen after subsequent concussions. Previously administered direct and indirect measures of depression were used to evaluate the depression symptoms in the athletes. I hypothesize that depressive symptoms in athletes following their first concussion will be significantly less than depression symptoms in athletes after subsequent concussions.

Methods

Participants

Subjects in this study were selected from participants in the Penn State Sports Concussion Neuropsychology Program. After exclusion of ineligible subjects, 312 subjects were selected for inclusion in this study. Subjects were excluded for incomplete data for the variables examined or for not fitting the criteria of any of the three groups discussed below. Of the included subjects, 234 are male and 78 are female. The ages of these subjects range from 17-23 years, with an average age of 18.50 years. Football is the most frequently played sport, with 116 subjects being past or current members of the Penn State football team (Table 1). The subjects were divided into three groups based on their concussion history. Group 1 (246 subjects) includes athletes who denied any history of a concussion. Group 2 (32 subjects) includes athletes who received a concussion while at PSU without any concussions prior to that injury. Croup 3 (34 subjects) includes athletes who received a concussion while at PSU and also a history of at least one concussion prior to that injury.

Diagnosis of a concussion was made by the team physician, who then referred the athletes to the sports neuropsychology program. Data were obtained as part of a neuropsychological test battery which tests for variety of cognitive factors.

Measures

This test battery is administered at baseline when an athlete enrolls at PSU, as well as after any concussion incurred. Several measures of depression were included.

Beck Depression Inventory - Fast Screen (BDI-FS; Beck et al., 2000). This measure asks examinees to rate themselves on a scale of 0-3 on seven depression-related items based on how they have been feeling over the past two weeks.

Affective Word List (Ramanathan et al., 2012). This word-list learning test involves reading a 16-item word list to examinees and asking them to recall as many words as they can. The list is repeated for three trials. Words comprising the list are either affectively negative (8 words) or affectively positive (8 words), but examinees are not informed of this differential affective content. A positive bias index is created that involves subtracting the total negative from positive words recalled across the three trials, such that a positive value reflects differential recall of positive words, and negative values reflect differential recall of negative words. This positive bias index has been shown to be associated with scores on the BDI-FS at baseline in collegiate athletes, with individuals showing a positive bias more likely to report low scores on the BDI-FS and those with a negative bias likely to report higher BDI-FS scores (Ramanathan et al., 2012).

Affect Rating. This experimenter observational rating developed in our lab requires examiners to rate the affect of examinees displayed during testing on a five-point scale. Examiners use cartoon face icons ranging from sad affect, mildly sad affect, neutral, positive affect, and very positive affect.

Post Concussion Symptom Scale (PCSS; Lovell et al., 2006). This self-report measure requires examinees to rate themselves on 21 common post-concussion symptoms on a scale of 0-6, with 0 representing no symptom and 6 representing extreme severity. Four PCSS items (feeling more emotional than usual, irritable, sad, anxious) were combined into one PCSS Affective total score and used in the data analysis.

The data from Group 1 was taken from their baseline (BL) tests, and the data from Groups 2 and 3 was taken from their first post-concussion test (PC1). Data were analyzed using SPSS 20.0, using a one-way ANOVA between all three groups with a post-hoc Tukey's test ($\alpha < .05$).

	Male	**Female**
Sex	234	78
	Mean (SD)	**Range**
Age in Years	18.50 (1.049)	17-23
Athlete Sport		
	Frequency	Percent
Football	116	37.2
Men's Soccer	28	9.0
Women's Soccer	29	9.3
Wrestling	4	1.3
Women's Lacrosse	30	9.6
Men's Lacrosse	37	11.9
Men's Ice Hockey	22	7.1
Women's Basketball	12	3.8
Men's Basketball	27	8.7
Softball	3	1.0
Rugby	1	0.3
Swimming/Diving	1	0.3
Women's Ice Hockey	2	0.6

Table 1: Demographic Information

Results

Analysis of the data revealed significant differences between groups for only BDI-FS total score ($p \leq .001$), but with a statistical trend for affect rating differences ($p \leq .07$). No significant between-groups differences in PCSS affective score or AWL positive bias were found (see Table 2).

	Group 1 Baseline, no previous concussions	Group 2 PC 1, no previous concussions	Group 3 PC 1, one or more previous concussions	F-Value (df=2)	P-Value
BDI-FS	$.886^{a}$ (1.53)	2.19^{b} (2.25)	1.82^{b} (2.41)	11.2	< .01
Affect Rating	3.93^{a} (.791)	3.84 (.767)	3.59^{b} (.783)	2.81	< .07
PCSS Affect Factor	1.56 (2.74)	.563 (.878)	1.24 (2.50)	2.19	< .12
AWL Positive Bias	1.12 (3.79)	1.13 (3.86)	.559 (4.09)	0.324	< .73

Table 2: Comparison of Means

Note: Values with different superscripts are significantly different per Tukey's post-hoc test ($p < .05$)

Post-hoc analysis was able to clarify the significant differences between groups. For BDI-FS total score, Groups 2 and 3 had significantly higher scores than Group 1 ($p \leq .001$ and $p \leq .01$, respectively). The difference between Groups 2 and 3 was not statistically significant. Group 3 was also found to have significantly lower affect ratings than Group 1 ($p = .050$). No other group differences were statistically significant.

Discussion

The goal of this study was to examine the differences in depressive symptoms in athletes with varying concussion histories. I hypothesized that athletes with prior concussions would exhibit greater deviation from baseline than athletes without any previous head injuries. When viewed with this hypothesis in mind, the study produced mixed results.

BDI-FS score between-group differences were found to be the most significant. Groups 2 and 3 were found to be significantly different from Group 1. The post-concussion BDI-FS scores were significantly higher than those scores obtained from athletes at baseline who had never reported a concussion. These results indicate an increase in BDI-FS scores, and therefore increased depressive symptoms, in athletes after receiving a concussion. The difference between scores of Groups 2 and 3, however, were not found to be significant. These results, inconsistent with the hypothesis, showed similar BDI-FS scores regardless of whether it was the athlete's first concussion or a subsequent concussion. While a concussion expectedly raised this measure of depressive symptoms, the athletes' varied concussion histories (one versus two or more past concussions) did not appear to play a role in this case.

The athletes' affect ratings also showed significant between-group differences. The differences between Groups 1 and 2, as well as between Groups 2 and 3, were not significant, but Groups 3 was found to have a significantly lower affect rating (sadder affect) than Group 1. While an athlete's first concussion did not significantly alter his or her affect from baseline, athletes with previous concussions were found to have a significantly lower affect rating upon PC1 testing. Consistent with the hypothesis, a history of previous concussions was found to correlate with increased post-concussion depressive symptoms. This result supports the idea that

a second or third concussion will have a greater effect on observable depressive symptoms than an athlete's first concussion.

Contrary to prior expectations, no significant differences were found between any of the groups when looking at AWL positive bias and PCSS affective scores. The post-concussion scores for both tests were similar to the baseline scores, regardless of concussion history. The results showed no difference between baseline scores and post-concussion scores on these measures of depressive symptoms, which is rather surprising when observed in the context of the current literature.

The limitations of this study may have contributed to the mixed results. Since tests such as the affect rating and PCSS were added to the test battery relatively recently, all of the athletes in the early years of the program were excluded due to incomplete data sets. The addition of the test scores obtained from these subjects (AWL and BDI-FS) may have influenced the significance of the results. Also, the athletes' concussion histories cannot be verified, so some athletes in Group 2 may have had undiagnosed concussions of which they are unaware.

The subjectivity of the tests may also have impacted the results. The affect rating is a subjective measure determined by the examiner during the test battery. Throughout the program, numerous examiners have administered test batteries to the athletes, and they may have slightly different perceptions of the same athlete. The BDI-FS and PCSS are both self-report scores which are solely dependent on the athletes to provide honest, accurate scores. These athletes are highly competitive individuals living in the setting of Division I athletics. After receiving an injury such as a concussion, they often approach the injury with the goal of returning to play their respective sports as soon as possible. As a result, some athletes may downplay their symptoms and minimize the severity of symptoms reported in order to accelerate their return to play. The frequency of this occurrence, in addition to its effect on the results, is unknown, but the possibility of a significant effect exists.

Also, the post-concussion scores used in this study were taken as soon as possible after the injury, usually within 48 hours; however, there was some inconsistency with the time between injury and post-concussion testing. Therefore, some athletes may have been in different stages of recovery than others, affecting the results. Also, the results only show the differences between groups soon after the injury. Significant differences may develop later over time during or after the recovery process. Differences in the recovery process may exist, but are unable to be determined from this study. Further research that takes into account data from multiple time points may be able to explore more details regarding the effects of multiple concussions on depressive symptoms. Looking at more long-term data taken after the athletes have officially recovered could provide more insight into the cumulative effects of concussions on depression. While this study provided some evidence of significant differences in depressive symptoms between an athlete's first concussion and a subsequent concussion, further research on a wider scale is needed to fully examine these relationships. Concussions will always remain an unfortunate consequence of athletics, so understanding how they can lead to depression or even suicide is a vital component of player safety.

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Research Interests

I have interest in neuropsychology, specifically with the effects of TBI on brain function. I am interested in long-term effects of mTBI, also known as concussions, as well as the cumulative effects of multiple concussions.