THE PENNSYLVANIA STATE UNIVERSITY
SCHREYER HONORS COLLEGE

DEPARTMENT OF PSYCHOLOGY

USING THE EMOTION WORD FLUENCY TEST AS A MEANS FOR IDENTIFYING AND PREDICTING DEPRESSION IN COLLEGIATE ATHLETES

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SPRING 2015

A thesis
submitted in partial fulfillment
of the requirements
for a baccalaureate degree
in Science
with honors in Psychology

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ABSTRACT

There has been increasing media attention with regards to sports-related concussions, particularly on depression following injury. While extensive research has been done on proper neurological testing to identify concussed athletes, little research has been conducted to identify and predict depression post-concussion. This research utilizes an affective-based measure, the Emotion Word Fluency Test (EWFT), to objectively identify depression in collegiate athletes at Penn State University. To do this, the test was statistically analyzed in relation to another validated affective-based measure, the Affective Word List (AWL), as well as a self-report Post-Concussion Symptom Scale, and the Beck Depression Inventory Fast-Screen (BDI-FS). All tests were a part of Penn State's neuropsychological concussion program, and athletes were administered all tests as baseline measures. In total, 160 participants completed the battery. Overall, it was found that the EWFT was significantly correlated with the AWL ($p < 0.05$), and there was a statistical trend for the correlation with the BDI-FS. In addition, the EWFT Positive Bias group (those who generated more positive than negative words) showed significantly higher BDI-FS scores when compared to the Negative Bias group (those who generated more negative than positive words). Finally, it was found that AWL and EWFT Positive and Negative Bias groups were significantly related as well. These findings suggest that the EWFT is a valid performance based measure for screening negative mood in collegiate athletes. Still, this research is preliminary, and additional studies with greater and more diverse populations are necessary to generalize the results. Future studies should also explore the use of the EWFT as a depression measure as part of a post-concussion battery as well.

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ACKNOWLEDGEMENTS

I would like to personally thank Dr. Peter Arnett for his guidance throughout this project. His mentorship over the past two years has helped me become a better researcher and scholar. The opportunities offered to me through this research lab are incomparable and have sparked my interest in neuropsychology as well as traumatic brain injury. I would also like to thank Victoria Merritt for her assistance throughout this project and for her support as a research coordinator throughout my years as a research assistant. In addition, I would also like to thank Jessie Meyer for her leadership and guidance as my current research coordinator. Without the efforts of these individuals, this project would not have been possible.

Introduction

Defining Concussion

Mild traumatic brain injury (mTBI), commonly referred to as a concussion, is defined as a trauma-induced head injury that results in a shift in mental status that may or may not include a loss of consciousness (Kelly, 1999). Often overlooked is the fact that the overwhelming majority (90%) of concussions are not accompanied with a loss of consciousness (Guskiewicz, Weaver, Padua & Garrett, 2000). Most frequently, concussions give rise to various cognitive and somatic symptoms that range in severity amongst those affected (Chen, Johnston, Petrides & Ptito, 2008). Early symptoms with an onset range of minutes to hours include (but are not limited to), headaches, dizziness, nausea, vomiting, and lack of awareness. Later symptoms with an onset range of day to weeks include headaches, sleep disturbance, lack of concentration and attention, irritability, and memory dysfunction (Barkhoudrian, Hovda & Gize, 2011). Much of the early signs tend to be more aggressive and somatic in nature whereas later symptoms impair cognitive ability and are often termed as part of post-concussion syndrome (PCS). This discrepancy in symptomology creates difficulty in on-field diagnosis. More specifically, blatant, clinical signs such as dizziness and vomiting often resolve well before cognitive impairment (Rosenbaum & Arnett, 2010). A lack of awareness of these neurocognitive signs gives rise to premature return to play and risk of further injury.

Trauma resulting in mTBI can be induced through various means. Most commonly, they result from vehicular accidents, falls, and sports and recreational activity. Particular mechanisms can vary heavily depending upon age group (Anderson, Heitger & Macleod, 2006). No matter the mechanism, however, there is a consistency in the cause of mTBI; an abrupt and aggressive change in inertia prompted by compressive, tensile, or shearing forces on the head and neck (Cantu, 1998; Busch & Alpern, 1998). While prevention of injury is unlikely in all settings, increasing efforts are being made in sports medicine with regards to diagnosis and prevention of sports-related concussions (SRC) in particular.

Epidemiology

While the exact number is still up for much debate, current estimates of sports-related concussion in the United States alone range from 1.6 million to 3.8 million athletes (Barkhoudarian, Hovda & Gize, 2011). Fortunately, recent media and public attention has given rise to a significant increase in research dedicated to the management and diagnosis of concussions. In fact, data collected from emergency department visits has shown a 62% increase in diagnosis from 2001 to 2009 (Broglio et. al., 2014). Still, these values include a significant amount of variability due to the fact that mild TBI still remains significantly underdiagnosed (Kelly, 1999). Two central factors can be attributed to the dearth of diagnosis that remains: Complexity of the injury and underreporting of symptoms. Patient symptomology varies significantly between individuals, and often times athletes and their respective trainers find difficulty in recognizing symptoms during athletic play. In addition, some athletes tend to underreport their symptoms due to pressures to continue participating in competition (Ramanathan, Rabinowitz, Barwick & Arnett, 2012).

Rate of injury differs depending on the level of play. In High School Athletics, 11.2 injuries occurred per 10,000 exposures as of 2010 (Noble & Hesdorffer, 2013). Again, this data is most likely underreported; in fact, one in five high school football players can expect to sustain a concussion (Cantu, 1998). At the collegiate level, the risk of injury increases. According to the NCAA, 25 concussions occur per 10,000 competition exposures. This difference is likely due to an increase in athletic ability, resulting in higher impact force. For comparison purposes, the National Football League reports even more staggering statistics. In 2010, they disclosed a rate of 19 concussions per 100 games, excluding practice data (Noble & Hesdorffer, 2013).

While all sports include an increase in risk of any injury, concussions tend to be seen most commonly in high impact sports including football, soccer, ice hockey, and lacrosse (Noble & Hesdorffer 2013). There are also several other factors that elevate risk of sustaining a brain injury. When compared to males, females not only exhibit a higher frequency of injury, but also an increase in symptom severity, and twice the likelihood of major depression following injury. Hormonal interaction, neuroanatomical and cerebrovascular differences, and less relative muscle mass have all been proposed as underlying explanations to this phenomenon (Covassin, Elbin, Harris & Kontos, 2012). In addition, age has been shown to correlate strongly with risk; younger athletes exhibit more severe symptoms during development and adolescence. A history of concussions leads to a subsequent increase of injury as well. Once a single concussion has been sustained, recurring risk increases to four times that of the baseline risk (Cantu, 1998). Genetics has found increased practicality through genome wide association studies that have linked many genes to recovery deficiencies. One gene, in particular, Apolipoprotein E4, has been reliably associated with deficits in outcome following TBI (Rabadi & Jordan, 2001).

The potential side effects of concussions on the individual should not be belittled, but secondary consequences of widespread concussions have a major impact on society as well. An estimated 9-10 billion dollars is spent solely on acute care annually in the United States. Due to a current lack of governmental financial support, TBI can create a staggering burden on families as well. Loss of job, depression, divorce, and alcoholism are all correlated with prolonged post-concussion syndrome (Kelly, 1999).

Return to Play

Not long ago, concussions were thought to be benign injuries (Barkhoudrian, Hovda & Gize, 2011). No long-term risks were identified at the time, and players would typically remain in competition if able. As research helped clearly verify the severity of head injuries amongst athletes, the responsibility of return to play decisions shifted exclusively to sports professionals. When a player sustains a potential head injury, they are immediately examined by the team's athletic training staff. On-field assessment typically involves a short, crude measure of cognitive impairment. The most common form of evaluation, called the Standardized Assessment of Concussion (SAC) typically takes above five minutes to perform. The SAC has benefited sport concussion diagnosis by providing an objective measure that can be performed by trainers with little to no neuropsychology background in a relatively quick time period (McCrea, Kelly, Randolph, Kluge, Finn & Baxter, 1998). Unfortunately however, it is not thorough enough to provide consistent diagnosis, and often players with low-grade cognitive symptoms are often cleared to return to play despite significant impairment. As a result, those prematurely cleared for play risk prolonged symptoms and further injury that could be prevented. Because of this, a more thorough neuropsychological evaluation is necessary for on-field diagnosis (Baily, Echemendia & Arnett, 2006).

Fortunately, more thorough evaluation of concussions exists for off-field evaluation. Traditionally, neurological testing is used post injury and has been proven to detect minute changes not noticeable by means of sideline testing (Lovell, Collins, Iverson, Johnston & Bradley, 2004). Generally performed by an experienced neuropsychologist, these tests provide a much more thorough evaluation. Prior to injury, athletes provide a baseline assessment of cognitive ability which allows for comparison if injury is sustained. While one of the primary arguments against neurocognitive testing is the inability to use neuropsychological testing on individuals who lack baseline testing, recent research has validated the use of post-concussive testing without baseline assessment as well. This typically involves using base rates of other individuals of similar intelligence (Echemendia et. al., 2012).

The overarching guideline for return to play requires an athlete to be asymptomatic for at least one week (Cantu, 1998). Approximately ten percent of those affected will experience prolonged periods of recovery, and these individuals are especially susceptible to major psychological and depressive disorders following injury (Noble & Hesdorffer, 2013). It is not uncommon in these situations for players to disregarded professional advice and return to play without medical clearance, if not closely monitored by a team's sports medicine professionals (Rosenbaum & Arnett, 2010). Desire to play, coach and teammate pressure, and a lack of understanding all play a role in furthering injury and permanent damage.

Pathophysiology of Concussion

According to the classification of a mild traumatic brain jury, no gross destruction of brain structure occurs. As a result, there is a common misconception that the brain undergoes no physical changes resulting from a concussion. In actuality, there is a drastic reaction cascade that occurs at the cellular level once the brain sustains any type of injury (Friede, 1961).

Immediately following injury, an increase in intracranial pressure occurs (Scott, 1940). While cerebral spinal fluid acts as a shock absorber for the brain, the excessive forces caused by mTBI triggers cellular damage and thus an inflammatory response (Holsinger et. al., 2002). In addition, significant damage is often inflicted upon the nerve cell membranes, resulting in a loss of ion regulation by membrane channels. Upon loss of regulation, a rapid efflux of potassium and influx of calcium occurs. Unchecked influx of calcium disrupts neurofilament and microtubule stability, thus impairing neuronal connectivity (Gize & Hovda, 2001). Perhaps more importantly, the efflux of potassium results in unregulated depolarization and action potential firing. Excitatory transmitters such as glutamate are then released and bind to NMDA receptors, leading to further depolarization of nerve cells.

Following unregulated depolarization, the cell makes attempts to rebalance its ion concentrations. Typically, when depolarization occurs, the cell's sodium potassium pump allows for repolarization and movement of sodium out of the cell and potassium in to the cell. Similarly, the cell will utilize the sodium potassium pump in this situation. Unfortunately, the imbalance is often too severe and unstable for the sodium potassium pump to restore proper concentrations of ions in the intracellular and extracellular fluid. As a result, the sodium potassium pump works much harder, increasing metabolic demand, and eventually leads the cell into an energy crisis (Gize & Hovda, 2001; Barkhoudrian, Hovda & Gize, 2011). Once the cell depletes its metabolic energy reserves, it plummets in to anaerobic respiration. Anaerobic respiration then produces an acidic byproduct called lactate. Excessive lactate production leads to local acidosis which eventually leads to cell death. Neural cell death is irreversible, and previous connectivity is thus permanently disrupted (Barkhoudrian, Hova & Gize, 2011).

Pathoanatomy of Concussion

While concussions, by definition, are not identifiable by any immediate gross anatomical changes, they do often result in anatomical changes over time. The recent emergence of magnetic resonance imaging (MRI) has given great insight in to some of these changes, even identifying minute changes previously unknown. Concussions almost always result in axonal blubbing and eventual disconnection. Mayer, Bellgowan, and Hanlon used functional MRI BOLD signaling to identify activation of specific brain regions following mTBI. They reported differences in activation in the dorsolateral prefrontal cortex (DLPFC) and inferior parietal lobe (Mayer, Bellgowan & Hanlon, 2015). In addition, BOLD studies performed by Gosselin showed decrease activation of the putamen, body of the caudate nucleus, and the right thalamus. (Gosselin et. al., 2011) Nerve cell loss in the brain and spinal cord is irreversible, and regeneration does not occur on cell bodies have been damaged. This lack of recovery may give insight as to why impaired neurocognitive and psychological functioning is often seen post-injury.

Depression following Concussion

Major depressive disorder (MDD), often referred to as clinical depression, affects an estimate of thirteen million Americans alone (Kessler & Wang, 2002). It is generally characterized by means of a multitude of depressive symptoms including sadness, decreased energy, sleep disruption, and loss of confidence (Guskiewicz et. al., 2007). Those formally diagnosed exhibit at least five depressive symptoms, one of which must be mood disturbance or the inability to experience pleasure. In addition, all individuals affected by MDD exhibit a significant amount of distress or impairment.

Interestingly, despite such a widespread prevalence of depression, the physiological and pathological causes behind the disorder are not entirely understood. Some studies have shown those affected with major depression have smaller hippocampal and amygdala volumes. It is believed that both brain regions play essential roles in the regulation of mood. It has also been hypothesized that depression leads to chronically elevated levels of glucocorticoids that eventually contribute to hippocampal cell death and thus smaller volumes (Arnett & Vargas, 2010). Other studies have also shown correlation between clinical depression and structural changes in the prefrontal cortex and basal ganglia regions. Similar to the hippocampal and amygdalar regions, these also have a known role in mood regulation (Guskiewicz, et. al, 2007). Dopamine, often referred to as the "pleasure neurotransmitter," is often found at reduced concentrations in individuals diagnosed with major depression (Chen, Johnston, Petrides & Ptito, 2008).While these finding are often inconsistent, they give evidence for that theory that depression is a result of clear structural and functional changes of the brain.

Clinical depression is the most common psychological disturbance experienced following brain injury. While studies have shown that risk increases with severity of injury, mild traumatic brain injury cannot be dismissed as harmless (Holsinger et. al., 2002; Bombardier et. al., 2010; Guskiewicz et. al., 2007). About six percent of those diagnosed with mTBI experience depression as a result. Lifetime prevalence of the disorder is common and often unpredictable. In addition, many symptoms do not occur until long after injury is sustained. Perhaps this is due to the elevated risk for depression following injury, inhibiting coping mechanisms that become apparent once significant hardship is faced by those affected (Holsinger et. al., 2002).

Major depressive disorder can be debilitating to those affected as well as their families. Along with MDD, rates of divorce, alcoholism, and suicide all increase. For this reason, depression following concussions has received increasing media attention at both the professional and amateur level. Studies done on National Football League (NFL) players showed further relation between lifetime depression and head injuries. Interestingly, players with one concussion did not show any correlation with depression. Instead, those with three or more concussions were shown to be at a threefold risk for depression.

Traditionally, depression is screened during post-concussion evaluation using self-report scales. Written scales such as the Beck Depression Inventory-Fast Screen (BDI-FS) as well as computerized scales such as the Patient Health Questionnaire (PHQ-9) are often used to categorize and identify athletes experiencing depression (Kroenke & Spitzer, 2002). Both measures are designed to crudely measure depression, but cannot diagnose depression itself. While they tend to be highly effective at identifying athletes experiencing severe depression, underreporting of symptoms often results in a lack of treatment for those experiencing preliminary depressive symptoms. In addition, once an athlete is categorized in to lower risk thresholds using these scales at post-concussion, there is often no follow-up testing. Because of this, it is suggested that a more thorough evaluation of depression occur following concussions experienced by athletes (Busche & Alpern, 1998; Kroenke & Spitzer, 2002).

Goals of the Study

Additional research and preventative measures have certainly begun to provide a safer environment for professional and amateur sport, but unfortunately, concussions are inevitable. Because of this, depression following mTBI is inevitable as well. Progressive changes to helmets provide additional protection against severe TBI, but there is little evidence that helmets can prevent the rotational and acceleration forces that cause concussions (Noble & Hosdorffer, 2013).

Many current measures such as the Beck Depression Inventory-Fast Screen (BDI-FS) rely solely on self-report. Naturally, self-report measures can create biases and lead to inconsistent measurement. For example, athletes may not be aware of their feelings and therefore underreport their symptoms. Much like other post-concussion self-report measures, athletes may also tend to minimize reporting of symptoms due to incentives (Ramanathan, Rabinowitz, Barwick, & Arnett, 2012). Devotion to team, sport, and career often leads to poor performance and a lack of symptoms reporting during testing (Bailey, Echemendia & Arnett, 2006).

Instead, additional measures need to be developed to provide better prediction for depression following injury. The following research posits that by using negative affective memory bias, there can be successful evaluation of depressive symptoms to supplement self-report scales. Affective memory bias is defined as the tendency for individuals in negative moods to recall more negatively valenced information. Previous research using tests such as the Affective Word List (AWL) have shown that significant levels of negative bias are positively correlated with depressive symptom reporting. Still, using a single, objective measure will result in false-positive identification due to statistical randomness and transient distress in athletes lives on any particular day (Busch & Alpern, 1998). However, by creating additional objective measures for depression, there is a greater chance that those showing signs of depression will be identified and minimal false-positives will occur.

By using objective measures to predict and identify depression amongst athletes, further steps can be taken to provide safety for players who may not be emotionally stable. Perhaps most importantly, lifestyle changes and further care such as therapy and medication can be pursued prior to return to play in order to prevent further injury and permanent post-concussive depression (Ramanathan, Rabinowitz, Barwick & Arnett, 2012).

Many of the problems with current post-concussion depression testing lie in the difficulty predicting depression after TBI (Bombardier et. al., 2010). Still, it is undeniable that prevention of recurrent injury would significantly reduce the risk for post-concussive depression. For this reason, objective measures need to be developed and included as part of routine neuropsychological concussion testing.

Hypotheses

Hypothesis 1: There will be a correlation between the affective bias on the EWFT and subsequent BDI-FS scores reported at baseline testing.

Hypothesis 2: There will be a correlation between the affective bias on the EWFT and the subsequent AWL affective bias at baseline testing.

Hypothesis 3: There will be a correlation between the affective bias on the EWFT and the Post-Concussion Symptoms Scale score at baseline testing.

Materials and Methods

Participants

All participants for this study were collegiate athletes recruited through The Penn State Sports Concussion Neuropsychology Program. Prior to participating in university athletics, each participant was administered a baseline testing battery. Among this battery are various neuropsychological tests. While many tests aim to measure neurocognitive performance, others aim to identify symptomology and affective memory bias. When athletes experience a concussion, they undergo a post-concussion battery as well. In this study, however, only baseline data were used.

While a total of 889 athletes have participated in the program, specific criteria must have been met for inclusion. Athletes must have completed and had data available for the following tests: Emotional-Word Fluency Test, Affective Word List, Post-Concussion Symptoms Scale, and the Beck Depression Inventory Fast-Screen. Out of the 889 athletes, 160 participants were found eligible according to these criteria.

The 160 athletes (116m, 44f) participated in a variety of collegiate sports including: Football, Men's Soccer, Women's Soccer, Wrestling, Men's Lacrosse, Men's Ice Hockey, Women's Basketball, Men's Basketball, Rugby, and Women's Ice Hockey. The average age of those at baseline was 18.65 years (SD = 1.24) and education level average was 12.26 years (SD = 0.94). Additional characteristics of participants can be found in Table 1.

Table 1 Descriptive Measures of Participants Used in Study

Measure	Frequency	Percent (%)
Gender		
Male	116	72.5
Female	44	27.5
Athlete Sport		
Football	21	13.1
Men's Soccer	13	8.1
Women's Soccer	29	18.1
Wrestling	19	11.9
Men's Lacrosse	32	20.0
Men's Ice Hockey	15	9.4
Women's Basketball	11	6.9
Men's Basketball	16	10.0
Rugby	1	0.6
Women's Ice Hockey	2	1.3
Other	1	0.6
Ethnicity		
Caucasian American	112	70.0
African American	41	25.6
Hispanic American	1	0.6
Biracial or Multiracial	5	3.1
Other	1	0.6

Procedure

Subjects were administered a baseline concussion test battery prior to participating in athletics at Penn State University. The testing consists of various paper and pencil assessments as well as three computerized assessments for various neuropsychological measures. These tests were conducted by either undergraduate research assistants or graduate assistants both under the supervision of a clinical neuropsychologist. All assessments in the battery were given in identical order to the participants, in a private room designed for minimal visual and auditory distraction.

Measures

While each athlete was administered all of the neuropsychological tests in the battery, only four measures were used for the purpose of the present study. These measures are listed and described below.

Post-Concussion Symptom Scale

The Post-Concussion Symptom Scale (PCSS) is a self-report measure designed to identify and assess symptoms athletes may experience related to a concussion. Each symptom was rated by the athlete, on a scale of 0 to 6, where 0 is none and 6 is severe. The athletes were specifically asked to rate their symptoms depending on how they were feeling at that immediate moment, regardless of how they may have felt in the past.

Emotion Word Fluency Test

The Emotion Word Fluency Test (EWFT) is a timed test in which the athlete is asked to generate as many different emotion words as they can in one minute. The examiner times the athlete using a stopwatch, and records every word or phrase the athlete says. Later, the word list is examined and words are either categorized as "positive," "negative," or "non-emotion words." Categorizations were based solely on valence, and were reviewed by a separate researcher as a validity check. Totals for each category and affective bias were both calculated. Affective bias for the EWFT was calculated by subtracting the total number of negatively valenced words from the total number of positively valenced words generated by each participant

Affective Word List

The Affective Word List (AWL) is an untimed test in which the administrator reads off a list of words to the participant. Words were read at roughly a one-word per second pace. Once the administrator was finished reading the words, the athlete was asked to state each word they recalled from the list. Once finished, the examiner repeated the list two more times (for a total of three times), and each time totals were calculated in the same fashion. In addition, a delayed recall was conducted later on in the test session; for this study, however, only the first three administrations were used. The administrator wrote each word stated by the athlete, regardless of whether or not a word was found on the list. Only words from the list were counted toward the total, however. Each word has a positive or negative connotation, and equal amounts of positive and negatively valenced words were on the list. Total words recalled, total positively valenced words, and total negatively words were combined from all three tests and calculated. In addition, total affective bias was calculated by subtracting the total number of negatively valenced words from the total number of positively valenced words.

Beck Depression Inventory Fast-Screen

The Beck Depression Inventory Fast-Screen (BDI-FS) is a self-report measure commonly used to measure depression in medical patients. It consists of seven statements, rated 0 to 2, all related to clinical depression. The athlete was asked to circle the number next to the statement that applied best to how they were feeling over the past two weeks, including the day of testing. The total score is calculated by adding up the score of all seven statements.

Results

Overall, the EWFT bias score were significantly correlated with the AWL bias score ($r=0.16$, $p<0.05$). In addition, though not statistically significant, there was a positive relation between EWFT bias scores and BDI-FS scores as well ($r= -0.15$, $p<0.1$). Interestingly however, there was an unexpected positive trend between PCSS scores and EWFT bias scores. It should also be noted that overall, EWFT scores for the athletes tested showed a negative average in scores, indicating that, as a whole, participants generated more negative emotion words than positive emotion words on the EWFT ($x=-3.05$). Additional descriptive data for each test can be found in Table 2 and additional correlational data can be found in Table 3.

When dichotomizing BDI-FS scores using a score of two or greater as the depression group and 0 to 1 as the non-depressed group, there was no statistically significant difference between the mean EWFT scores of the groups. However, when dichotomizing EWFT scores using one standard deviation above the mean as the positive bias group and one standard deviation below the mean as the negative bias group, the groups were significantly different on the BDI-FS scores of the groups, if equal variance was assumed ($p < 0.05$, df=37). The mean BDI-FS score of those in the negative bias group was 2.8 whereas the mean score of the positive bias group was 0.9. Still, due to heterogeneity of variance between the groups, as indicted by the Levene's Test for Equality of Variances, degrees of freedom were adjusted accordingly. Upon doing this, the difference between the groups was reduced to a statistical trend ($p < 0.1$, df=16.92). Additional information can be found in Tables 4 and 5.

Additional comparisons were conducted between the non-depressed and depressed groups on the BDI-FS. Specifically, examining those who also fell in the positive and negative bias groups on the EWFT, 20 (67%) of those who scored in the non-depressed BDI-FS group also scored in the positive bias EWFT group. In comparison, only 10 (33%) of those who scored in the non-depressed BDI-FS group scored in the negative bias EWFT group. Of the 9 individuals who scored in the BDI-FS depressed group, 4 (44%) scored in the non-depressed EWFT group and 5 (55.6%) scored in the negative bias EWFT group. Statistical significance of the difference in group distribution, however, was not found (X^2=1.44, p=0.23). Additional Chi-square statistics can be found in Table 6.

Finally, a comparison was made between those who scored in the negative bias AWL bias group and those who scored in the positive bias AWL bias group. Of the 9 participants who fell in the positive bias group, 8 (88%) also scored in the positive bias EWFT group. Similarly, of the 6 participants who scored in the negative bias group 5 (83%) also scored in the negative bias EWFT group. Statistical significance of the difference in group distribution was found (X^2=7.82, p=0.005). Additional Chi-square statistics can be found in Table 7.

Table 2 Descriptive Statistics for Depression Predictor Tests in Collegiate Athletes

	Minimum	Maximum	Mean	Std. Deviation
EWFT Bias	-16	4	-3.05	1.87
AWL Bias	-7	7	0.42	3.09
BDI-FS Total	0	15	1.03	1.87
PCSS Total	0	74	6.08	9.84

Table 3 Correlational Statistics of Depression Measures and the EWFT

	Pearson Correlation	Significance (2-Tailed)
AWL Bias	0.16	0.04**
BDI-FS Total	-0.15	0.06*
PCSS Total	0.11	0.17

**. Correlation is significant at the 0.05 level
*. Correlation is significant at the 0.10 level

Table 4 t-Test for Difference in EWFT Score Means Between BDI-FS Groups

	N		Mean		Std. Deviation		Std. Error Mean		
Depressed Group	20		-3.35		3.53		0.79		
Non-Depressed Group	140		-3.01		2.89		0.24		
	Levene's Test		t-Test for Equality of Means						
								95% Confidence Interval of the Difference	
	F	Sig.	t	df	Sig.	Mean Difference	Std. Error Difference	Lower	Upper
Equal Variance Assumed	1.75	0.19	-0.48	158	0.63	-0.34	0.71	-1.748	1.062
Equal Variance Not Assumed			-0.42	22.8	0.68	-0.34	0.83	-2.052	1.367

Table 5 t-Test for Difference in BDI-FS Total Means Between EWFT Groups

	N		Mean		Std. Deviation		Std. Error Mean		
Depressed Group	15		2.80		3.84		0.99		
Non-Depressed Group	24		0.92		1.56		0.32		
	Levene's Test		t-Test for Equality of Means						
								95% Confidence Interval of the Difference	
	F	Sig.	t	df	Sig.	Mean Difference	Std. Error Difference	Lower	Upper
Equal Variance Assumed	4.890	0.033	2.15	37	0.038	1.88	0.88	0.10790	3.65877
Equal Variance Not Assumed			1.81	16.92	0.088	1.88	1.04	-0.31410	4.08076

Table 6 Chi-Square Crosstabulation Between BDI-FS and EWFT Bias Groups

			EWFT Groups		Total
			Positive Bias	Negative Bias	
BDI-FS Groups	Non-Depressed	N	20	10	30
		% within	66.6%	33.3%	
	Depressed	N	4	5	9
		% within	44.4%	55.6%	

Table 7 Chi-Square Crosstabulation Between AWL Bias and EWFT Bias groups

			EWFT Groups		Total
			Positive Bias	Negative Bias	
AWL Groups	Positive Bias	N	8	1	9
		% within	88.9%	11.1%	
	Negative Bias	N	1	5	5
		% within	16.7%	83.3%	

Discussion

The EWFT as a Measure of Affective Bias and Depression

This study aimed to validate the Emotion Word Fluency Test (EWFT) as a performance-based measure sensitive to depression. Overall, the results indicated that the EWFT was indeed related to depression. Offering support for the second proposed hypothesis, there was a significant correlation between EWFT scores of participants and their corresponding Affective Word List (AWL) scores. The AWL has been previously verified as a viable measure of affective bias in collegiate athletes by Ramanathan et al. (2012). Therefore, these results provide support for the Emotion Word Fluency Test as an effective measure of affective bias. When examining both positive and negative bias groups according to the EWFT and AWL scores, there is an even stronger significance. Unfortunately, the sample size for this aspect of the study was quite low, something that certainly could have affected the results. Still, these findings provide promising results and warrant future studies with larger sample sizes. While the correlation coefficient between the EWFT scores and the corresponding BDI-FS scores did not quite reach a correlation coefficient that reached traditional levels of statistical significance ($p < 0.05$), there was still a statistical trend between the two. As a result, while support for the first proposed hypothesis cannot be claimed, it does offer justification for future studies for validation purposes. Both the EWFT and AWL scores of participants were related to their BDI-FS scores, giving further support for the theory that those who display a negative affective bias are more likely to be depressed. Interestingly, there was not a very strong correlation between the EWFT affective bias scores of athletes and their subsequent Post-Concussion Symptom Scale (PCSS) scores. Still, this may be due to the fact that the PCSS measures a broader range of symptoms than just depression. Therefore, it may be more indicative of overall symptomology and less indicative of depression alone.

Limitations and Future Work

This research focused solely on collegiate athletes and, as a result, is only generalizable to those playing a sport in college. Additional research should focus on utilizing the Emotion Word Fluency Test to measure affective bias in individuals participating in sports at all levels; professional collegiate, and amateur. In addition, the sample contained a disproportionate amount of males, and additional samples consisting of a larger proportion of females would be beneficial. Also, this research focused solely on athletes' performance at baseline. By doing so, the relation between the scores on each test was consistent and easily comparable. As a result, it was possible to study the effectiveness of the Emotion Word Fluency Test as a measure of affective bias and as a measure of sensitivity to depression. Still, the results cannot be used as evidence to justify the use the Emotion Word Fluency Test as a means of measuring affective bias change following a concussion. To do this, baseline and post-concussion scores need to be collected and compared following concussion. Only then can the Emotion Word Fluency Test be used in a neuropsychological concussion testing battery as a means of identifying objective changes in affect following concussion. Future research should reflect this, and focus on comparing baseline and post-injury scores of athletes.

Implications

Current protocol advises athletes to be removed from play until they are symptom-free. Premature return to play greatly increases an athlete's risk of further injury and prolonged symptoms. Neuropsychological testing has provided examiners the ability to objectively measure neurocognitive performance. Alterations in memory, concentration, and processing speed are all easily identifiable using a battery of tests that have been validated as effective tools for the measurement of such performance. As a result, it is relatively easy to detect athletes who display these symptoms. Unfortunately, this is often not the case for psychological symptoms such as depression, irritability, and anxiety. Most of the current testing for these symptoms relies on self-report scales. This method of testing is subjective in nature, and may to lead to bias reflecting motives other than the measurement of depression. For example, athletes may find difficulty in identifying these symptoms, which makes it more difficult to report them to the examiner. Even more so, athletes often have ulterior motives for reporting their symptoms. Too often athletes are aware that by reporting their symptoms, they may be more likely to remain removed from play. In hopes of returning to their sport as soon as possible, they often underreport their symptoms.

Additional measures need to be created that allow examiners to objectively measure these symptoms. With regards to depression, an important method for doing so is through performance based affective bias measures. Those who present a more negative bias are also more likely to also be depressed. Therefore, by measuring affective bias, it may be possible to effectively identify depression by supplementing the use of self-report scales. The present research has provided evidence that the Emotion Word Fluency Test may be an effective measure of bias, as indicted by its significant correlation with the Affective Word List. Furthermore, it appears to be sensitive to self-reported depression as well, based on its statistical relation to the BDI-FS. Because both the AWL and EWFT explain a relatively low proportion of the variability of the results, it is necessary for additional affective bias measures to be created as well. By using more than one measure to test affective bias, a thorough identification of affective bias would be possible. This would be particularly useful in allowing concussion examiners to more effectively identify changes in affective bias following injury.

Conclusion

Currently, concussions are an inevitable occurrence in sports at every level of involvement. As additional safety measures begin to increase awareness and prevention of head injuries in sports, it is paramount that we effectively identify symptoms athletes may be suffering from before allowing them to return to play. This may be particularly important with regards to depression, due to high rate of mood disturbance and chronic suffering following injury. Psychology is at the forefront of developing such safety measures. As a result, it is the responsibility of researchers and clinicians to advance the knowledge and care for mild traumatic brain injuries.

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Undergraduate Research Assistant *University Park, PA*

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-Administered and scored neuropsychological testing battery
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Resident Assistant *University Park, PA*

Earth and Mineral Sciences Special Living Option *Fall 2014-Present*

-Oversee the well-being of thirty-seven residents
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Lifeguard and Swim Instructor *Hatfield, PA*

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-Head Lifeguard and instructor
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<u>Intern at SKILLS of Central Pennsylvania</u> *State College, PA*

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