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Effects of Gender and Concussion History on Depression Symptom Reporting

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## ABSTRACT

The effects of depression following sport-related concussions are a growing concern in medical and sports fields. To better screen for depression among collegiate athletes, analyses of pre-existing depression screening tools, the Beck Depression Inventory Fast-Screen (BDI-FS) and the affective symptom cluster of the Post-Concussion Symptom Scale (PCSS), are necessary. The effect of these two different neurocognitive depression screening tools on patterns of depression symptom ratings among collegiate athletes was analyzed by a 2 (Gender: Male, Female) x 2 (History of Diagnosed Concussions: No Previous Concussions,  $\geq 1$  Previous Concussions) between-participants factorial design, with a difference score between the BDI-FS scale and the affective cluster of the PCSS as the dependent variable. A total of 1057 Division I collegiate athletes took part in this study. Consistent with predictions, male collegiate athletes reported lower BDI-FS scores relative to PCSS affective scores compared to female collegiate athletes; collegiate athletes with no previous concussions reported greater symptoms of depression on the BDI-FS compared to the affective symptom cluster than those with previous concussions. In contrast to predictions, no interaction was found between Gender and History of Diagnosed Concussions. Discrepancies found between the two depression screening tools may be indicative of underreporting of depressive symptoms, particularly in collegiate athletes who are male and have had previous concussions. It is important to consider patterns of underreporting to ensure full and proper recovery of athletes for optimal health.

*Key words:* Sport-related concussion (SRC), Beck Depression Inventory Fast-Screen (BDI-FS), Post-Concussion Symptom Scale (PCSS), post-concussion, post-concussion symptoms, affective symptoms, depression, symptom underreporting, return-to-play, gender, concussion history

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## Chapter 1

### Introduction

Concussions are a form of mild traumatic brain injuries (mTBIs) that affect a great portion of the United States population. The vast majority of people affected by concussions are athletes. One of the most common mechanisms of mTBIs is sports, resulting in sport-related concussions. Past estimates have suggested that approximately 1.6 to 3.8 million sport-related concussions (SRCs) occur per year (Langlois et al., 2006). This subset of concussions is the second most common type of TBI among people between 15 to 24 years old (Gessel et al., 2007). More specifically, Gessel et al. (2007) found that SRC rates are particularly high among collegiate athletes. As participation in collegiate sports continues to rise, the prevalence of SRCs will increase as well. These concussions are thus significant clinical incidents within the sports medicine field that require additional attention.

Concussions can occur from a direct blow to the head or body, altering neurological functioning with or without loss of consciousness (McCrory et al., 2012). Symptoms may range from mild to severe across physical, cognitive, and emotional domains. Often times, SRCs are linked to mental health difficulties, most commonly depression (Rice et al., 2017). Post-concussion depression has a great effect on neurological functioning and overall quality of life. Collegiate athletes face an increased risk of sustaining a concussion, preventing return-to-play progression and minimum recovery time (Vargas et al., 2015). Due to the known relationship between SRCs and depression symptoms, analyses regarding diagnostic measures of depression are crucial for further advancement in SRC identification and treatment.

The presence of depression symptoms following SRCs is high. Previous studies have found a relationship between SRC and adverse neuropsychological defects, such as depression (Kontos et al., 2012). In this particular study, the relationship between depression symptoms and SRC among concussed

high school and collegiate athletes was examined. Male and female student-athletes were assessed on neuropsychological tests that measured neurocognitive performance and levels of depression at baseline, 2-, 7- and 14-days post-injury. The study found that levels of depression were statistically significant among concussed high school and collegiate athletes from baseline at 2 days and at 7 days (Kontos et al., 2012). Therefore, there were prolonged effects of depressive symptoms among high school and collegiate athletes following a concussion, signifying a relationship between sustained depression and SRC and the need for further analysis of this relationship.

The Beck Depression Inventory-Fast Screen (BDI-FS) is a widely used abbreviated version of the Beck Depression Inventory-II that screens for depression among various medical patients. The BDI-FS is described as a brief self-report measure of depression in the clinical field that includes the diagnostic criteria for depressive disorder outlined in the DSM-IV. The test measures seven items: sadness, hopelessness, feeling like a failure, anhedonia, self-esteem, self-blame, and suicidality. Systematic review of the BDI-FS for detecting depression in medical settings has been done, including clinics of cardiology, neurology, obstetrics, brain injury, nephrology, chronic pain, chronic fatigue, oncology, and infectious disease (Wang & Gorenstein, 2013). Through this study, the validity of the BDI-FS as a screening tool for depression symptoms among various types of patients was established.

Past work dealing with the BDI-FS has also provided analyses on this specific measure of depression and its relevance to the sport concussion field (Vargas et al., 2015). Researchers used the BDI-FS as a screening tool for depression among collegiate athletes at the pre-concussion and post-concussion levels. It was hypothesized that there would be higher levels of depression symptoms post-concussion than at baseline. Researchers used a BDI-FS score cut-off of 4 or higher to assess presence of clinical depression among athletes. Using the BDI-FS, Vargas and colleagues (2015) were able to find an increase in depression following concussion in collegiate athletes. The BDI-FS has thus become an important depression screening tool used to assess levels of depression in not only medical patients, but also concussed athletes.



Due to the relevance of depressive symptoms following SRCs, new methods of depression measures should be analyzed to better identify depression to treat concussed athletes in an appropriate manner. The effectiveness of the affective symptom cluster of the Post-Concussion Symptom Scale (PCSS) has been evaluated in its ability to diagnose depression following SRCs. The PCSS is a self-report measure that asks participants to score feelings of cognitive, physical, affective, and sleep post-concussion symptoms on a 7-point Likert scale (0 being none and 6 being severe). The PCSS does not directly measure depressive symptoms, but rather a wide variety of post-concussion symptoms that may indicate severity of SRCs. However, the PCSS contains an affective symptom cluster that can be used to screen for levels of depression among concussed athletes.

Past research has explored the validity of the affective symptom cluster of the PCSS as a screening method for depression (Riegler et al., 2018). This study discusses the potential relationship between the affective symptom cluster of the PCSS and the BDI-FS, and how both can be used to screen post-concussion depression. The affective symptom cluster includes post-concussion symptoms related to mood, including irritability, nervousness, sadness, and feeling more emotional. It is addressed that although these two diagnostic tests exist, the use of the affective symptom cluster of the PCSS as a formal screening for depression in the sport concussion field is uncommon. The article reiterates the need to correlate the two tests in order to verify the validity of using the PCSS affective symptom cluster as a depression screening tool for concussed athletes. Riegler and colleagues (2018) found higher levels of correlation between the affective symptom cluster of the PCSS and the BDI-FS, and lower levels of correlation between the three other symptom clusters (cognitive, physical, and sleep) of the PCSS and the BDI-FS. Since results indicate both the PCSS affective symptom cluster and the BDI-FS are valid measures of depression symptoms for sport concussions, these tools can be used to determine patterns of underreporting of depression symptoms among collegiate athletes, in terms of gender and concussion history.

To determine the optimal cutoff of depression for the affective symptom cluster of the PCSS, one study analyzed its 85th, 90th, and 95th percentile for both males and females (Riegler et al., 2018). The percentiles were examined based on gender, as past literature has shown that females tend to report more symptoms than males during post-concussion diagnostic testing. Male athletes are less likely to disclose their symptoms, which may be indicative of underreporting of post-concussion depression symptoms compared to that of female athletes. The best classification values indicative of clinical depression for males and females were seen at the 90th percentile of the affective symptom cluster of the PCSS. The 90<sup>th</sup> percentile cut-off of the affective symptom cluster of the PCSS will be used for this study.

The presence of sex differences has been analyzed in the sport related concussion literature. Merritt and colleagues (2019) found sex differences in post-concussion neurological functioning by assessing measures of cognition in terms of mean performance, number of impaired scores, and intra-individual variability (IIV). Results were indicative of sex differences in neurocognitive summary scores, as females showed more impairment and inconsistencies in performance when taking the neuropsychological battery. Contrary to past findings, there were not any sex differences in mean performance on neurocognitive variables after adjusting for time since injury and post-concussive symptoms. However, this may have occurred because a sample of male and female collegiate athletes with similar demographics (age, school, level of education) was used, limiting the study (Merritt et al., 2019). The need for further analysis of the impacts of gender differences in the field of sport concussion is emphasized.

For this specific study, the variable of history of diagnosed concussions will be dichotomized as no previous diagnosed concussions and one or more previous diagnosed concussions. Analysis of the effects of the lack or presence of past concussions will be conducted. It is important to consider concussion history, as experience with concussion testing can skew results due to prior knowledge of the test battery. A history of diagnosed concussions could also familiarize athletes with desire to return-to-play as soon as possible. Studies have shown that athletes tend to underreport post-concussion symptoms

due to an increased motivation to return-to-play (Echemendia & Cantu, 2003). To see whether presence of previous diagnosed concussions has an effect on patterns of underreporting of depressive symptoms for faster return-to-play options, additional analysis is thus needed.

The affective symptom cluster of the PCSS may serve as a depression screening tool with less face valid measures since its post-concussion symptoms associated with the affective cluster are intermixed with post-concussion symptoms related to cognition, physical difficulties, and sleep. The PCSS could allow for a more representative screening of depression symptoms than the more obvious BDI-FS that tests for depression symptoms only. Collegiate athletes taking the BDI-FS will clearly know what this test is measuring based on the seven items all related to symptoms of depression only. Therefore, a greater chance is more likely for underreporting of depression with the BDI-FS than the affective PCSS.

### **Hypotheses and Proposed Research**

This study will compare the patterns of depression symptom ratings between the BDI-FS and the affective symptom cluster of the PCSS among male and female collegiate athletes, as well as collegiate athletes with a lack or presence of past diagnosed concussions. Evaluation of underreporting of depression symptoms based on differences in standard scores of the BDI-FS and the affective PCSS will be conducted. It is hypothesized that 1) male collegiate athletes will report lower BDI-FS scores relative to affective scale scores compared to female collegiate athletes; 2) collegiate athletes with no history of diagnosed concussions will report higher BDI-FS scores relative to affective scale scores compared to those with a history of diagnosed concussions; and 3) there will be a significant interaction between sex and history of diagnosed concussions, such that male collegiate athletes with a history of concussions will have the greatest discrepancy between BDI-FS scores relative to affective scale scores. Furthermore,

female collegiate athletes with no history of concussions will have the smallest discrepancy between BDI-FS scores relative to affective scale scores.

Differences in depression symptom scores among collegiate athletes may be the result of an increased sensitivity of the affective symptom cluster of the PCSS, evident in its more representative method of screening. Greater differences in scores between the BDI-FS and the affective symptoms cluster of the PCSS may indicate patterns of symptom underreporting, as collegiate athletes will better be able to discern that depression symptoms are specifically being measured by the BDI-FS compared to affective items embedded within the larger PCSS scale. Recognition of the purpose of each scale is important since this may allow collegiate athletes to intentionally underreport their depressive symptoms based on history of concussions and sex. Similar scores between the two depressive symptom scales would indicate a lack of symptom underreporting among collegiate athletes. This will signify that both the BDI-FS and the affect PCSS equally measure depressive symptoms among collegiate athletes, despite differences in history of concussions and sex. In this case, both scales could be considered sensitive measures and thus representative methods of screening for symptoms of depression among collegiate athletes.

## **Chapter 2**

### **Method**

#### **Design**

This study involved a 2 (Gender: Male, Female) x 2 (History of Diagnosed Concussions: No Previous Concussions,  $\geq 1$  Previous Concussions) between-participants Analysis of Variance (ANOVA) design with a difference score between the BDI-FS scale and the affect PCSS scale as the dependent variable.

## Participants

Participants were 1057 Division I collegiate athletes (785 men and 272 women) involved in a concussion management program at The Pennsylvania State University. The mean age of the participants was 18.6 years ( $SD = 1.12$ ), ranging from 17 to 24 years old. Student-athletes were primarily Caucasian (74.5%). Table 1 indicates the frequencies and percentages of additional ethnicities within the sample population. Varsity athletes were referred to the program by team physicians following a sport-related concussion. Diagnoses of concussions were based on presence of post-concussion amnesia, loss of consciousness, or any other physical or mental post-concussion symptoms after the injury. Sports within the program included: football, wrestling, men's and women's basketball, men's and women's lacrosse, men's and women's soccer, men's and women's ice hockey, baseball, softball, swimming and diving, golf, cheerleading, crew, tennis, track and field, and volleyball. Participants were assessed a concussion test battery, consisting of differing neuropsychological tests and questionnaires.

Eligible participants were those who had completed both the BDI-FS and the PCSS screening tools at baseline. Athletes were further analyzed based on their BDI-FS total score and their affective symptom cluster of the PCSS total score. For each of these depression screening tests, athletes were examined based on their gender (male or female) and history of diagnosed concussion (no history of concussion or history of concussion). The mean level of depression in each of the two groups (gender and history of diagnosed concussion) was evaluated. Athletes with baseline ImPACT impulse control composite performance (ICCs)  $\geq 30$  were also considered ineligible for data analyses, as ImPACT ICC  $\geq 30$  often indicates invalid data. Subjects were deidentified for analyses purposes.

## Measures

### *Depression Screening Tools*

**BDI-FS.** The Beck Depression Inventory-Fast Screen (BDI-FS) is a brief self-report measure of depression used in the clinical field. The screening tool includes the diagnostic criteria for depressive disorder outlined in the DSM-IV. It measures seven items: sadness, hopelessness, feeling like a failure, anhedonia, self-esteem, self-blame, and suicidality. The BDI-FS is commonly used to screen for depressive symptoms among athletes. The athlete will be asked to rate each item on a scale of 0-4 (0 being the least severe measure and 4 being the most severe measure). A final score measuring the level of post-concussion depression among concussed athletes will be calculated by adding up the scores from the seven questions. Past studies have shown that a BDI-FS score of 4 or higher is indicative of clinical depression (Vargas et al., 2015). Refer to Appendix A for a sample of the BDI-FS test.

**Affective Symptom Cluster of PCSS.** The Post-Concussion Symptom Scale (PCSS) is a self-report test that asks participants to rate cognitive, physical, affective, and sleep post-concussion symptoms on a 7-point Likert scale (0 being none and 6 being severe) based on severity of symptoms at that moment. A total of 22 symptoms related to feelings of cognitive, physical, affective, and sleep are included in the PCSS. Refer to Appendix B for a sample of the PCSS test.

This study specifically used the affective symptom cluster of the PCSS. The affective symptom cluster includes post-concussion symptoms related to mood, including irritability, nervousness, sadness, and feeling more emotional. The affective symptom cluster of the PCSS serve as a second measure of post-concussion depression symptoms for the collegiate athletes of this study.

**Difference score.** Standard Scores for the BDI-FS total score and the PCSS Affective Symptom Cluster score were calculated in order to create a difference score between the BDI-FS and the PCSS Affective Symptom Cluster. The difference score between the two standard scores of the BDI-FS and the affective PCSS was intended to measure potential discrepancy between BDI-FS scores relative to affective PCSS scores. Discrepancy between the two depressive screening tools is indicative of differences in symptom reporting patterns between the two tests. A positive difference score denotes

relatively higher BDI-FS scores, while a negative difference score denotes a relatively higher affective PCSS scores. This difference score served as the outcome variable.

## **Procedures**

The Sports-Concussion Program at The Pennsylvania State University is based on the “Sports as a Laboratory Assessment Model (SLAM)” model (Baily et al., 2009). Participants completed a three-hour neuropsychological battery that included the BDI-FS and affective symptom cluster of the PCSS measure. The test battery consisted of paper-and-pencil assessments as well as computerized tasks. The neuropsychological tests were administered by trained graduate or undergraduate students under the supervision of a clinical neuropsychologist. Informed consent was obtained from all participants of the study.

## **Chapter 3**

### **Results and Data Analyses**

All analyses were conducted using the Statistical Package for the Social Sciences (SPSS), Version 27.0. An ANOVA was conducted to examine the effect of gender and history of diagnosed concussions of collegiate athletes on patterns of symptom reporting between two different depression screening tools. This study employed a 2 (Gender: Male, Female) x 2 (History of Diagnosed Concussions: No Previous Concussions,  $\geq 1$  Previous Concussions) between-participants factorial design, with a difference score between the BDI-FS scale and the affect PCSS scale as the dependent variable. Following analyses using SPSS, the effect of sex and history of diagnosed concussions in collegiate athletes on differences in standard scores of the BDI-FS and the affect PCSS were compared.

Consistent with hypotheses, results indicated a main effect of gender on the difference score between the BDI-FS and the PCSS affective symptom cluster. Specifically, male collegiate athletes (mean =  $-.73$ ,  $SD = 14.65$ ) had lower BDI-FS scores compared to PCSS affective scale scores than female collegiate athletes (mean =  $1.75$ ,  $SD = 14.81$ ) ( $F(1,894) = 4.01$ ,  $p = .046$ ,  $\eta^2 = 0.004$ ). See Table 2 for ANOVA results.

Also consistent with predictions, there was a main effect of history of diagnosed concussions on the difference score between the BDI-FS and the PCSS affective symptom cluster, such that collegiate athletes with no previous concussions (mean =  $.93$ ,  $SD = 14.34$ ) reported greater symptoms of depression on the BDI-FS compared to the affective symptom cluster than those with previous concussions (mean =  $-1.63$ ,  $SD = 15.18$ ) ( $F(1,894) = 4.69$ ,  $p = .031$ ,  $\eta^2 = 0.005$ ). See Table 2 for ANOVA results.

Inconsistent with predictions, there was no significant interaction between gender and history of diagnosed concussions among the collegiate athletes ( $p > .05$ ). See Figure 1 for a visual representation of the key findings.

## **Chapter 4**

### **Discussion**

The goal of this study was to evaluate differences in depression symptom reporting of the BDI-FS and affective cluster of the PCSS among collegiate athletes in terms of gender and history of concussion. Differences in depression symptom reporting between the two screening tools may be indicative of underreporting of depression symptoms among concussed student-athletes. Prior research has shown correlation between the affective symptom cluster of the PCSS and the BDI-FS depression diagnostic test. The present study aimed to use the affective symptom cluster of the PCSS as a depression screening tool alongside the BDI-FS for comparison and evaluation among collegiate athletes. Greater discrepancy between the depressive symptom standard scores of the BDI-FS and the affect PCSS might indicate the



need for caution when using these tools as diagnostic measures of depression among collegiate athletes with differences in sex and history of concussions.

Consistent with hypotheses, results indicated that male collegiate athletes reported lower BDI-FS scores relative to PCSS affective scores compared to female collegiate athletes. This relationship was predicted because the BDI-FS screening tool was viewed as a much more obvious diagnostic measure of depression. Since the BDI-FS clearly screens for depressive symptoms, collegiate athletes, especially males, were hypothesized to be more likely to indicate lower levels of depression relative to the less face valid PCSS affective scale, highlighting the possibility of underreporting of depressive symptoms. Gender often plays a significant role in symptom reporting, as males may be less likely to truthfully report their symptoms. Knowing this, male collegiate athletes might indicate lower BDI-FS scores than female collegiate athletes because of known differences in patterns of depression symptom reporting based on gender. Male collegiate athletes may consequently have increased motivation to underreport their depressive symptoms using the BDI-FS as it clearly measures for depression. On the other hand, the PCSS affective scale is a less obvious and face valid index of depression. This screening tool measures not only depression in SRCs, but also many other post-concussion symptoms, with affective items embedded among these other items as well. Student-athletes might thus be more likely to accurately report true indications of depressive symptoms using the PCSS, as it is less clear that the test specifically screens for depression. Male student-athletes were thus expected to report higher depressive symptoms on the affective symptom cluster of the PCSS compared to the BDI-FS than female student-athletes. The results of this study supported this hypothesis, as shown with the significant main effect of gender on the difference score between BDI-FS and the affective symptom cluster of the PCSS.

Regarding history of diagnosed concussions and differences in symptom reporting between the BDI-FS and the affect PCSS, it was predicted that collegiate athletes with one or more past concussions would score lower on the BDI-FS than the PCSS affective scale compared with those with no past concussions. This hypothesis was derived based on the conceptualization that student-athletes with

previous concussion history might be more familiar with concussion battery tests and the need to return-to-play as soon as possible. Therefore, it was predicted that these athletes might be more likely to underreport their symptoms of depression when an obviously face valid measure of depression like the BDI-FS was used. In contrast, student-athletes might be more likely to report true indications of depressive symptoms on the PCSS affective scale, as it is less obviously specifically screening for depression. Athletes with past diagnosed concussions may show lower scores of depressive symptoms on the more obvious BDI-FS screening measure than on the less obvious affect PCSS screening measure in order to quickly return-to-play and pursue athletic endeavors. In this way, compared to athletes without a history of diagnosed concussions, collegiate athletes with a history of diagnosed concussions were expected to show patterns of underreporting of depression with lower scores on the BDI-FS compared to the affective symptom cluster of the PCSS. Results supported this specific hypothesis, as there was a significant main effect of history of diagnosed concussions on the difference score between BDI-FS and the affect PCSS screening tools.

Discrepancies between the main effects of gender and history of diagnosed concussions on the BDI-FS and the affect PCSS would denote differences in depression symptom scores in a single collegiate athlete. High differences in depression symptom scores seen in the BDI-FS and the affect PCSS might be indicative of underreporting of depressive symptoms regarding gender and history of diagnosed concussions. It was thus predicted that patterns of underreporting would be most evident among male collegiate athletes who had one or more diagnosed concussions in the past. However, results did not indicate a significant interaction between gender and history of concussion on the difference score between the BDI-FS and the affective cluster of the PCSS.

Previous studies have reported that the rate of depression in women is 1.5–3 times higher than that in men (Kessler, 2003). This gender difference in depression among the general population serves as a potential threat to the validity of collegiate athlete sex differences in screening for depression post-concussion. Female athletes may thus have higher BDI-FS scores because they are more likely to have

depression in general. Male collegiate athletes may not necessarily have lower scores in the BDI-FS due to underreporting, but because they are less likely to have depression compared to females in general. However, past studies have shown that female athletes are much more likely to report post-concussion symptoms than male athletes (Miyashita et al., 2016). The results of the present study suggest that male athletes may have lower ratings on depression measures like the BDI-FS due to patterns of symptom underreporting.

In addition, it is also possible that prior concussion history could have some impact on participants' current mood status so, alternatively, it may be that those with prior concussions will report greater depressed mood (Price et al, 2019). Considering this possibility sets up two competing hypotheses. Previous concussions may cause prolonged neurological deficits, increasing severity of post-concussion symptoms, including depression. Despite this possible threat to the validity of testing history of diagnosed concussions in collegiate athletes as a variable of this study, athletes as well as coaches remain very motivated to implement return-to-play as soon as possible, thus potentially influencing patterns of symptom underreporting (Echemendia & Cantu, 2003). Past concussions may familiarize athletes with this process, making history of diagnosed concussions an important and valid variable to consider for underreporting of post-concussion depression symptoms.

This study had some limitations. First, it involved a small sample of female collegiate athletes ( $N = 272$ ) compared to males ( $N = 785$ ). A small sample size of female student-athletes may thus limit the generalizability of the results to the female collegiate athlete population to some degree. With that said, although the sample size for females was smaller relative to males, it was still relatively large, with over 250 participants.

Additionally, this study involved only Division I athletes at The Pennsylvania State University. This limits the sample to a very selective type of athletes. Therefore, the results of this study may not necessarily generalize to collegiate athletes at Division II or Division III Universities. Caution is needed when generalizing these results to other types of concussions, such as those received in the work place or

in motor vehicle accidents. Nevertheless, the Sports-Concussion Program at The Pennsylvania State University is a long-standing program that involves a variety of different collegiate-level sports and athletes. Many different types of students are tested, as demographics vary. A wide range of student-athlete participants are thus tested, helping with the external validity of conducted studies.

Data from the study was also based on self-reporting measures of depression symptoms. Self-reporting scales of depression symptoms may be subjective and thus lead to biased or inaccurate results compared to clinical assessments. It is important to consider this limitation, even though the BDI-FS has shown very high correlations with clinical identification of depressive symptoms.

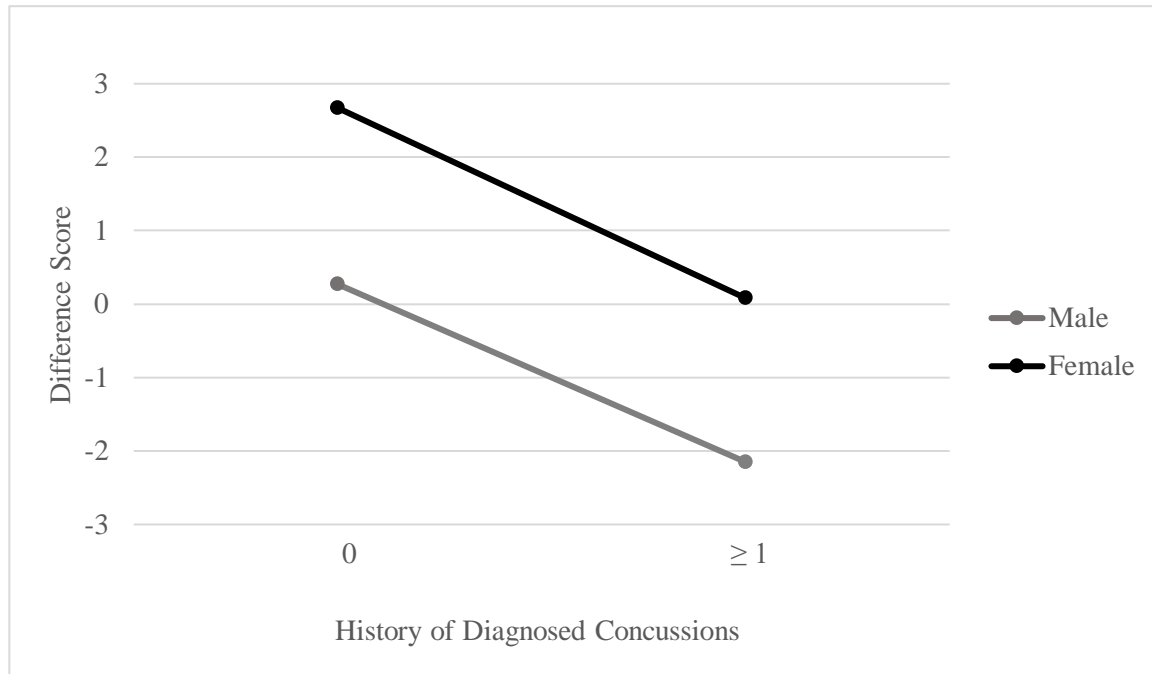
Further analyses are necessary and highly recommended. Constructive replication of the study may be done. Additional exploratory variables should be considered, such as the effect of contact sports vs. non-contact sports, other physical injuries, and the non-athlete population vs. athlete population. The effect these additional variables may have on underreporting in depression symptoms seen in the BDI-FS and affect PCSS can be analyzed to clarify the present findings. These results can be used to compare the efficiency in diagnostic abilities between the two clinical assessments. Instead of evaluating underreporting in depression symptoms, future studies should also look at underreporting in neurocognitive symptoms as well.

Depression is a highly prevalent and common post-concussion symptom seen in various athletes, including collegiate-level sport athletes. Often times, symptoms of depression among student-athletes go undiagnosed, leading to premature return-to-play decisions and prevention of full health recovery. Appropriate understanding and use of depression screening tools are vital for correct diagnoses and treatments of athletes with sport-related concussions. Increased specificity of the affective symptom cluster of the PCSS, especially with males and those with a history of past concussions, could lead to more accurate screening of depression in these athletes. A more representative, accurate depression screening tool provides healthcare providers with the best recovery and return-to-play protocols to prevent dangerous accumulation of post-concussion symptoms in athletes. Ultimately, the use of less

obvious depression indices such as the PCSS affective scale could prevent premature return-to-play decision, as early return to play can worsen post-concussion symptoms and overall health if done too soon. Presence of underreporting in depression symptoms following an SRC is important to identify, and the results of this study show that this may be circumvented, in part, by employing measures such as the PCSS affective scale, especially with males and those with a history of prior concussions.

**Figure 1**

*Interaction between History of Diagnosed Concussions and Gender on Difference Score between the BDI-FS and the Affective Cluster of the PCSS*



*Note.* This figure demonstrated the interaction effects between history of diagnosed concussions (no previous concussion (0) and previous concussions ( $\geq 1$ )) and gender (male and female) on the difference score between the BDI-FS and affective symptom cluster of the PCSS tests.

**Table 1***Frequency and Percentage of Ethnicities in the Sample Population*

Ethnicity	n	%
Caucasian American	787	74.5
African American	196	18.5
Hispanic American	12	1.1
Asian American	12	1.1
Biracial or Multiracial	30	2.8
Other	13	1.2
Caucasian-European	4	.4
Latin American	3	.3
Total	1057	100.0

**Table 2**

*ANOVA Results using the Difference Score between the BDI-FS and the Affective Cluster of the PCSS as the Criterion*

Predictor	df	F	p	Partial $\eta^2$
Intercept	1	0.143	.706	.000
History of Concussion	1	4.69*	.031	.005
Gender	1	4.01*	.046	.004
History of Concussion * Gender	1	0.01	.942	.000
Error	894			

\*p &lt; .05

## Appendix A

### BDI-FS Screening Tool

#### *Sample of Beck Depression Inventory-Fast Screen Test*

This questionnaire consists of groups of statements. Please read each group of statements carefully, then pick out the one statement in each group which best describes the way you have been feeling during the past 2 weeks, including today. Circle the number beside the statement you picked. If several statements in the group seem to apply equally well, circle the statement which has the largest number.

1.
  - 0 I do not feel sad.
  - 1 I feel sad much of the time.
  - 2 I am sad all the time.
  - 3 I am so sad or unhappy that I can't stand it.
2.
  - 0 I am not discouraged about my future.
  - 1 I feel more discouraged about my future than I used to be.
  - 2 I do not expect things to work out for me.
  - 3 I feel my future is hopeless and will only get worse.
3.
  - 0 I do not feel like a failure.
  - 1 I have failed more than I should have.
  - 2 As I look back, I see a lot of failures.
  - 3 I feel I am a total failure as a person.
4.
  - 0 I get as much pleasure as I ever did from the things I enjoy.
  - 1 I don't enjoy things as much as I used to.
  - 2 I get very little pleasures from the things I used to enjoy.
  - 3 I can't get any pleasure from the things I used to enjoy.
5.
  - 0 I feel the same about myself as ever.
  - 1 I have lost confidence in myself.
  - 2 I am disappointed in myself.
  - 3 I dislike myself.
6.
  - 0 I don't blame or criticize myself more than usual.
  - 1 I am more critical of myself than I used to be.
  - 2 I criticize myself for all my faults.
  - 3 I blame myself for everything bad that happens.
7.
  - 0 I don't have any thoughts of killing myself.
  - 1 I have thoughts of killing myself, but I would not carry them out.
  - 2 I would like to kill myself.
  - 3 I would kill myself if I had the chance.

\_\_\_ TOTAL



## Appendix B

### PCSS Screening Tool

#### *Sample of Post-Concussion Symptom Scale Test*

This form lists symptoms that people sometimes have. On a scale of 0 to 6, where 0 is none and 6 is severe, please rate the extent to which you are experiencing each symptom right now.

None
Rating
Severe  
0      1      2      3      4      5      6  
Moderate

SYMPTOMS	RATING
Dizziness	
Headache	
Nausea	
Vomiting	
Balance problems	
Trouble falling asleep	
Sleeping more than usual	
Drowsiness	
Low energy	
Sensitivity to light	
Sensitivity to noise	
More emotional than usual	
Irritability	
Sadness	
Nervous/anxious	
Numbness or tingling	
Feeling slowed down	
Feeling as though "in a fog"	
Feeling "pressure" in the head	
Difficulty concentrating	
Difficulty remembering	
Other	
<b>TOTAL SCORE</b>	

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## ACADEMIC VITA

### EDUCATION

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**The Pennsylvania State University | The Schreyer Honors College** **University Park, PA**  
*College of Liberal Arts | Eberly College of Science*  
*Anticipated: May 2021*  
Intended Major: Bachelor of Science in Psychology – Neuroscience Focus (Pre-Med Track)  
Intended Minor: Natural Science

### PROFESSIONAL EXPERIENCE

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**Yuoung Sang Summer School Teacher** **Horsham, PA**  
*Grade School English Teacher* *July 2019-August 2019*

- Facilitated instruction of the 3<sup>rd</sup>, 4<sup>th</sup>, and 5<sup>th</sup> grade English curriculum (Language Arts and Reading Comprehension) to children of ages 8-10 years old in preparation for the upcoming school year
- Mediated any conflicts among children and redirected inappropriate behaviors accordingly

**The Hospital of the University of Pennsylvania**

**Cardiovascular Prevention Research** **Philadelphia, PA**  
*Student Research Writer/Assistant* *July 2018 – September 2018*

- Gathered research about the benefits of lifestyle changes in regards to cardiovascular disease prevention
- Distributed collected research to patients in the form of patient educational outreach (pamphlet writings)
- Collaborated with additional cardiologists to work to further research findings into a formal review

**The Hospital of the University of Pennsylvania Summer Observation** **Philadelphia, PA**  
*Student Clinical Volunteer/Observer* *May 2018 – July 2018*

- Job shadowed multiple medical professionals in the Cardiovascular Prevention department at Penn Hospitals
- Witnessed professional interaction between doctors, nurse practitioners, and patients
- Enhanced own knowledge regarding clinical, cardiovascular-related tasks (EKG readings, CAT Scan interpretations, blood pressure measurements, and stethoscope listening)

### LEADERSHIP EXPERIENCE

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**Chemistry 202 & 210 LA** **University Park, PA**  
*Learning Assistant for Fundamentals of Organic Chemistry I & Organic Chemistry I* *January 2020 – Present*

- Assisted students with any questions or concerns regarding organic chemistry, specifically in relation to homework problems, test preparation, in-class lectures, and other course material during lectures and office hours
- Attended weekly meetings discussing methods to enhance students' understanding of organic chemistry

**Dr. Peter Arnett's Sports Concussion Lab RA** **University Park, PA**  
*Undergraduate Research Assistant* *August 2018 – Present*

- Administered concussion test batteries to various D1 athletes as well as the baseline student population

- Checked, entered, labeled, and filed lab's data (concussion test results) using Excel and IBM SPSS
- Scored a plethora of concussion-based tests within the lab's neuropsychological testing battery

**Chemistry 110B LA**

**University Park, PA**

*Learning Assistant for Introductory Chemistry with Biological Focuses August 2018 – December 2019*

- Aided students in fully understanding the course's material of introductory chemistry with biological aspects by answering questions, assisting with homework, and holding additional office hours
- Helped plan different learning approaches and strategies for current students in the class to improve scores

**HONORS/SKILLS**

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- **Honors:** T. Levendusky Honors Scholarship (Jan '20-May '20), Dean's List (Jan '18-present), Schreyer Academic Excellence Scholarship (Sep '17-present), Tsui Honors Scholarship (Sep '17-May '19)
- **Skills:** Advanced in Microsoft Office, Excel, PowerPoint, Google Drive, and Internet  
Proficient in Spanish; Proficient in Korean; Advanced in English
- **Other Involvements:** Liberal Arts Ambassador (Aug '19-present), Christian Medical & Dental Association (Aug '19-present), Asian American Christian Fellowship Member (Aug '19-present), NEXUS (Network of Excellence in Undergraduate Science) Student Leader (Aug '18-present), Wegmans Front End Cashier (April '20-present), Yuoung Sang Summer School Teacher Assistant (Jul '17-Aug '18)