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How Anxiety in Adolescent Athletes May Affect Baseline Neuropsychological Test Scores

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HOW ANXIETY IN ADOLESCENT ATHLETES MAY AFFECT BASELINE NEUROPSYCHOLOGICAL TEST SCORES

by

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ABSTRACT

Background: Anxiety is highly prevalent in the adolescent population and can affect performance on cognitive tasks. As part of a concussion protocol, measuring cognitive ability through the use of baseline neuropsychological testing is recommended in the high school setting. Because of the cognitive nature of baseline testing, there is potential for anxiety to influence scores. **Purpose**: To examine the effects of varying levels of state and trait anxiety on a baseline computerized neurocognitive assessment in the adolescent population. **Methods**: 75 adolescent athletes (age:15.91±1.33, height (cm): 168.72±9.07, weight (kg): 62.97±12.04) participated in the study. Cognitive ability was measured utilizing the Immediate Post-Concussion Assessment and Cognitive Test (ImPACT), while the anxiety screen utilized was the State Trait Anxiety Inventory. Data collection took place during preseason, and measures were administered within five minutes of each other. Participants were split into high and low groups based upon their level of state and trait anxiety. **Statistical Analyses:** Descriptive statistics were run on all demographic variables and outcome measures. Two one-way ANOVAs were conducted to compare ImPACT composite scores across high and low anxiety groups. **Results:** Significant differences were found between the high and low state anxiety groups for reaction time (LS 0.60±0.10, HS 0.69±0.09, $F_{(1, 73)} = 6.28$, p =.01, r = -0.43, Cohen's d = -0.95). No significant differences were found between the state and trait anxiety groups for any other composite score ($p > 0.05$). **Summary:** Adolescent athletes consistently perceive situations as stressful, and those in the high state anxiety group have slower reaction times during baseline concussion assessment. Concussion is highly covered in media leading to a change in public perception and awareness. This heightened awareness potentially creates an environment where adolescent athletes do not assess baseline testing as stressful, thereby reducing the overall effect of anxiety on performance. The current concussion paradigm places substantial weight on neuropsychological testing, however post-injury testing may be more stress provoking. Therefore, future research should examine how anxiety affects the post-injury examination.

INDEX WORDS: State anxiety, Trait anxiety, Concussion, Cognitive testing, High school

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by

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DEDICATION

I would like to dedicate this thesis to Audrey Krause-Dickman, ATC. Without her guidance and inspiration, I would have never found the intense and wonderful profession of athletic training. Thank you for being a valued mentor, but more importantly an irreplaceable friend.

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CHAPTER 1

INTRODUCTION

Anxiety is the most prevalent mental disorder in the United States to date, specifically effecting 31.9% of adolescents.[1] A disorder that affects such a large percentage of the adolescent population, it is prudent to explore the impacts on various aspects of health. Anxiety is often defined as a negative emotional state characterized by the variant manifestation of both physiological and/or psychological symptoms.[2,3] Cognitive symptoms are psychological in nature and influence the mental state of the person and include feelings of worry, apprehension, and self-doubt.[4] Conversely, somatic symptoms are physiological in nature and can include nausea, muscle tremors, and 'butterflies'.[4] The manifestation of cognitive and somatic symptoms is directly influenced by two variable-based factors of anxiety.

State anxiety and trait anxiety are two factors that dictate the frequency, manifestation, and severity of emotional responses to external stimuli. These factors have unique aspects that determine their role in the anxiety response and are derived from multiple anxiety-based variables.[5] State anxiety can be classified as the conscious transitional emotional state that is depicted by the manifestation of symptoms (cognitive and/or somatic).[6] In other words, state anxiety describes the ever-changing emotional states and are direct expressions of personality states.[5,6] This component of anxiety is primarily situational, but it can also be influenced by trait anxiety.

Trait anxiety is the aspect of personality that dictates if a person will perceive a wide range of situations as stressful.[6] Being rooted in personality makes trait anxiety a stable construct that will have an impact on almost every encounter an adolescent has with their external environment. Due to its constant presence, trait anxiety has partial control over the level of presenting state anxiety, thereby influencing the frequency and severity of state anxiety responses.[2,6] It is clear that anxiety will always play a role in the interpretation of the external world, and it is important to understand how this may affect tasks.

Various studies have identified that the distribution of mental resources as the link to performance detriments on cognitive tasks.[7–11] Anxiety can have an overriding effect on the distribution of mental resources due to athlete self-preoccupation. The cognitive-attentional view states that worry anxiety symptoms will decrease performance by causing an interference in attentional capacity.[8–10] The attentional systems of adolescents can be hypersensitive to stressful stimuli and in response redirect mental resources to self-relevant variables instead of promoting full concentration to task-relevant variables.[10,12] Additionally, capacity sharing postulates that the brain processes share capacity (mental resources). When a person is performing more than one task, utilizing multiple cognitive systems, and/or high level of difficulty there is less capacity for each individual task and thus performance is impaired.[11] As a result, this division of resources decreases an adolescent's cognitive capacity, with a resulting negative consequence on performance. However, performance may not always be negatively affected, there are some instances where anxiety may have a positive effect.[13] The dynamic influence that anxiety has on cognition may lead to complications in assessing injuries that involve cognitive testing.

The Center for Disease Control has labeled concussions as an epidemic due to their high occurrence rate, especially in the athlete population. Approximately 63,000 adolescent sport-related concussions occur annually in the United States.[14] The prevalence of this mild-traumatic brain injury is most critical in the high school population, with an estimated incidence rate of up to 15.3% in football alone.[14] The epidemic status of concussion has forced the injury into the forefront of media and research drastically increasing public awareness.

Concussions are considered to be a complex brain injury and thereby requires a multifaceted approach to both diagnosis and management.[15–18] Over the past decade, there has been an increase in emphasis on the altered levels of cognition following concussion in making clinical assessments.[17,18] Therefore, the measurement of cognitive ability has become a staple in clinical practice, especially for return to play decisions.[17] In the recommended concussion protocol, cognitive ability is assessed by neuropsychological testing.

Computerized neuropsychological batteries assess specific cognitive functions, and are highly utilized in the high school population.[17,19] Adolescents present uniquely during neuropsychological testing with differences arising across a variety of variables including age, sex, and athletic status.[20–22] To insure the most sensitive measure of individual cognitive ability, these test batteries are compared to a baseline assessment.[15–17] Literature is beginning to show that psychological comorbidities (e.g. depression and anxiety) may influence baseline concussion assessments.[21,23,24] Anxiety has specifically been shown to effect computerized baseline concussion assessments in collegiate athletes.[24] Due to the reliance of neuropsychological testing by clinicians in the high school setting, it is paramount to examine both state and trait anxiety as a mitigating factor that may jeopardize baseline assessments.

Obtaining an accurate benchmark of premorbid cognitive status is essential for managing concussions in the adolescent population. Anxiety during baseline testing may increase or decrease the capacity to execute cognitive tasks, which can lead to alterations in baseline performance. These alterations should be worrisome to healthcare professionals in the high school setting because it could further complicate adolescent concussion assessment. Without consideration, anxiety could adversely affect baseline testing leading to a decrease in quality of care for adolescent athletes in regards to concussion. Therefore, the purpose of this study is to examine the effects of state and trait anxiety on baseline neurocognitive assessment in the adolescent population. It is hypothesized that adolescent athletes will differ in performance and symptomology based on their level of state and trait anxiety at baseline.

CHAPTER 2

METHODS

2.1 Participants

A total of 81 participants were enrolled in this study, and after exclusion criteria were imposed the final analysis included 75 adolescents (male 35, female 40) currently attending high school and participating in interscholastic athletics (Figure 1). All participants were required to complete both a computerized neuropsychological battery (Immediate Post-Concussion Assessment and Cognitive Test; ImPACT) and an anxiety screen (State Trait Anxiety Inventory; STAI). All participants were recruited from two high schools in southeast Georgia. Participants' ages ranged between 13-18 (15.91±1.33), and all interscholastic sports (junior varsity and varsity) were eligible. Exclusion criteria included: history of a concussion in the past six months, injured (musculoskeletal, concussion, and/or other head trauma) at the time of testing, self-reported use of medication for ADD/ADHD, self-reported use of medication for diagnosed psychiatric disorder (depression and anxiety), English as a second language, incomplete data on either measure (ImPACT and/or STAI), invalid baseline ImPACT score, and poor effort on ImPACT baseline test (determined by a Composite Impulse Score above 14). A total of six athletes were excluded based upon these criteria. Three of the athletes were excluded because they self-reported taking medication for ADD/ADHD, two athletes were excluded because they had a Composite Impulse Control score higher than 14, and one athlete was excluded because he reported having a concussion within six months prior to baseline testing (Figure 1).

The methodology was approved by the Georgia Southern University Institutional Review Board prior to recruitment.

2.2 Main Outcome Measures

Neuropsychological Battery: Immediate Post-Concussion Assessment and Cognitive Test (ImPACT)

The ImPACT (ImPACT Applications Inc. San Diego, CA) is one of the most highly utilized computerized concussion batteries in the high school setting.[17,25] The internet-based computerized battery contains three primary domains of concussion assessment (demographics, symptomology, and neuropsychological testing). In addition, a configuration of six modules (Table 1) measures three speed indices and calculates five composite scores. The three speed indices include simple reaction time, complex reaction time and speed of information processing, with both simple and complex reaction times measured in seconds.[26,27] The quantitative composite scores calculated consist of Verbal Memory, Visual Memory, Visual-Motor Speed (Processing Speed), Reaction Time, and Impulse Control.[26] Each one of these composite scores is representative of cognitive ability in the test-taker except for Impulse Control, which is generally used to detect poor effort during testing.[28] Poor effort on the part of the participant can skew data, therefore, any scores that surpass the cutoff score of 14 were excluded from the analyses.[28]

Psychometric properties of the ImPACT have been calculated in previous research where it has been shown to be a valid assessment for cognitive deficits following a concussion resulting in a high sensitivity (81.9%-91.4%)[29,30] and moderate to high specificity (69.4%-89.4%).[29,30] Reliable change intervals for each composite score have also been calculated with a confidence level of 80%.[27] Validity of each composite score of has also been established when administered in a group setting.[30,31]

State-Trait Anxiety Inventory Y Form (STAI-Y)

The STAI is an accepted measure of both state and trait anxiety, and is widely used in the literature. The Y form is utilized to measure these variables in the adolescent and adult population. This inventory consists of two separate 20 item questionnaires that assess emotional state (state anxiety, S-Anxiety scale) and consistent personality (trait anxiety, T-Anxiety scale).[32] Each questionnaire is designed utilizing a 4-point Likert style scale in order to gauge intensity of individual aspects associated with both factors of anxiety.[32] The anchors are consistent across both scales with 1 indicating less likely to 4 indicating more likely. The S-Anxiety scale is labeled using wording that more accurately represents the emotional state at the moment of administration, while the T-Anxiety scale uses labels associated with the personality characteristics of the individual.[32]

Scoring for each individual scale can range from 20-80 and a cutoff range of 40 (S-Anxiety) and 36 (T-Anxiety) has been suggested when making interpretations of high levels.[32–34] Scoring within the high range on the S-Anxiety Scale indicated that a participant was endorsing an emotional reaction to a stressful stimuli which is an expression of their current emotional state.[32] Scoring within the high range on the T-

Anxiety scale indicated that a participant possessed behavioral positions that are associated with consistently interpreting external situations as stressful.[32]

Psychometric properties for the STAI-Y have been established for both reliability and validity. Test-retest reliability coefficients have been recorded ranging from 0.31-0.86 over multiple time intervals.[33] It is important to note that since state anxiety is situational and can fluctuate frequently the lower coefficients were generally found for the S-Anxiety Scale. In addition, internal consistency has been found to be high in adolescents (a=0.86).[33] Strong construct validity has been established for both adults and adolescents; utilizing two criterion scales (Taylor Manifest Anxiety Scale and IPAT Anxiety Scale), and has been found to range between 0.73-0.85.[33]

2.3 Procedures

Recruitment

Before any recruitment took place, the investigators received approval from both the local county school system, and each individual high school. Once all necessary authorizations were obtained the recruitment process began. The investigators contacted athletic trainers at approved high schools before the start of preseason to gauge interest. The athletic trainers and investigators then met with individual athletic teams to explain the study and distribute packets which contained an informational letter, parental consent form, minor assent form, and demographic questionnaire. The athletes were informed to take them home and have their parent(s)/guardian(s) review and sign them. Once an athlete returned their completed packet to the athletic trainer they were enrolled in the study. Both parents and participants were ensured that participation in this study did not influence/interfere with academic or athletic involvement in anyway. Furthermore, the participants were informed that participation was strictly voluntary and they could have withdrawn from participation at any time without repercussion.

Data Collection

All schools involved utilized the ImPACT for their baseline neuropsychological battery in their concussion protocol, and each school had different administration methods. Differences included testing group size, time of day the test was taken, testing environment, and if multiple teams were tested simultaneously. The investigators assisted the high school's athletic trainer in administration of the ImPACT according to their administration methods. Regardless of school all baseline testing was completed before the start of the competitive season for fall, winter, and spring sports. The ImPACT takes approximately 30 minutes to complete, and was administered by either the athletic trainer(s) and/or the investigators. All parties were properly trained in administrating the ImPACT in order to maintain consistency. All athletes were prompted to accurately complete the demographics section emphasizing on age, sex, grade level, and sport. When feasible the investigators and athletic trainers ensured that at least one chair space was between each participant. The ImPACT testing took place in the computer lab and libraries of both schools, and either during a physical education period or immediately after school.

Although there was slight variability in administration protocols for the ImPACT based on school, the administration of the STAI was consistent across all sites. The inventory instructions were explained to each participant individually by one of the investigators prior to administration. The participant was instructed to report their name, age, sex, sport, and grade level during the STAI so that it could be matched to their respective ImPACT report. During administration, the primary researcher was available to answer any questions participants had. The STAI takes approximately two minutes to complete and was administered either before or after completing the ImPACT based upon the number of athletes in each testing session. The average time between measure administrations was less than five minutes, and the entire data collection process took approximately 30-45 minutes depending on how long it took each participant to complete the ImPACT. Confidentiality was maintained by keeping all forms in a locked filing cabinet on the Georgia Southern University campus.

Once each participant completed both the ImPACT and the STAI they were informed that they had completed the study. Upon completion, each participant received a twenty-dollar gift card. ImPACT scores were obtained by the researchers from each school’s athletic trainer after baseline testing for an entire team was complete. Depending on the school this was done by either printing out hard copies of the output sheet, or electronic copies were emailed to the research team on a secure network. If electronic copies were received they were printed out and the file was deleted. All hard copies received were locked in a filing cabinet with the same stipulations as the STAI forms. All data was manually imported into the SPSS v23.0 (IBM Inc. Armonk, New Castle, NY) for statistical analysis.

Statistical Analysis

Descriptive statistics (means, standard deviations and frequencies) were run on all demographic variables, the 5 composite ImPACT scores and total symptom score, and the STAI scores (S-Anxiety and T-Anxiety). Statistical assumptions were also assessed for normal distribution and the presence of outliers. If outliers were found (±2 standard deviations) they were removed from the analysis.

Participants were split into high and low groups based on their S-Anxiety and T-Anxiety scores. Distinguishing between high and low groups was determined by the cutoff scores for each scale (S-Anxiety: 40, T-Anxiety: 36).[32,33] Once groups were established, a one-way ANOVA was run to observe significant differences between high and low groups for each individual scale. Significance levels were set *a priori* $p<0.05$, and all statistics were run on SPSS v. 23 (IBM, Armonk, North Castle).

CHAPTER 3

RESULTS

The current study included a sample of adolescent athletes (n=75). The sample was 53% female with a mean age of 15.91±1.33. The majority of the sample was in the eleventh grade (36%) and white (77%). Participants were recruited from a variety of interscholastic sports with boys' and girls' soccer having the largest representation (44%). Participants were split into one of two groups based upon their S-Anxiety and T-Anxiety score (high state anxiety group, n=10, 13%; high trait anxiety group, n=35, 47%). Performance on ImPACT for all groups were similar to normative population data (Table 4 & 5). Descriptive statistics for the entire sample are reported in Table 2 and Table 3.

A one-way ANOVA revealed significant differences (Table 4) between the high state (HS) and low state (LS) anxiety groups for Composite Reaction Time (LS 0.60±0.10, HS 0.69±0.09, $F_{(1, 73)} = 6.28$, p =.01, r= -0.43, Cohen's d = 0.95). Due to the uneven group distribution, and the violation of homogeneity of variance for the Total Symptom Score comparison ($p = 0.02$) an Independent-Samples Mann-Whitney U Test was run to confirm all significant findings. A significant difference was found once again for Composite Reaction Time ($p = 0.01$), therefore we rejected the null hypothesis.

No significant differences (Table 4) were observed between HS and LS for Composite Verbal Memory (LS 88.14±9.52, HS 85.50±8.09, $p = 0.41$), Composite Visual Memory (LS 78.26±11.72, HS 76.30±10.43, $p = 0.62$), Composite Visual Motor Speed (LS 39.91±6.70, HS 36.36±4.56, $p = 0.11$), Composite Impulse Control (LS 4.51±2.90, HS 4.30±3.20, p = 0.84), and Total Symptom Score (LS 4.34±6.11, HS 8.10±9.36, p = 0.10).

Similarly, a one-way ANOVA was run to determine significant differences between the high trait (HT) and low trait (LT) anxiety groups (Table 5). The analysis yielded no significant differences between groups for Composite Verbal Memory (LT 88.41±9.93, HT 87.03±8.65, p = 0.53), Composite Visual Memory (LT 78.44±10.76, HT 77.47±12.51, p = 0.72), Composite Visual Motor Speed (LT 40.71±6.32, HT 37.91±6.57, p = 0.06), Composite Reaction Time (LT 0.60±0.12, HT 0.63±0.08, p = 0.21,), Composite Impulse Control (LT 4.73±2.93, HT 4.18±2.92, p = 0.42), and Total Symptom Score (LT 3.66±6.41, HT 6.27±6.82, p = 0.09).

An additional analysis was conducted in order to account for possible sex influence in our sample. A one-way ANOVA revealed no significant differences between sexes for Composite Verbal Memory (Male 87.09±9.05, Female 88.40±9.64, p=0.55), Composite Visual Memory (Male 79.60±10.78, Female 76.60±12.08, p=0.26), Composite Visual Motor Speed (Male 39.29±6.90, Female 39.56±6.29, p=0.86), Composite Reaction Time (Male 0.62±0.08, Female 0.61±0.12), Composite Impulse Control (Male 4.09±3.19, Female 4.83±2.65, p=0.28), and Total Symptom Score (Male 4.37±6.91, Female 5.25±6.53, p=0.57).

CHAPTER 4

DISCUSSION

The study aimed to examine anxiety in the adolescent athlete population and the potential effect it may impose on baseline concussion neuropsychological testing. We hypothesized that adolescent athletes presenting with high and low state and trait anxiety during baseline testing would significantly differ in performance. We found that participants presenting with high state anxiety at baseline had significantly slower reaction times than those with low state anxiety (Figure 2).

The national average for adolescent anxiety disorders is reported at 31.9%[1], however that number does not break down into state and trait anxiety and focuses on diagnosed anxiety disorders. It appears that a large portion of our sample (47%, n=35) experienced trait anxiety and as such will consistently interpret situations as stressful. Of those participants, a small portion (13%, n=10) of the sample experienced emotional reactions to stress at the time of testing. However, the question still remained whether high levels of state and trait anxiety would affect ImPACT baseline scores.

We found significant differences between high and low levels of state anxiety for composite reaction time. The athletes in the high state anxiety group had significantly slower reaction times compared to the low state anxiety group (Figure 2). Our finding is consistent with previous literature that high state anxiety can create decreased performance on reaction time variables.[24,35–37] Bailey et al.,[24] found that collegiate athletes with high levels of anxiety during baseline testing performed worse on both complex and simple reaction time. Therefore, this finding supports that anxiety during baseline testing may negatively affect an athlete's reaction time performance regardless of age. In adolescent athletes specifically, reaction time has been shown to be influenced by sex where females have slower reaction times than their male counterparts.[38] Our analysis revealed no differences in reaction time between males and females, increasing the likelihood that high state anxiety was the cause for performance differences. The nature of reaction time tasks may provide insight into how high state anxiety may influence poor performance in adolescent athletes.

Reaction time tests within computerized neuropsychological batteries involves multiple cognitive systems. Composite reaction time is calculated by components of three ImPACT modules, and in order to complete them accurately the athlete must efficiently coordinate various cognitive tasks such as attention and motor response.[26] The combination of cognitive tasks creates an increased demand on the amount of cognitive resources an athlete needs to complete the assigned activity, which the theory of capacity sharing states will inherently inhibit maximal performance.[11] Deficits could be marginally increased if athletes are distributing capacity to self-relevant variables such as managing anxiety symptoms. Participants in the high state anxiety group might have experienced cognitive and somatic anxiety at the time of testing. These participants, may not efficiently use cognitive resources to support these symptoms[4,8–10] Even though high state anxiety appears to significantly affect reaction time when compared to peers with low anxiety, overall performance of participants with high state anxiety for reaction time still fit into average normative population ranges.[26] This suggests that state anxiety does slow reaction time performance, but not to the extent where adolescent athletes are performing uncharacteristically to the population.

This study found no additional significant differences between state groups for any composite scores. The relative lack of athletes presenting with high state anxiety and performance differences for the majority of composite scores of ImPACT may indicate that baseline concussion testing is not stressful to adolescent athletes. This finding may be explained by current concussion paradigms. The best practice for baseline testing recommends that adolescent athletes (specifically high school athletes) obtain a new baseline every two years, and because of this, a majority (61%) of our sample were not first-time ImPACT takers.[15] ImPACT has been validated against practice effects, but previously experiencing the baseline testing process could result in an unexpected calming effect in our sample.[26] Currently, the social climate surrounding concussion may offer insight into why concussion baseline testing may not be stress inducing to athletes.

Concussion has garnered high amounts of coverage over the past decade that spans across multiple domains of media. The participants in our study is a part of one the first generations to grow up in this era of heightened awareness and focused concussion education. The substantial increase in national awareness has catapulted the injury to the forefront of scientific and legal agendas, and has been labeled an epidemic by the CDC.[39] The drastic increase in national attention, research, and education has brought concussion into the public eye and may have desensitized the issue for adolescent athletes. Thereby, reducing stress surrounding the concussion baseline protocol which could contribute to decreasing anxiety in adolescent athletes. Adolescent athletes interpreting baseline testing as non-stressful (creating a lack of state anxiety) may have decreased the gap of perceived stress between groups, in lieu of a blanket statement that state anxiety does not affect neuropsychological performance.

Contrary to the original hypothesis, we found no significant differences between the high and low trait anxiety groups for any ImPACT composite score. These findings are inconsistent with previous literature that demonstrated deficits in multiple cognitive processes in high trait anxious individuals.[35,40,41] Trait anxiety is a personality characteristic, and it appears that almost half of our population are functioning daily under high levels of trait anxiety. Daily high levels of trait anxiety materialize as normal for our sample of students in the high group as they consistently navigate through social, academic, and athletic situations successfully. Specifically, over half (60%, n=21) of the high trait anxiety group reported GPA's greater than a 3.5, demonstrating that a constant state of high trait anxiety does not negatively affect their academic performance. Therefore, it is not surprising that we did not see any significant differences in our participants in regards to neuropsychological testing.

While we did not see differences between our groups with trait anxiety, it should be mentioned that trait anxiety does not directly cause the manifestation of anxiety symptoms.[5] Rather, trait anxiety will lower the threshold for a situation to be deemed stressful by an athlete, and increases the likelihood of experiencing state anxiety. Even though a large portion of our sample consistently interprets situations as stressful, only 25% (n=9) also endorsed a high emotional response at the time of testing. The lack of participants that experienced both high trait and state anxiety provides further evidence that adolescent athletes may not interpret baseline testing as a stressor. Furthermore, since trait anxiety does not directly cause symptomology, then without a coupled state anxiety response, it would have no mechanism to interfere with neuropsychological testing. Regardless of level of trait or state anxiety, the composite scores for our adolescent athlete population fell within the normative ranges for the average high school student reported by ImPACT (Table 4, Table 5). This initial impression that our sample is generally unaffected by trait anxiety academically seems to also transfer to performance on concussion baseline testing.

The current study was not without limitations. First, the participants were a sample of convenience. As a result of the timing of data collection, we did not collect data from football which usually constitutes a large portion of participants in concussion research conducted in the high school setting. Overall, our sample of convenience was consistent with normative data published by ImPACT.[26] Omitting football decreased the uneven recruitment of males to females in our study. After careful examination, no differences existed between males and females and despite our sample of convenience, it appears that our sample performed comparable to normative ImPACT data by age and sex.

Finally, our study may have been influenced by reporting bias. The STAI is self-reported questionnaire and inherently can be subjected to reporting bias. Adolescent athletes may feel uncomfortable to disclose information about anxiety which may have increased the likelihood of under-reporting. Therefore, the STAI was administered individually to decrease discomfort and promote honesty. Further, the measure’s instructions were thoroughly explained and all questions were answered. Each participant was ensured that their results would not be shared with anyone outside the research team.

Future research should not only expand the generalizability of these findings to the greater adolescent population, but also examine the role anxiety may play on the post-injury assessment. Specifically, the current concussion paradigm relies heavily on neuropsychological testing in order to make return-to-play decisions, and poor performance can further prolong time out of sport. The emphasis placed on neuropsychological testing in this setting holds higher consequence for athletes which may be more stress provoking.

CHAPTER 5

CONCLUSION

The current study was a preliminary study that aimed to examine anxiety in adolescent athletes and how it interacts with baseline neuropsychological test scores. These findings demonstrate that adolescent athletes consistently perceive situations as stressful, but appears to have a limited effect on baseline neuropsychological testing. Athletes experiencing high levels of state anxiety have significantly slower reaction times than those with low state anxiety. Reaction time is a complex cognitive function that requires the utilization of multiple cognitive systems which could minimize performance. Within this adolescent athlete sample, it appears that high levels of trait anxiety have no effect on this concussion test battery.

The overall lack of differences seen in our study can be an indicator that adolescent athletes do not assess baseline concussion testing as stressful. Media has increased coverage of concussion extensively over the past decade, and have since influenced the current social climate surrounding the injury. A dramatic increase in public awareness, legislation, and education has brought concussion to forefront of athletics, and may have normalized the injury. In addition, through increased exposure, adolescents may have a higher level of understanding regarding the long-term consequences of concussion. All of these societal factors could have played a role in why our adolescent sample did not appear to assess concussion baseline testing as stressful, thereby decreasing the severity of the emotional response experienced.

The current study initially set out to determine whether screening for anxiety during baseline concussion assessment was warranted. Our findings do not support the need for anxiety specific screening. This research did support previous findings that anxiety affects reaction time, and the limited findings should be expanded to establish the generalizability to a greater portion of the adolescent population. Until such time, we recommend that clinicians continue to utilize the multifaceted approach with particular focus on psychological and social comorbidities such as anxiety, depression, mental health conditions, and socioeconomic status as it relates to concussion assessment in adolescent populations.

APPENDIX A

TABLES AND FIGURES

Table 1: ImPACT Modules

Module	Description
Module 1: Word Discrimination	Measures attentional processes and verbal recognition memory
Module 2: Design Memory	Measures attentional processes and visual recognition memory
Module 3: X's and O's	Measures visual working memory, visual processing speed, and visual memory
Module 4: Symbol Matching	Measures visual processing speed, learning and memory
Module 5: Color Matching	Measures impulse control and response inhibition
Module 6: Three Letters	Measures working memory and visual-motor response speed.

Table 2. Descriptive Statistics of Sample

Variable	**Mean(SD)**
Age	15.91(1.33)
Height (cm)	168.72(9.07)
Weight (kg)	62.97(12.04)
S-Anxiety Scale	31.53(8.58)
T-Anxiety Scale	35.20(9.57)
Verbal Memory Composite	87.79(9.33)
Visual Memory Composite	78.00(11.51)
Visual Motor Speed Composite	39.44(6.54)
Reaction Time Composite (sec)	0.61(0.10)
Impulse Control Composite	4.48(2.92)
Total Symptom Score	4.84(6.68)
Cognitive Efficiency Index	0.33(0.14)

N=75

Table 3. Distribution of Sample

	n	%
Sex		
Male	35	46.67
Female	40	53.33
Race		
White	58	77.33
Black	11	14.67
Asian/Pacific Islander	3	4.00
Hispanic	2	2.67
Other	1	1.33
Education Level		
9^{th} Grade	24	32.00
10^{th} Grade	5	6.67
11^{th} Grade	27	36.00
12^{th} Grade	19	25.33
Sport		
Cheerleading	10	13.33
Softball	11	14.67
Volleyball	10	13.33
Basketball	1	1.33
Wrestling	2	2.67
Soccer	33	44.00
Baseball	8	10.67

N=75

Table 4. ImPACT Composite Scores and Norms for State Anxiety Groups

Composite Scores	Low State	High State	Average Normative Male Scores$^{\alpha}$	Average Normative Female Scores$^{\alpha}$
Verbal Memory	88.14 ± 9.52	85.50 ± 8.09	80-92	84-93
Visual Memory	78.26 ± 11.72	77.47 ± 12.51	71-88	70-88
Visual Motor Speed	39.91 ± 6.70	36.36 ± 4.56	33.7-42.5	32.8-42.3
Reaction Time (sec)	0.60 ± 0.10*	0.69 ± 0.09*	0.58-0.50	0.60-0.51
Impulse Control	4.51 ± 2.90	4.30 ± 3.20	N/A	N/A
Symptom Score	4.34 ± 6.11	8.10 ± 9.36	1-6	1-8

*Denotes significance at *a priori* $p<0.05$, $^{\alpha}$ Ranges were based off the natural distribution of scores (25^{th}-75^{th} percentile) for the average high school student.[26]

Table 5. ImPACT Composite Scores and Norms for Trait Anxiety Groups

Composite Scores	Low Trait	High Trait	Average Normative Male Scores$^{\alpha}$	Average Normative Female Scores$^{\alpha}$
Verbal Memory	88.41 ± 9.93	87.03 ± 8.65	80-92	84-93
Visual Memory	78.44 ± 10.76	76.30 ± 10.43	71-88	70-88
Visual Motor Speed	40.71 ± 6.32	37.91 ± 6.57	33.7-42.5	32.8-42.3
Reaction Time (sec)	0.60 ± 0.12	0.63 ± 0.08	0.58-0.50	0.60-0.51
Impulse Control	4.73 ± 2.93	4.18 ± 2.92	N/A	N/A
Symptom Score	3.66 ± 6.41	6.27 ± 6.82	1-6	1-8

*Denotes significance at *a priori* $p<0.05$; $^{\alpha}$ Ranges were based off the natural distribution of scores (25^{th}-75^{th} percentile) for the average high school student.[26]

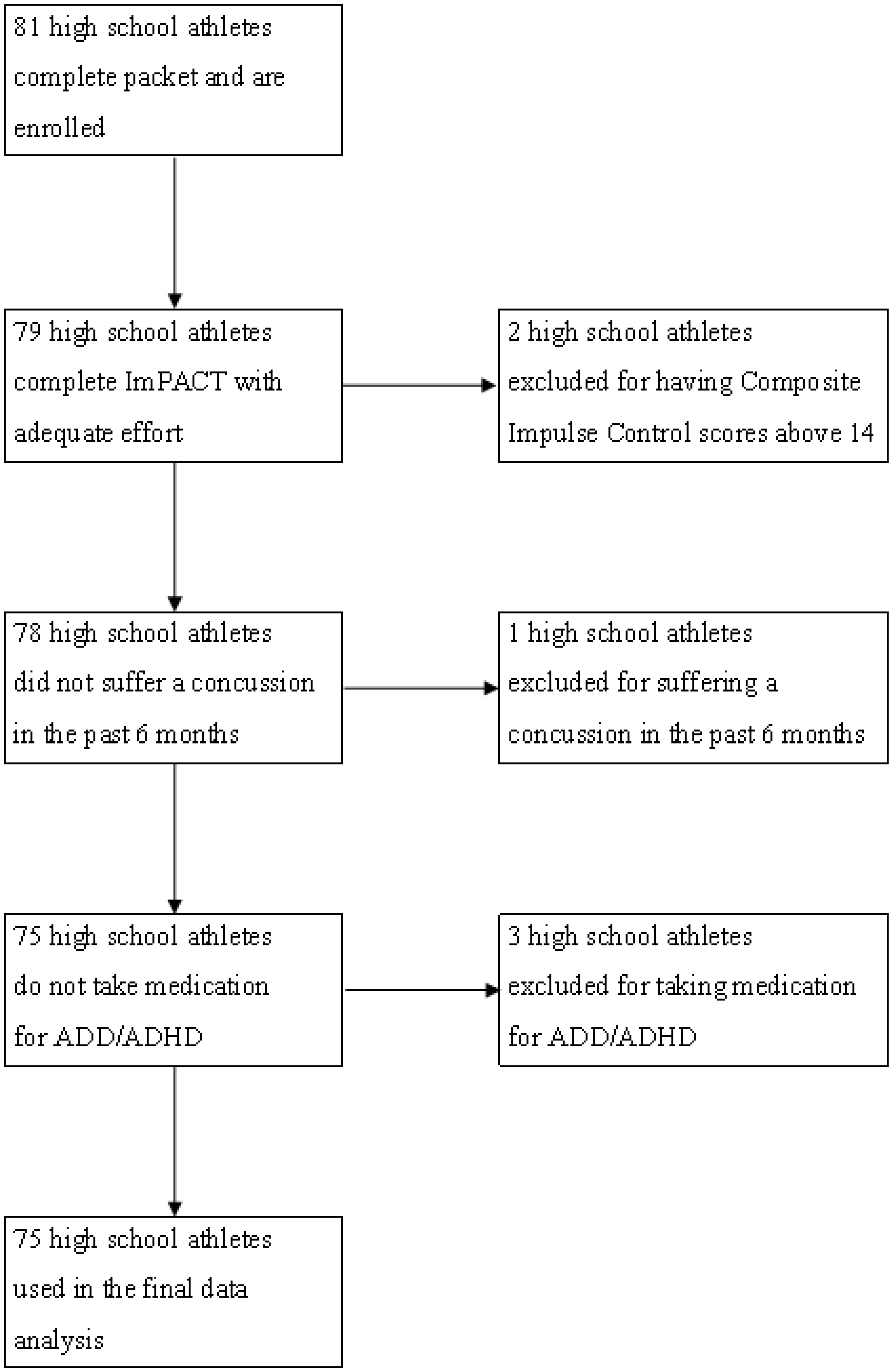


Figure 1. Exclusion criteria for final analysis.

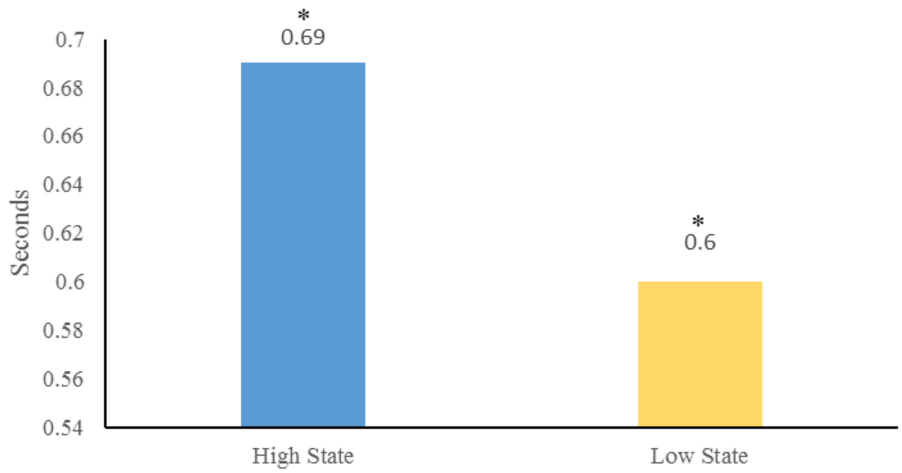


Figure 2. Composite Reaction Time scores for adolescent athletes with high and low state anxiety. *Asterisk indicates significance at p<0.05*

APPENDIX B

RESEARCH SPECIFICS

B.1 Research Questions

- RQ_1: Will adolescents presenting with varying levels of state and trait anxiety differ in performance on baseline concussion neurocognitive tests?

B.2 Hypotheses

- H_0: Anxiety will have no effect on baseline ImPACT performance or symptom score in the high school athlete population.
- H_1: High school athletes will differ in performance and symptoms scores on the ImPACT based on their levels of state and trait anxiety at baseline.

B.3 Inclusion/Exclusion Criteria

- Inclusion Criteria
  - Currently participating in a high school sport
  - Currently enrolled in a high school located within the Bulloch County School System
  - 13-18 years of age
- Exclusion Criteria
  - History of a concussion in the past six months
  - Injured (musculoskeletal, concussion, and/or other head trauma) at the time of testing
  - Self-reported use of medication for ADD/ADHD
  - Self-reported use of medication for diagnosed psychiatric disability (depression, anxiety, etc.)
  - English as a second language
  - Incomplete data on either measure (ImPACT and/or STAI-Y)
  - Poor effort on ImPACT baseline test (determined by a Composite Impulse Score above 14)

B.4 Limitations/Delimitations

- Limitations:
  - Potential Distractors during group administration

    - Imbalances in group size (Low State: 65, High State: 10; Low Trait: 41, High Trait: 34)
- Delimitations:
    - Convenience sample (only data collecting from high schools in the Bulloch County School System)
    - Only looking at state and trait anxiety
    - Utilizing the ImPACT as the only neuropsychological battery

B.5 Assumptions

- Participants will put forth full effort on ImPACT
- Participants will be honest in completing the STAI
- Demographic information will be correct

APPPENDIX C

REVIEW OF LITERATURE

C.1 Anxiety: A Brief History

Anxiety has been the topic of research across multiple disciplines for decades, beginning as far back as Darwin himself. Throughout history, many influential scientists have weighed in on the topic of anxiety and have molded the psychological phenomenon into what it is today. Sigmund Freud is considered the pioneer of anxiety and the original psychologist that brought anxiety into the forefront of research.

Freud went through many iterations of his theory of anxiety and how it is perceived, understood, and treated. Throughout the many changes and adaptations, his simplistic definition always remained relevant: "anxiety is something felt."[42] In the end, Freud postulated a schema that shared similarities with the already accepted learning theory observed by Pavlov.[43] Freudian theory in its simplistic form is the idea that anxiety is a secondary drive to fear; stating that anxiety is conditioned part of fear.[43] Therefore, anxiety is a conditioned response to repetitive exposure to unconditioned stimuli in the form of fear. In this light, Freud described that the repression of instinctual impulses served as the unconditioned stimuli leading to the manifestation of anxiety, or the conditioned response.[42]

With this explanation came two central truths regarding anxiety. The first truth stated that anxiety is a instinctual response to a perceived external threat (i.e. the unconditioned stimulus).[42] He supported this truth by using the example of an infant's experience of separation anxiety from his/her mother. The second truth was that anxiety leads to repression of behavior, going against what he originally believed.[42] Since anxiety is a direct result of an external threat, this will activate escape behavior in order to relieve the internal excitation of anxiety. In return, the person will alter their behavior, usually in the form of repression, in order to reduce anxiety.[43] Additionally, he described that anxiety can stem past just simple unpleasurable experiences, and begins to hint at the fact that anxiety is multifaceted affecting different parts of the body.[42] This school of thought has led to the examination the effects (both positive and negative) of anxiety on a multitude of biological processes, including diseases, other mental disorders, and even bodily injury. All in all, the two central truths proposed by Freud, along with the speculation of a multifaceted phenomenon have been used in part to formulate not only the current definition of anxiety, but also all proceeding theories.

C.2 Defining Anxiety

As with many medical disorders, there can be varying levels of specificity, but anxiety as a whole is most commonly described as a negative emotional state characterized by nervousness, worry, and apprehension associated with activation and arousal of the body.[2] When discussing anxiety and how it is personally perceived, it is pertinent to understand the concept of specific constructs of anxiety and arousal.

As aforementioned, anxiety in general is considered a negative emotional state, but research has been conducted to further parse out specific domains of anxiety. Anxiety has both cognitive (mental) and somatic (physiological) portions that are interdependent of each other. These two domains were originally described by Liebert and Morris[4] when examining the effects of worry and emotionality on test takers. It was found that anxiety can manifest with cognitive symptoms including worry and apprehension, and with somatic symptoms such as nausea and 'butterflies'.[4] Both components play a primary role in how anxiety will manifest in a person at any given moment, and typically work independently of each other.[44] Cognitive and somatic anxiety describe the symptomology of anxiety, but there is also a factorial component essential to understanding anxiety on a personal level.

Anxiety is variable to every person in both manifestation and severity. These subtle differences can be easily observed in people and are often associated with personality. Cattell and Scheier[5] were the first to examine specific anxiety variables in order to fully understand how anxiety factors into the personality of an individual. They examined 814 separate anxiety variables and by utilizing factor analyses parsed out two distinct anxiety factors: state and trait anxiety. These analyses isolated and loaded specific variables in which the authors interpreted the outcomes as the presence of two different and distinct factors that as whole make up anxiety. One factor is a product of situation (state) and the other is concerned with personality (trait).[5]

State anxiety is formally defined as an "emotional state characterized by subjective, consciously perceived feelings of apprehension and tension, accompanied by or associated with activation or arousal of the autonomic nervous system".[6] State anxiety defines the concept of the ever-changing mood state of an individual, and is transitionary in nature.[5,6] In the discovery of state anxiety, Cattell and Scheier saw that the factor followed a distinct pattern of variables that co-varied over occasions and measures.[5] In return, this defined a distinct transitionary phase in which a person would fluctuate from variable to variable over the course of time. Specifically, physiological variables were often loaded during these times of fluctuation including, respiration rate and systolic blood pressure.[5] State anxiety is the cause of changing levels of both cognitive and somatic symptoms during certain situations. During these transitionary phases, cognitive state anxiety is the amount of adverse or negative thoughts experienced, and somatic state anxiety is perceived (not actual) changes physiological activation.[2]

Athletes participating in a sporting event are often used to describe the effects of state anxiety. An athlete may be experience heightened anxiety (both cognitive and somatic) at the start of competition, but decreases as the game progresses. For example, this level may remain consistent until a drastic increase when that athlete is called upon to make a game-winning shot. During these fluctuations the state anxiety factor is being loaded, and the person is perceiving anxiety in correspondence to that load. This phenomenon makes state anxiety situational in nature, and is determined by either external or internal stimulation.[2]

Research has suggested that state anxiety has a component of perceived control that can act as regulatory mechanism.[45] The perception a person has on access to the necessary resources and their ability to control state anxiety plays a key role in how state anxiety will effect performance. Both the extent and the control of state anxiety in certain situations is influenced by an individual's personality, specifically the trait anxiety factor.

Trait anxiety is a part of personality associated with a behavioral tendency that influences behavior. Trait anxiety predisposes an individual to perceive a wide range of situations as threating even if it is not physically or emotionally dangerous.[6] The resulting response to a situation is increased state anxiety usually disproportionate in magnitude to the objective danger.[6] Therefore, trait anxiety factor is a measure of stable individual differences in unitary, relatively permanent characteristics, with certain characterological variables (i.e. ego weakness, suspiciousness, and tendency to be embarrassed) that are heavily loaded.[5]

Trait anxiety factor has three subcomponents (somatic, cognitive, and concentration disruption) that interact within personality and will always be present to influence a perceived threat. Somatic trait anxiety is the perception of intensity of physical symptoms that has been brought upon by a threatening stimulus.[46] Cognitive trait anxiety is the level of worry or self-doubt someone experiences consistently.[46] The final component, concentration disruption, refers to the intensity of altered concentration while trying to perform a task under a threating situation.[46] All three components play a crucial role in how someone will interpret a situation as threating, which will determine the intensity of behavioral response to said situation.

Trait anxiety will heavily determine the effects of any given situation on a person's physical and emotional response. Returning to the athletic scenario, an athlete who has high trait anxiety personality may perceive taking the game winning shot a monumental threat. Thereby, increasing the state anxiety response, leading to greater cognitive/somatic symptoms and decreased performance. People who heavily load the trait anxiety factor can be categorized as highly anxious individuals which can lead to performance deficits in life. Both state and trait anxiety have been demonstrated to influence the symptomology (cognitive and somatic) of anxiety. Therefore, it is also important to understand the physiological mechanism in which the body uses to manifest these symptoms.

Arousal is most often referred to as a blend of physiological and psychological activity in a person.[2] Furthermore, arousal represents the varying intensity of a person's internal motivation at any particular moment.[2] Therefore, arousal falls on a spectrum ranging from comatose (not aroused) to frenzied (completely aroused).[47] Arousal is directly followed by a certain level of activation of the body. This often parallels the level of arousal and can include both physical and mental components. It is important to distinguish that arousal can be either positive or negative in nature, and a person can be aroused by a variety of reasons, including anxiety. It is through this balance of arousal and activation that anxiety will influence behavior. Whether a person will be comatose or frenzied in a situation is primarily determined by their levels of trait and state anxiety. Additionally, each situation will call for a unique spread of symptoms thereby leaving how they body will be aroused/activated (cognitively and/or somatically) also predetermined by anxiety.

Anxiety is multidimensional and allows for extensive understanding of how people perceive, internalize, and express anxiety brought upon by their environment. Every person may perceive the same situation different based on specific components of anxiety. The ability to distinguish between them vastly increases the knowledge, which can be ascertained from these scenarios. Moving forward, an examination of the effects of anxiety on performance will be conducted to fully understand the mechanisms in which this disorder takes effect.

C.3 Stress and Anxiety: A Vicious Cycle

Anxiety is a negative emotional response to the external environment, and can be invoked by both internal and external stressors. Stress can be clinically defined as a significant imbalance between demand (either physical and/or psychological) and response capability, under conditions where failure to meet that demand has paramount consequences.[48] One particular way that stress negatively effects people is by initiating an anxiety response, especially in those who are trait anxious.

A widely accepted model was proposed consisting of four interconnected stages outlining the stress process, including what constitutes as stress and the physical/psychological response that can arise from it. According to McGrath[48] stress, consists of four distinct, but related stages: One, environmental demand, Two, perception of demand, Three, stress response, and Four, behavioral consequences. Each stage will be elaborate on while simultaneously being linked to an area of anxiety previously discussed.

Stage one concerns itself with the environmental demand placed on the individual. The nature of the demand will determine whether the consequential response is either physical and/or psychological.[48] One way a demand can invoke a physical stress response is if it includes a physical task. Due to the physicality component of the event, it can be expected that a physical stress response will follow.[48]

Conversely, a psychological demand will cause a heavier psychological stress response. Peer pressure is great example of a psychological demand that will trigger a subsequent psychological stress response. It is important to note that a stress process can include both physical and psychological components and often do. However, the environmental demand(s) will have a large effect on which component is weighted higher.[48] Stage one directly aligns with Freudian theory of anxiety as the external threat, which will cause anxiety and eventually lead to repression of behavior.[42] Demand determines the type of stress response, the personalized perception of that demand determines magnitude.

Stage two revolves around the individual's perception of environmental demand. Perception will not alter which type of stress is emulated (physical and/or psychological), but rather how much consequence this stress process will have.[48] The individual's personality will be a key determinant in how stress demands are evaluated. No one situation will be perceived exactly the same by different individuals, and this will cause variations in the second stage of the stress process. Relating stage two to anxiety, it is clear that trait anxiety factor plays a huge role in how a person will interpret environmental demands. Trait anxiety will often lead to a disproportionate perception of a threatening situation, and can cause serious ramifications during the stress response.[6,48] A person who is heavily influenced by trait anxiety may perceive rather unimportant situations as dangerous, and thus lead to more frequent and heightened stress responses.

Stage three is the manifestation of the stress process on an individual level, through an increased state anxiety response.[2,48] At this point in the process both symptom type(s) and severity have already been determined, leaving the third stage as strictly the response presentation. Specifically, what the person is feeling. It is during this stage that attention and concentration deficits will arise due to a taxing of resources, which will further be discussed.[2] Overall, the stress response is synonymous with an anxiety response, and is dictated by anxiety based constructs.

Finally, the fourth stage is the behavioral response of the person who is under stress. Every step leading up to this point has influenced the behavioral response that will ensue, and will subsequently play a role in whether the person succeeds or fails in the given situation.[48] Because of the dependent nature of the stress process, the behavioral response can lead to a continuous cycle depending on the outcome. If performance is negatively impacted it can lead to task failure and the negative social evaluation will become an additional demand, therefore restarting the process. The same scenario may also cause similar demands to be perceived as even more threatening, due to the negative experience. It is important to note that state anxiety may also increase performance and the opposite effect can happen on the stress process.

It is clear that stress is a main factor in invoking an anxiety response. The stress process is highly connected with anxiety and even dependent on its constructs (i.e. state and trait anxiety factors). McGrath's[48] simplistic model demonstrates the implications of stress on both the individual and subsequent performance, while simultaneously illuminating the fact that the process can compound upon itself. Not only is it essential to understand how stress effects a person, but it is also just as vital to know possible sources of stress.

There are thousands of sources of stress encompassing anything from major life events, occupational changes, personal tragedy, and even simple daily inconveniences.[49] With so many sources of stress, specific people may be more highly susceptible to frequent episodes of anxiety. This in return may negatively impact life and performance. Specifically, anxiety has high incidence in youth and since they are frequently undergoing evaluation, whether at school or at home. It is of the upmost importance to understand how this disorder effects this population.

C.4 Anxiety in Adolescents

Anxiety disorders are the most prevalent form of mental illness in USA, with the range of disorders effecting 15% of the nation's adult population.[50] This value drastically increases when concerned with the nations' youth population. Youths are highly susceptible to anxiety disorders while in both middle school and high school, based on the CDC reporting that the median age for onset of anxiety disorders is 11.[51] In 2010, it was reported that anxiety disorders were the most common mental illness present in US adolescents ages 13-18, with an incidence rate of 31.9%.[1] The same study also reported that the prevalence of an anxiety disorder to present severe impairment and/or distress was 8.3%.[1] Incidence differences have been found between sexes as well, with females have a higher incidence rate for anxiety than males in both the adolescent and adult populations.[1,50] With anxiety being the most prevalent mental illness in the country, it is to pertinent to understand how this mental illness will affect the developing adolescent.

It is not uncommon for a child to experience fear and activate the stress process, but it has been shown that the over-activation of the stress process can lead to permanent consequences, especially in children who are still developing.[52] Excessive exposure to threatening situations during brain development can cause an alteration in brain architecture, specifically concerning the amygdala and the hippocampus.[52] Physical, emotional, and sexual abuse along with persistent maltreat of one parent by another, and a constant threat of violence in the community have all been identified as situations that lead to high susceptibility to developing anxiety in maturing children.[52] Additionally, increased stress during brain growth has been shown to also adversely affect the development of the prefrontal cortex, leading to deficiencies in decision making later in life.[52] Finally, children who are put in these compromising experiences will begin to associate fear within the context of the situation. When this occurs children undergo fear conditioning, which is heavily linked to developing anxiety based personality factors (trait anxiety) and disorders in adulthood.[52] It is abundantly clear that frequent exposure to stress can lead to altered brain development and even condition anxiety into an individual’s personality. This fact is even more concerning considering the human brain continues to develop through the age of twelve, with certain areas surpassing that well into adulthood. Leaving a potential for these changes in brain architecture to occur in adolescence.[53,54]

With avoidance of excessive amount of negative stressors being advantageous in the healthy development of the brain, there have been studies conducted to examine common causes of anxiety in adolescents. Bernstein et al.[55] was one of the first to examine how adolescents self-reported their anxiety. Their findings supported the notion that adolescent females are more likely to experience trait anxiety than males, along with listing the most popular reasons for high anxious episodes.[55] Adolescents were more likely to experience anxiety if they possessed certain personality characteristics (i.e. substance abuse, low motivation, poor grades, etc.) and if they had experience with a tragic/stressful event in the last month.[55]

The increased level of anxiety in adolescents has been clearly documented.[1,55] When coupled with the realization that frequent exposure to stressors can be linked to high development of an anxious personality, derives a need to distinguish differences present between adults and adolescents. There has been a clear divide in the way adults and adolescents cope with stressful situations that lead to symptoms of anxiety. These negative life events can compound which may lead to more negative consequences.

Adolescents have been shown to utilize common coping strategies less than adults following a negative life event, especially when the event brought about symptoms of anxiety.[56] Positive reappraisal, or the process of creating a positive meaning out of a negative experience, was shown to be used the least by adolescents.[56] The misuse of this coping strategy in adolescents is concerning, especially when considering the cyclic nature of the stress process. If adolescents are less likely to follow a negative situation with a positive behavior then the this will load another negative demand on the individual, restarting the stress process.[48]

Since trait anxiety is most commonly developed during maturation, alongside changes in brain architect, speculation can be made that this personality factor may present adversity in adolescents when dealing with a secondary disease or injury. It is clear that anxiety can have negative effects on multiple areas of an adolescent's life, therefore it is important to understand how this disorder may take effect. Because of this, multiple theories have been proposed to further explain how anxiety effects not only physical, but mental performance.

C.5 Theoretical Framework of Anxiety and Performance

Performance is often considered simply as an "execution of an action".[57] This broad definition leaves action open for interpretation, which in this case will refer to a mental task. For decades, the effects of anxiety and arousal on performance have been examined in attempts to explain both the positive and negative relationships that appear. It is within these relationships where a multitude of theories have been proposed, each one offering a different perspective on anxiety and performance.

There is no definitive and unifying theory to date, but test anxiety theory brings to light the possible effects of anxiety and performance on mental tasks. Test anxiety theory was originally proposed to better understand the extent in which anxiety responses were evoked during testing situations, and their subsequent affect they had on learning and performance.[58] Liebert and Morris[4] stimulated a heavy amount of research when they argued that test anxiety can be split into two separate components: worry and emotionality. Worry deals with the cognitive side of anxiety, while emotionality is concerned with the somatic side of anxiety.[4] It has been shown that cognitive anxiety highly correlates with the expectancy to avoid failure (i.e. test anxiety) and somatic anxiety is the degree of activation of the body.[2,4] Following these distinctions, many studies further determined that performance is more negatively affected by the worry (cognitive) component of anxiety rather than the emotionality (somatic) portion.[7]

In the case of test anxiety, worry is defined as self-preoccupation, concern over evaluation, and concern over level of performance.[4,7] Morris, Davis, and Hutchings[7] proposed that the there is an inverse relationship between anxiety and various performance variables. This relationship demonstrated that under appropriate conditions, it is the worry component of anxiety that is primarily the cause, further supporting a cognitive-attentional view on performance decrements.[7] By utilizing this view, Sarason[9] further delineated that test anxiety focuses more on the increased incidence of self-preoccupation, or more specifically worry over evaluation.

Through these studies, a cognitive-attentional view has been described as the key factor in performance deficits. Worry, accompanied by negative internal thoughts, effects performance by causing an interference in attentional capacity.[8–10] Wine[10] noted that highly anxious individuals split their attentional resources between self-relevant variables and test-relevant variables, therefore decreasing the capacity in which they could focus on the task at hand. The presence of worrisome thoughts can cause a person to devote attentional resources to the resolution of these self-relevant thoughts, leading to a reduction in resources devoted to task. As a consequence, performance is impaired.

Worry and attentional interference offers two basic predictions. The first prediction centers on the fact that worry is the main component responsible for the decrement of performance. In theory, trait anxious people will have increased state anxiety under test taking conditions. This increase in state anxiety will lead to a greater volume of worrisome (negative) thoughts.[6,9,10,48] Accordingly, the higher level of trait anxiety, the larger the decreases in performance.

The second prediction states that as task difficulty increases, the greater the decreases in performance will be.[59] This prediction hinges on the fact that the increase in difficulty requires a greater use of attentional resources. Humphreys and Revelle[60] explored this route in their own framework which set out to explain the interaction between arousal, anxiety, and avoidance motivation. Similarly, they found that high amounts of anxiety will increase avoidance and decrease the amount of attentional resources devoted to on-task stimuli.[60] Although, they distinguished two main tasks in which attentional interference has the greatest effect, sustained information transfer (SIT) and short-term memory (STM).

SIT tasks were defined as tasks where the subject had to process a stimulus, associate an arbitrary response to the stimuli, and execute the response. In contrast, STM tasks were defined as tasks that required subjects to maintain information in an available state or retrieve information that has not been attended in short time.[60] Through this distinction, they found that worry not only interferes with attention, but effort as well.

Decrements in effort played a bigger role in reducing SIT task performance, but STM tasks were heavily influences by attentional interference.[60] The authors found that as a task required higher usage of STM, the greater adverse effect anxiety had on performance of said task.[60] These findings aid in demonstrating that increased task difficulty requires greater use of attentional resources which may be unavailable when anxiety is present.

Criticism has been addressed with the worry and attentional control interference. Arguments have been made that test anxiety is not always related directly to performance. Calvo et al.[61] compared a high anxiety and low anxiety group on tasks using a transfer paradigm and found no significant effect between state/trait anxiety and performance. Although this study was primarily focused on learning and the insignificant differences were found there. Even so, they state that attentional interference still has some effect on external performance.[61] A second major criticism is that attentional interference does not truly define task difficulty, but through the use of Humphreys' and Revelle's[60] delineations the second prediction is reinforced. Test Anxiety Theory deals primarily with the deficits observed on performance when dealing with anxiety, but positive effects have also been observed.[13] With anxiety (state and trait) clearly defined and examined, it is important to discuss the way in which it is measured in research.

C.6 Clinical Measures of Anxiety

Anxiety can be measured in the clinical setting in a variety of different ways. Anxiety inventories are a quick, valid, and cost efficient way to measure a various aspects of anxiety. Dozens have been developed and validated in the literature, but not all are applicable to every situation. Certain inventories specialize in one aspect of anxiety while others can be broader, and it is dependent on the researcher to distinguish which inventory will allow for the most appropriate measurement. Two inventories that are often used in similar research areas are the Beck Anxiety Inventory and the State Trait Anxiety Inventory.

The Beck Anxiety Inventory (BAI) is a brief twenty-one item measure that focuses primarily on the somatic symptoms of anxiety.[62] The BAI was developed in response to the need of an inventory that was adept in discriminating between anxiety and depression in the psychiatric population. Each question focuses around a subset of somatic symptoms (nervousness, dizziness, and the inability to relax, etc.) and how often each one has been bothersome over the previous week.[33] The inventory is constructed as a self-reported 4-point Likert scale ranging from 0 (not at all) to 3 (severely).[62] Scoring consists of simply summing the total of each question, leaving a total score range of 0-63.[33,62] Furthermore, specific ranges have been recommended to utilize for interpretation: 0-9, normal or no anxiety; 10-18, mild to moderate anxiety; 19-29, moderate to severe anxiety; and 30-63, severe anxiety.[33,62]

The BAI has been psychometrically established in a variety of clinical settings. Construct validity has shown good convergent of the BAI when compared to other measures of anxiety such as the Hamilton Anxiety Rating Scale (r=0.51) and the State Trait Anxiety Inventory (r=0.47-0.58).[33,63] The BAI correlates less with depression scales than other competitors (i.e. State Trait Anxiety Inventory), but these correlations are still substantial (i.e. r=0.61 with the Beck Depression Inventory).[33,64] Reliability has also been established for the BAI including robust internal consistency (Cronbach's alphas: 0.90-0.94) for the psychiatric, college, and community-dwelling adult populations.[33,65–67] Additionally, test-retest reliability has been moderately established for a 1-week interval (0.62) and a 7-week interval (0.93).[33] The BAI is popular in the adult population and offers a good measurement of somatic anxiety, but more in-depth inventories exist.

The State-Trait Anxiety Inventory (STAI) is widely popular measure of both state and trait anxiety levels. It was originally developed by Spielberger et al.[32] in regards to the distinctions made by Cattell and Scheier[5] between state and trait anxiety. The goal was to create an inventory that could accurately measure both components of anxiety affect. The STAI consists of forty questions, half of them pertain to state (S-Anxiety) and the other half trait (T-Anxiety). [32] The S-Anxiety scale is constructed in a 4-point Likert scale with 1 referencing 'not at all' and 4 referencing 'very much so'. The T-Anxiety scale is constructed in a similar fashion with 1 referencing 'almost never' and 4 referencing 'almost always'. It is important to note that the rationale for the difference in labeling of the Likert scale is to specify each scale to either their emotional state (state anxiety) or their constant personality (trait anxiety).

Scoring for each subscale can range from 20-80 with higher values correlating with greater anxiety. [32,33] Based on normative data, a cut off of 39 (S-Anxiety) and 36 (T-Anxiety) has been suggested when making clinical interpretations of high anxiety.[33,34] Psychometric properties of the STAI have been established including reliability and validity. Specifically, the test-retest reliability coefficient ranged 0.31-0.86 over an intervals ranging from 1 hour to 104 days.[32,33] Since S-Anxiety measures state anxiety which is a transitory factor its test-retest coefficients were lower. Additionally, internal consistency was high in both adults and adolescents (a=0.95 and a=0.86, respectively).[32,33] To obtain construct validity for the STAI, 10,000 adults and adolescents were tested and corresponding correlations were made between the STAI, the Taylor Manifest Anxiety Scale[68] and the IPAT Anxiety Scale[69] which were both popular anxiety scales developed prior to the STAI. Overall correlations between the STAI and the two criterion scales were 0.73 and 0.85 respectively.[33] The T-Anxiety scale has been shown to have some difficulty distinguishing between trait and anxiety and depression, but this was mostly found in geriatric populations.[70] Overall, the STAI is highly utilized, valid, and reliable measure of both state and trait anxiety.

Two possibilities for clinically measuring anxiety (BAI and STAI) have been reviewed and validated in the literature. As aforementioned, it is pertinent that the researcher deems which inventory is the most appropriate for their research. For the present study the STAI has been deemed the most appropriate, and valid measure for anxiety. This assessment was based off the STAI giving a more robust look into anxiety by dividing classifications between state and trait anxiety.[32] In addition, concerns with the validity of the BAI in the adolescent populations exist. Due to the emphasis on somatic symptoms alone the BAI does not perform as effective in the younger, healthy populations.[33,64] Specifically, discriminant validity is diminished when utilizing it in the desired population.[64] The STAI has been shown to maintain its psychometric properties when examining the adolescent population, and has been utilized in this setting in previous literature.[32,71,72]

Anxiety has been previously discussed to have a detrimental effect on both health and performance. Both state and trait anxiety have been looked at in regards to how they specifically effect certain situations, exams, and diseases. One area where anxiety can possible be adverse, but has not been fully demonstrated is concussion. In the following section concussion will be briefly defined and the areas where anxiety may cause deficiency will be laid out.

C.7 Concussion Definition, Epidemiology, and Implications

Concussion is a complex injury, with active debates still raging on the technical definition. There are still multiple definitions in use today by various healthcare professionals, but the most widely accepted definition is a complex pathophysiological process affecting the brain, induced by biomechanical forces.[16] Not included in this definition is a widely accepted construct stating that concussions are accompanied by a period altered mental status.[15] A more consistent definition has increased the ability to obtain more accurate epidemiological data.

Concussions happen frequently in the both the athletic and the general population. There is an estimated range of 1.6-3.8 million sport-related concussions (SRC) annually in the United States alone.[73] This number differs from another widely accepted estimate of 300,000 concussions annually, which only examined the number of concussion evaluated in an emergency room.[74] Football has been identified as the highest incidence of rate of concussion in both collegiate and high school (4.4% and 5.6% respectively).[75] This rate increases further in the high school population (15.3%) when adjusted for underreporting.[14] Approximately 1.4 million concussions occur in the general public annually, mostly resulting from motor vehicle accidents and falls.[73] These rates have lead concussion to be considered an epidemic by some and sequentially thrown into the forefront of research. This research is starting to include the interaction between concussion and other pathologies.

Anxiety and concussion both have complex roots in neurobiology, and a disruption by one may have an effect on the other. During a concussive injury the brain undergoes a neurometabolic cascade due to axonal disruption and stretching after a traumatic blow. The main detriment presented from the neurometabolic cascade is a system-wide energy crisis.[76] Anxiety is processed in the brain through extensive neuronal connections between the amygdala and the cortical exteroceptive systems.[77] The effect of the neurometabolic cascade of concussion on the systematic pathways of anxiety has not been exclusively examined, but due to the hypersensitivity of the brain following concussion, it can be postulated that the normal heightened activation of anxiety pathways in an anxious individual may lead to further energy consequences. The developmental variability of the brain between individuals has been demonstrated in regards to anxiety, but it is prudent to understand how age may affect concussion as well.

Concussion in the adolescent setting has been debated heavily over the previous decades. Previous literature thought that younger brains had increased neural plasticity, therefore the outstanding effects of the neurometabolic cascade would dissipate quicker.[78] This notion is combated on multiple levels with the literature demonstrating longer concussion recovery trajectories in adolescents, along with increases anatomical and cognitive plasticity disparities found later in life in individuals that experienced adolescent concussion.[79,80] The plasticity of the brain is only one area where age can play a mitigating factor. With concussion being a multifaceted injury it requires a multifaceted approach to management. The measurement of cognitive ability has become an important facet in the approach to managing concussion.

C.8 Neuropsychological Testing in Concussion

Neuropsychological tests are specially designed cognitive tests that have been linked to specific neurological pathways which code for specific cognitive functions.[19] In concussion assessment neuropsychological tests are used to monitor cognitive functioning, and only started to be utilized in the past few decades.[16,81] It is standard practice for a neuropsychological test to be compared to a reference in order to detect cognitive deficits. It has been highly suggested to compare post-injury scores to a baseline assessment in order to facilitate the most sensitive comparison.[16,17] There have been advances on which neuropsychological tests are administered in concussion protocols.

Neuropsychological testing has been developed throughout the years, and through the grouping of specific tests into batteries have become more robust and efficient. This continual advancement has brought cognitive concussion assessment to be computerized, with a popular battery being the Immediate Post-Concussion Assessment and Cognitive Test (ImPACT). A more thorough description of the battery will be provided, but in essence this battery involves six modules derived from traditional neuropsychological tests that when factored together measures certain aspects of cognition. With apparent developmental differences established between age groups, it comes as no surprise that the ImPACT mirrors these same distinctions. When comparing across high school and collegiate athlete's significant differences have been found in cognitive processing speed, and reaction time.[79,82] Specifically collegiate athletes demonstrate consistently higher processing speed composite scores[79,82] and faster reaction times.[79] These deficits often seen in adolescents when compared to adults plays a significant role in how clinicians manage concussions in the younger populations. The ImPACT is a complex neuropsychological battery and consists of many different parts, working together to give the clinician an accurate snapshot of an athlete's cognitive capacity.

C.9 Immediate Post-Concussion Assessment and Cognitive Test

Originally neuropsychological tests were pencil-and-paper administered and tested a variety of functions, including executive function, reaction time, and processing speed.[83] Due to the time consuming nature and the need for a clinical neuropsychologist to administer these tests, the field has progressed to computerized neuropsychological battery's. Battery assessments combine commonly used traditional neuropsychological tests to create composite scores that are more easily interpreted by the standard clinician. Currently, the ImPACT (ImPACT Applications Inc. San Diego, CA) is a widely popular computerized neuropsychological battery that is heavily utilized in both the collegiate and high school settings.[17] It has been shown that 90% of all high school athletic trainers utilizing a computerized neuropsychological battery administer the ImPACT.[25]

The ImPACT consists of six distinct modules, each one measuring different aspects neurocognitive functioning (Table 1).[30] An algorithm utilizes a specific combination of these modules to yield five quantitative composite scores: Verbal Memory, Visual Memory, Processing Speed, Composite Reaction Time, and Composite Impulse Control. An aggregate score for concussion symptoms is also calculated. Each of these composite scores can be used by the clinician to assess cognitive function in an athlete, both pre and post injury.

In order to effectively detect changes is cognition, reliable change confidence intervals were calculated for each composite scores.[27] Theses indices were calculated using non-concussed adolescents and young adults in order to make them generalizable to the population most likely to utilize the ImPACT. The values reported were found at an 80% confidence interval. [27]

- Verbal Memory: Deficit (10 points), Improvement (10 points)
- Visual Memory: Deficit (14 points), Improvement (14 points)
- Processing Speed: Deficit (3 points), Improvement (7 points)
- Reaction Time: Deficit (0.07 seconds), Improvement (0.07 seconds)
- Total Symptom Score: Deficit (10 points), Improvement (10 points)

Several psychometric properties for the ImPACT have been established. The ImPACT has been shown to be a valid measure of neurocognitive function and accurate in detecting deficits, (sensitivity 81.9%, and specificity 89.4%[84]) especially when compared to a baseline.[85] The ability of the ImPACT to pick up on cognitive deficits has been shown to be sensitive enough even when athletes are asymptomatic.[86] In addition, the ImPACT has been shown to be able to detect cognitive deficits in undiagnosed concussions up to 48 hours post-injury in high school athletes.[87] ImPACT has also the ability to be administered in a group setting without loss of validity.[31] These findings not only supports the use of the ImPACT as a concussion management tool, but neuropsychological testing as a whole. Even with solid psychometric properties there may still be differences present when comparing different demographics.

Differences have been established for both baseline testing and post-injury testing between sex, age, and athletic status.[22,82,88] Specifically, females have consistently score higher on Verbal Memory Composite and lower on Visual Memory Composite than males.[88] Colligate athletes consistently scored higher on cognitive processing speed than adolescents. [82] High school athletes have faster reaction times and reported less symptoms than their non-athlete peers.[22] Age, sex, and athletic status are a few examples of possible causes of variance when interpreting the ImPACT and should be considered when making clinical decisions. Overall, neuropsychological batteries, such as the ImPACT, involves the use of testing to determine the state of neurocognitive functioning both before injury (baseline) and post-concussion in the standard concussion protocol.

C.10 Anxiety and the Concussion Protocol

The complexity of concussion has warrant a multitude of research in a variety of domains, including psychology. Depression has been the first step into the psychological field for concussion research. Many studies have been published observing the interaction of depression both pre and post-injury. At baseline, both high school and collegiate athletes who present with severe depression have significantly higher symptom scores and lower verbal memory scores on the ImPACT.[23] Depression also has a significant interaction with concussion management post-injury in the high school population. These athletes have been shown to have increased symptomology (especially depression-based symptoms), along with increased reaction times, and lower visual memory capacity.[21] These findings have further pushed the concussion literature into exploring the effects of other aspects of mental illness.

The next logical progression from depression is to examine anxiety and how it effects the concussion management process. Although, research in this subset of the concussion field is sparse with most studies focusing on post-injury. There are increased state and trait anxiety presentations in concussed athletes following injury, leading to a disproportionate representation of post-concussive symptoms.[89] Additionally, athletes experiencing anxiety at the time of baseline testing have been shown to endorse anxiety symptoms post-injury.[90] These preliminary post-concussion findings may suggest that some post-concussion symptoms may stem from this temporary heighted state of anxiety and not the altered pathophysiological state of the brain. This misinterpretation may play a role in why youth athletes who experience pre-injury anxiety can take double the amount of time to asymptomatic and return-to-play (149 days vs. 64 days, 168 days vs. 64days, respectively).[91] Protracted recovery may also have a compounding affect when considering that concussed athletes rely heavily on social supports such as their friends, coaches, and teammates to handle the increases in anxiety and the current management of concussion can lead to temporary isolation.[89] There have been very few studies that specifically look at anxiety at baseline neuropsychological assessment, and less examining the adolescent population. The preliminary findings at baseline did demonstrate an increase in both simple and complex reaction time in collegiate athletes.[24] Although, that study did not look at anxiety in much detail, and did not utilize a commonly used neuropsychological battery.[24]

As shown, anxiety is starting to be understood as a possible comorbidity of concussion with research starting to appear focusing on specific populations and facets of the diagnosis and management process. Research establishing the effect of anxiety and baseline neuropsychological testing needs to be enhanced, due to the crucial role baseline testing plays in the concussion protocol. In addition, there are millions of adolescent athletes that undergo baseline neuropsychological testing (ImPACT) for the concussion protocol. The inherent possibility that anxiety may alter baseline testing on a significant proportion of the adolescent athlete population calls for immediate investigation.

APPPENDIX D

MEASURES

D.1 Immediate Post-Concussion Assessment and Cognitive Test

ImPACT is a computerized neuropsychological battery designed to measure cognitive ability in athletes suspected of concussion. The program contains three sections: 1) demographics and background information, 2) symptoms, and 3) neuropsychological testing. Cognitive functioning is measured in the third section and contains six distinct modules. These modules were derived from traditional neuropsychological tests and measure multiple domains of cognition including: Attention span, Working memory, Reaction time, Verbal and Visual Memory, Response variability, and Non-verbal Problem Solving. An algorithm then takes the scores of each individual module and computes five quantitative composite scores: Verbal Memory, Visual Memory, Visual-Motor Speed, Reaction Time, Impulse Control. In addition, a total symptom score is calculated using the results of the symptom scale in section two. Once completed a performance report is generated automatically and stored on the ImPACT website where verified healthcare professionals can access and review. An unidentified example of a performance report is provided below.

ImPACT®Clinical Report [redacted]

[redacted] Passport ID: CMEM-EBXA-

Organization: [redacted] Age: 17
Date of Birth: 07/16/2000 Height: 68 inches

ImPACT®Clinical Report

[redacted]

[redacted]

Passport ID: CMEM-EBXA-Q4AF

Organization:	[redacted]	**Age:**	17
Date of Birth:	07/16/2000	**Height:**	68 inches
Gender:	Female	**Weight:**	142 lbs
Handedness:	Right		

Native country/region:	United States	**Second language:**	
Native language:	English		

Years of education completed excluding kindergarten:	10	**Repeated one or more years of school:**	No
Received speech therapy:	No	**Diagnosed learning disability:**	No
Attended special education classes:	No	**Problems with ADD/hyperactivity:**	No

Current sport:	Volleyball	**Current level of participation:**	High School
Primary position/event/class:	outside	**Years of experience at this level:**	2

Number of times diagnosed with a concussion (excluding current injury):	0
Concussions that resulted in loss of consciousness:	0
Concussions that resulted in confusion:	0
Concussions that resulted in difficulty remembering events that occurred immediately after injury:	0
Concussions that resulted in difficulty remembering events that occurred:	0
Total games missed as a result of all concussions combined:	0

Concussion history:

Treatment for headaches by physician:	No	**History of meningitis:**	No
Treatment for migraine headaches by physician:	No	**Treatment for substance/alcohol abuse:**	No
Treatment for epilepsy/seizures:	No	**Treatment for psychiatric condition (depression, anxiety):**	No
History of brain surgery:	No		

Diagnosed with ADD/ADHD:	No	**Diagnosed with Autism:**	No
Diagnosed with Dyslexia:	No	**Strenuous exercise in the last 3 hours:**	No

ImPACT® Clinical Report

[redacted]

Exam Type	Baseline				
Date Tested	08/09/2017				
Last Concussion					
Exam Language	English				
Test Version	3.2.3				

Composite Scores	**Percentile scores if available are listed in small type.**				
Memory composite (verbal)	82 35%				
Memory composite (visual)	69 36%				
Visual motor speed composite	33.02 17%				
Reaction time composite	0.61 25%				
Impulse control composite	6				
Total Symptom Score	9				

Cognitive Efficiency Index * 0.29

The Cognitive Efficiency Index measures the interaction between accuracy (percentage correct) and speed (reaction time) in seconds on the Symbol Match test. This score was not developed to make return to play decisions but can be helpful in determining the extent to which the athlete tried to work very fast on symbol match (decreasing accuracy) or attempted to improve their accuracy by taking a more deliberate and slow approach (jeopardizing speed). Low scores (0 to .20) may in some cases suggest a very poor performance on this subtest.

Scores in **bold RED** type exceed the Reliable Change Index (RCI) when compared to the baseline score. However, scores that do not exceed to RCI index may still be clinically significant. Percentile scores if available are listed in small type.

Hours slept last night					
Medication					

ImPACT is not intended to provide a diagnosis or decision about the Test Taker. ImPACT results should be interpreted only by qualified healthcare professionals.

ImPACT® Clinical Report [redacted]

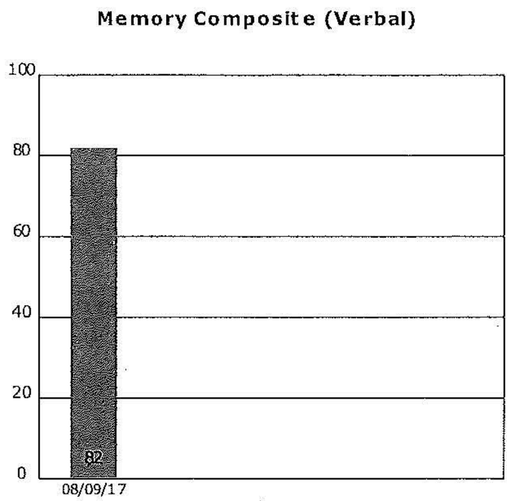
Word Memory					
Hits (Immediate)	12				

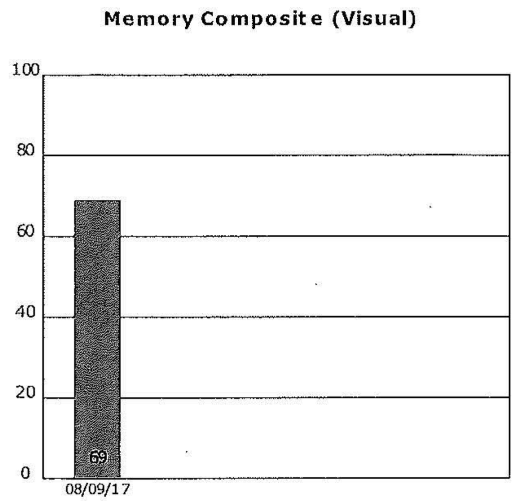
Word Memory					
Hits (Immediate)	12				
Correct distractors (immed.)	12				
Learning percent correct	100%				
Hits (delay)	8				
Correct distractors (delay)	12				
Delayed memory % correct	83%				
Total percent correct	92%				
Design Memory					
Hits (Immediate)	10				
Correct distractors (immed.)	11				
Learning percent correct	88%				
Hits (delay)	10				
Correct distractors (delay)	11				
Delayed memory % correct	88%				
Total percent correct	88%				
X's and O's					
Total correct (memory)	6				
Total correct (interference)	113				
Average correct RT (interference)	0.51				
Total incorrect (interference)	6				
Average incorrect RT (interference)	0.41				
Symbol Match					
Total correct (visible)	27				
Average correct RT (visible)	1.46				
Total correct (hidden)	5				
Average correct RT (hidden)	1.55				
Color Match					
Total correct (visible)	9				
Average correct RT (visible)	0.84				
Total commissions	0				
Average commissions RT	0.00				
Three Letters					
Total sequence correct	5				
Total letters correct	15				
% of total letters correct	100%				
Average time to first click	2.45				
Average counted	12.6				
Average counted correctly	12.6				

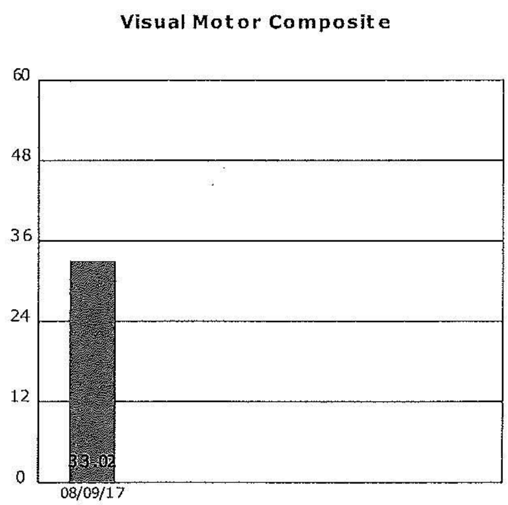
ImPACT® Clinical Report

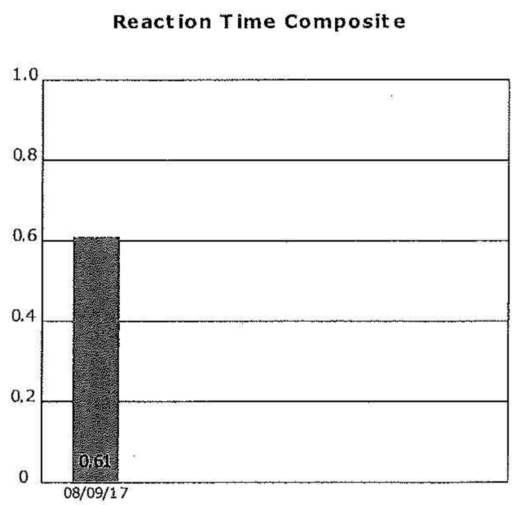
Symptoms Scores					
Headache	0				
Nausea	1				
Vomiting	0				
Balance Problems	0				
Dizziness	0				
Fatigue	0				
Trouble falling asleep	0				
Sleeping more than usual	0				
Sleeping less than usual	3				
Drowsiness	0				
Sensitivity to light	1				
Sensitivity to noise	1				
Irritability	0				
Sadness	0				
Nervousness	0				
Feeling more emotional	0				
Numbness or tingling	0				
Feeling slowed down	0				
Feeling mentally foggy	0				
Difficulty concentrating	3				
Difficulty remembering	0				
Visual problems	0				
Total Symptom Score	9				

ImPACT®Clinical Report [redacted]

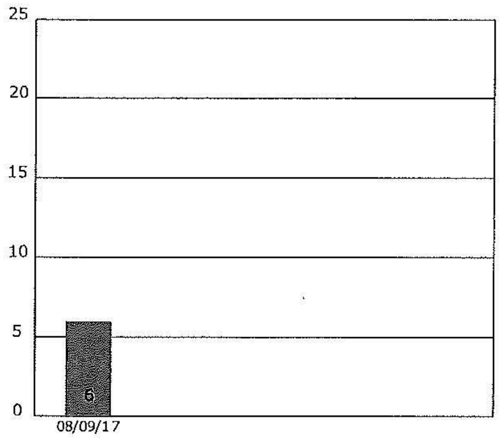




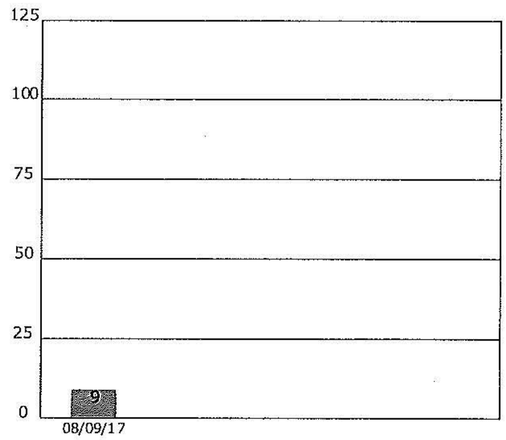




Impulse Control Composite



Symptom Score



D.2 State Trait Anxiety Inventory (Form Y-1, Form Y-2, and Scoring Sheet)

The State Trait Anxiety Inventory is a self-reported inventory that accurately evaluates the levels of state and trait anxiety of an individual. The inventory is split up into two scales, the S-Anxiety Scale measures the individual's level of state anxiety, and the T-Anxiety Scale measures the individual's level of trait anxiety. Each scale includes 20 items, all rated on a 4-point Likert scale, with 1 being low and 4 being high. This creates a score range from 20-80. Due to the differences between state and trait anxiety, the wording of the items in their corresponding scale is written to address the unique aspects (S-Anxiety: feel right now, at this moment; T-Anxiety: Feel generally). Since the STAI is copyrighted Figures 3 and 4 provide example items for both the S-Anxiety Scale and the T-Anxiety Scale.

Figure 3: The S-Anxiety Scale (Example Questions)

1 = NOT AT ALL 2 = SOMEWHAT 3 = MODERATELY SO 4 = VERY MUCH SO
A. I feel at ease 1 2 3 4
B. I feel upset 1 2 3 4
C. I feel calm 1 2 3 4
D. I feel frightened 1 2 3 4
E. I feel jittery 1 2 3 4

Note: Consists of twenty statements that evaluate how respondents feel "right now, at this moment"

Figure 4: The T-Anxiety Scale (Example Questions)

1 = ALMOST NEVER 2 = SOMETIMES 3 = OFTEN 4 = ALMOST ALWAYS

A. I am a steady person 1 2 3 4
B. I lack self-confidence 1 2 3 4
C. I feel satisfied with myself. 1 2 3 4
D. I am happy 1 2 3 4
E. I make decisions easily 1 2 3 4

The T-Anxiety scale consists of twenty statements that evaluate how respondents feel "generally"

APPENDIX E

INSTITUTIONAL REVIEW BOARD APPLICATION

E.1 IRB Study Approval Letter

Georgia Southern University
Office of Research Services & Sponsored Programs

Institutional Review Board (IRB)

Phone: 912-478-0843
Fax: 912-478-0719
IRB@GeorgiaSouthern.edu
Veazey Hall 2021
P.O. Box 8005
Statesboro, GA 30460

To: Hunt, Tamerah

From: Office of Research Integrity, Institutional Review Board (IRB)

Date: 10/11/2017

Approval Date: 12/12/2016

Expiration Date: 11/30/2017

Subject: Approval with Conditions from the Georgia Southern University Institutional Review Board

After a review of your proposed research project numbered: "**H17160**" titled: **"Concussion in Youth Sport: The influence of learning disabilities, previous history of concussion, grade point average, cognitive maturity, socioeconomic status and effort on concussion baseline scores"** it appears that (1) the research subjects are at minimal risk, (2) appropriate safeguards are planned, and (3) the research activities involve only procedures which are allowable.

Therefore, as authorized in the Federal Policy for the Protection of Human Subjects, I am pleased to notify you that the Institutional Review Board has approved your proposed research **with the understanding that you will abide by the following conditions:**

- **The researcher is approved to conduct the study at the following school(s):**
  - **South Effingham High School**
- **The researcher is approved to conduct the study at the following school(s) within the Bulloch County School System (please note, to include additional schools in the Bulloch County, the research will need to submit letters of cooperation for each school to IRB):**
  - **Statesboro High School**
- **Note: If the researcher wishes to collect data from other school systems, she will need to submit an amendment to IRB along with a letter of cooperation from each school.**

Brief study description: This studies hope to identify confounding variables that affect performance of cognitive assessments in adolescents in rural environments.

This IRB approval is in effect for one year from the date of this letter. If at the end of that time, there have been no changes to the research protocol; you may request an extension of the approval period for an additional year. In the interim, please provide the IRB with any information concerning any significant adverse event, **whether or not it is believed to be related to the study**, within five working days of the event. In addition, if a change or modification of the approved methodology becomes necessary, you must notify the IRB Coordinator **prior** to initiating any such changes or modifications. At that time, an amended application for IRB approval may be submitted. Upon completion of your data collection, you are required to complete a *Research Study Termination* form to notify the IRB Coordinator, so your file may be closed.

Sincerely,

Eleanor Haynes

Eleanor Haynes
Compliance Officer

APPENDIX F

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