Spring 2014

Does the Preparticipation Examination Aid in Identifying Future Risk of Concussion?

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DOES THE PREPARTICIPATION EXAMINATION AID IN IDENTIFYING FUTURE RISK OF CONCUSSION?

by

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(Under the Direction of Thomas Buckley)

ABSTRACT

Context: A pre-participation examination (PPE) has become standard practice among the athletic community. This examination commonly includes a multifaceted baseline concussion assessment and an injury history survey. Recent evidence suggests that neuropsychological testing can aid in predicting individuals at an increased risk of lower extremity injury. However, no known previous study has investigated the relationship between neuropsychological function and potential risk of sustaining a concussion.

Objective: This study sought to identify a relationship between components of a standard PPE and an elevated risk of concussion.

Design: All data was extracted from the institution concussion database.

Setting: A large university in Southeast Georgia.

Participants: One hundred and sixty-six participants were recruited for this study, of these participants eighty-two were in the concussed experimental group and eighty-two were in the matched healthy control group, with two excluded for invalid or incomplete ImPACT data.

Main Outcome Measurements: Statistics included a descriptive analyses of gender, sport, and concussion history, a frequency analysis of the four ImPACT composites, total

BESS score, total SAC score, gender, sport, and injury history, a series of one-way ANOVAs, a ROC analysis, and a discriminant function analysis.

Results: The frequency analysis determined that there was some missing data, the descriptive analysis determined the following group means, verbal memory composite: 85.7 ± 11, visual memory composite: 73.1 ± 16.3, reaction time composite: 0.577 ± 0.080, processing speed composite: 39.8 ± 7.7, BESS: 13.1 ± 6.1, SAC: 27 ± 2. The series of nine one-way ANOVAs showed no significant group differences. The ROC analysis determined the following cut off values for each PPE component, verbal memory composite: 83.5, visual memory composite: 81.5, reaction time composite: 0.63, processing speed composite: 33.05, BESS: 13, and SAC: 26. The discriminant function analysis revealed no significant predictors.

Discussion: This study began to show that the basic components of the PPE may not be clinical predictors of concussions. This is clinically significant because it rules out the baseline assessment approach as something that could help identify individuals at an increased risk.

Key Words: Neuropsychological testing, prediction, concussion, postural assessment, neurocognitive assessment, prevention

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by

KASSANDRA JOHNS B.S., Florida Southern College, 2012

A Thesis Submitted to the Graduate Faculty of Georgia Southern University in Partial Fulfillment of the Requirements for the Degree

MASTER OF SCIENCE

STATESBORO, GEORGIA 2014

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Spring 2014

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CHAPTER 1

DOES THE PREPARTICIPATION EXAMINATION AID IN IDENTIFYING FUTURE RISK OF CONCUSSION?

INTRODUCTION

Approximately 1.6-3.8 million sports-related concussions occur annually in the United States; these are common and serious injuries that are frequently under reported.[1,2] To date, there has been limited focus on concussion prevention with most concussion research focused on mechanisms of injury, acute assessment, and recovery phases.[2-6] The profession of athletic training focuses within five main domains: injury/illness prevention and wellness protection, clinical evaluation and diagnosis, immediate and emergency care, treatment and rehabilitation of injuries, and organizational and professional health and well-being; with the first arguably being the most important. If an athletic trainer could identify an individual at an elevated risk of a specific injury then they could start identifying methods to prevent the injury, or refer to clinical prediction and prevention guides that already exist within the sports medicine community. To date there are limited methods to identify individuals who may be at an elevated risk of concussion other than previous history of concussion. The current multifaceted baseline assessment, which includes a postural control component, a cognitive component, and a computerized neuropsychological testing component, may be a useful aid in concussion prediction. In conjunction with the multifaceted assessment approach recent evidence suggests that neuromuscular function and control could be linked to concussions.[7-10] By identifying those individuals at risk, a training mechanism could potentially be implemented to assist in prevention of concussions, otherwise known as a clinical prevention guide.

Prediction of prolonged recovery following sports-related concussions can be based on identifying initial presentation of signs and symptoms as well as history of previous concussion(s).[2,11] There are four symptom clusters associated with concussions; the migraine, neuropsychiatric, cognitive, and sleep.[12] The symptom cluster that is most commonly associated with a prolonged recovery is the migraine cluster, which includes headache, dizziness, noise and/or light sensitivity, balance problems, and numbness or tingling; this is also the most common cluster upon initial presentation.[1,13-15] Concussion history plays a role in these effects of sports-related concussion; previous concussions may also be indicative of a slower recovery process.[2,16] A dose response relationship has been established which suggests once one concussion is sustained there is a two to six times greater risk of sustaining subsequent concussions; prolonged recovery is associated with these subsequent concussions.[16-18] Individuals who have suffered three or more diagnosed concussions are also more likely to experience on-field loss on consciousness (LOC), anterograde amnesia, and confusion.[16] Any posttraumatic amnesia (PTA) or confusion can indicate a longer recovery process.[1,4,15] To potentially prevent recurrent injuries and prolonged recovery, prediction and prevention techniques of sports-related concussion need to be acquired to reduce the risk of the first sports related concussion from taking place.

Concussions within the medical community are taken very seriously, if an athlete does not recover fully before returning to play there is a possibility of a rare but frequently fatal condition known as second impact syndrome.[14,19,20] Emerging research has suggested there may be multiple long term cumulative effects associated from sustaining repetitive concussions or other head trauma.[2,4] These chronic effects may include post-concussive syndrome, amyotrophic lateral sclerosis, clinically diagnosed depression, Alzheimer's disease, chronic traumatic encephalopathy, and elevated rates of suicide amongst the military population.[21-27] The potential risk of late-life consequences appears to increase with the number of concussions an individual has suffered; three or more concussions may be the point where individuals are more likely to suffer from cumulative effects.[2]

In order to start investigating ways to prevent concussions, researchers need to establish ways to predict individuals who are at a greater risk of suffering a concussion. Previous studies have evaluated prevention mechanisms and identified slower reaction times and processing speeds may help with risk reduction.[9,28] If characteristics within individuals can be identified that elevate an individual's risk of sustaining a concussion, prevention strategies can then be formulated to reduce these risks thus potentially reducing sport-related concussions. It has been speculated that gender, neck strength, and motor control all factor into individuals being at an increased risk of concussion. Tierney et al. found that females have a decreased neck strength through angular acceleration when compared to males, it has been hypothesized that males are more capable of bracing for the impact where as females may shy away from it.[8]

Sports-related concussions are unique injuries that present in a variety of ways; therefore, a multifaceted assessment is a commonly utilized approach for baseline measurement and positive post injury evaluation, including neuropsychological testing, cognitive testing, postural stability assessment, and a graded symptom checklist.[3] The Fourth International Consensus Statement (4th CIS) recommends the use of the standardized concussion assessment (SAC), the balance error scoring system (BESS), a computerized neuropsychological exam, and a graded symptom checklist.[29] Neuropsychological testing has become an integral part of the multifaceted concussion assessment recommended by the most recent international consensus statement on concussion management.[29] One of the most commonly used neuropsychological tests is the ImPACT test.[30-34] The ImPACT test is a computerized neuropsychological test that is divided into four composites: reaction time, processing speed, verbal memory, and visual memory. These tests are considered to be valid and reliable.[35] Other recommended tests in the assessment battery include the SAC and BESS. The SAC is a cognitive test that is sensitive in determining initial neurocognitive deficits, but has a practice effect that reduces sensitivity throughout the recovery process.[36,37] The BESS test assesses postural stability following a concussion; it has the same practice effect limitation but is useful for determining initial postural deficits.[4,38]

The multifaceted concussion assessment may be useful in prediction of sports injuries. Recent evidence suggests that there is a possible link between poorer neuropsychological test performance at baseline and an elevated risk of lower extremity sprain and strains.[28,39] Further, all four composites of the ImPACT test have been associated with an elevated risk of ACL injury.[39] This is clinically relevant as it suggests that neuropsychological differences could be predictive of impaired neuromuscular control, coordination errors, or delayed reaction time which may in turn predispose individuals to noncontact ACL injuries or other lower extremity sprains or strains.[39] This association could be pertinent to concussion prediction as well; with these studies serving as models. If specific individuals could be identified to be at a greater risk of concussion based off ImPACT composite scores and other aspects of the multifactorial baseline assessment then those individuals could potentially train to improve those areas of weakness. Butler et al. utilized the Star Excursion Balance Test to determine athletes at an increased risk of noncontact lower extremity injury in collegiate football players.[40] These studies show the importance of neuropsychological testing and balance assessment in predicting lower extremity injuries. Retrospectively the BESS test is effective at differentiating a healthy individual from an injured individual.[41]

PURPOSE OF THE STUDY

It is common clinical practice to administer a pre-participation exam (PPE) before allowing athletes to participate across many levels of athletics. A multifaceted baseline concussion assessment is an integral piece of the PPE; neuropsychological testing has become a standard component of the assessment. The ImPACT test is the most commonly utilized test among health care professionals. Neuropsychological deficits have traditionally been used to aid in the diagnosis of a concussion; however, emerging evidence has suggested that neuropsychological function, more specifically reaction time and processing speed, may be linked to an increased risk of lower extremity injury.[28,39] The purpose of this study was to examine the components of the PPE as potential predictors of future concussion risk. It was hypothesized that a difference would be found between all components of the PPE and future risk of concussion. It was also hypothesized that all components of the PPE would serve as predictors of future concussions.

CHAPTER 2

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METHODS

PARTICIPANTS

This study recruited 166 collegiate student-athletes from a NCAA division I institution in southeast Georgia. The 166 participants included 82 in the experimental group and 82 in the control group. The inclusion criterion for this study was any athlete who had sustained a concussion at the institution and any current athlete that matched those individuals based on gender, sport, and concussion history. The exclusion criterion for this study was incomplete or invalid ImPACT data. One participant was excluded for invalid ImPACT data and one for incomplete ImPACT data. All participants provided written informed consent as approved by the University's institutional review board (IRB).

INSTRUMENTATION

The ImPACT, BESS, and SAC were used for baseline concussion assessment. A medical history questionnaire was also used to determine if the participants had sustained a concussion before entering the institution or had a history of knee and/or ankle injury. (Appendix C, figure 1)

The ImPACT test (version 2.1 ImPACT applications Inc., Pittsburg, PA, USA) is a CNT, which is divided into five composites. These five composite scores are categorized as memory composite (verbal), memory composite (visual), visual motor speed composite (processing speed), reaction time composite, and impulse control composite. (Appendix C, Figure 2) The six tests include word memory, design memory, X's and O's, symbol match, color match, and three letters. (Appendix C, Figure 3) In the first module, word discrimination, a series of twelve words is displayed on the screen, once the list has appeared on the screen twice the participant is asked to identify those words out of a list of twenty-four. The second module, design memory, involves a series of twelve designs displayed on the testing screen, once these designs have shown up twice the participant is asked to identify which designs they saw out of twenty-four. The X's and O's is the third module, which involves a screen of X's and O's in a random assortment with three of them illuminated in yellow, which is displayed for 1.5 seconds. Following a distractor test, which is a display of two colored shapes and the participant is asked to react per the test instructions, the participant is asked to identify where the three illuminated X's and O's were. The fourth module, symbol matching, in composed of a series of symbols each over a number, the participant is required to remember these matches and identify later which number is associated with the shape. The fifth module, color match, shows the words red, green, and blue in one of the three colors, the participant is asked to react as quickly as possible when the word is in the matching color. The sixth module is three letter matching and comprises of three letters being displayed on the screen for 1.5 seconds, the participant is then asked to complete a distractor test, backwards counting from twenty-five, they are then asked to type the three letters in the order they appeared. The ImPACT test that not every section has a perfect score and each section is scored differently; for the reaction time composite of the test a lower score is better and for the verbal and visual memory composites, and processing speed composite of the test a higher score is better. For each composite multiple tests are computed together to make a net score. (Appendix C, Figure 4)

Overall, ImPACT has a sensitivity rate of 65.2-81.9 percent (moderate to good) and a specificity rate of 80.4-89.4 percent (good).[42-44] The reliability of the ImPACT test has been assessed for four of the five composites, motor processing speed ranges from poor to good, reaction time ranges from poor to moderate, visual memory ranges from poor to moderate, and verbal memory from poor to moderate**.** The impulse control composite is to correct for error or misunderstanding of instructions, or trying to intentionally sandbag the test, and to date there is no reliability value.[42,45,46] In order to account for this, a set of standards have been developed to determine an invalid test, these include: a word memory learning score below 69, a design memory learning score of less than 50 percent, an X's and O's total incorrect interference of greater than 30, a symbol match average correct reaction time score of greater than 1.75, a three letters total correct score of less than nine or average correctly counted less than ten, and an impulse control composite greater than thirty. The construct validity of ImPACT ranges from -0.96-0.87 for speed/reaction time and .69-.87 for memory; which suggests validity ranges from very poor to good.[47,48]

There are multiple postural control assessments available to athletic trainers, however, the BESS test is the most commonly used test and is recommended by the fourth international consensus statement and the national athletic trainer's association position statement.[29] The BESS test consists of three stances (double leg, single leg, and tandem) on two surfaces (firm and foam). A 41.6 x 50.1 x 6.1 cm Airex Balance Pad (Airex AG, Sins, Switzerland) was used and the test was video recorded for each individual. (Appendix C, Figure 5) The BESS test has a known practice effect associated with it, but has a sensitivity value of 0.34-0.80 in the initial assessment stages of concussions.[49-51] The interrater reliability of the test is 0.57-0.96 and the intrarater reliability is 0.74.[45,52,53] The test has been validated against the sensory organization test (SOT) and static measure force plates.[54,53,55]

The SAC is a cognitive mental-status test that is scored out of 30 points according to a standardized testing form, the higher the score on the test the better the athlete performed.[56] The SAC is composed of five sections; orientation, immediate memory, neurological screening, concentration, and delayed recall. (Appendix C, Figure 6) The test-retest reliability of the SAC is only 0.55, thought to be due to a practice effect associated with test; however it is highly sensitive (~95%) and moderately specific (76%) during the initial post-injury assessment.[56,57] The validity of the SAC has been found to be 0.75.[57]

PROCEDURES

All participants who have sustained a concussion were extracted from the university concussion database, per IRB approval. Each participant included in this study had completed baseline measurements on, BESS, SAC, ImPACT, and a PPE questionnaire upon entering the university. These baseline measurements were assessed during their PPE; the athletes were assessed on SAC, BESS, and later ImPACT with the team athletic trainer. The ImPACT test is generally assessed in a group setting, unless an athlete transfers in mid academic year. Unfortunately, the setting in which each participant was administered ImPACT was not recorded by the clinical staff during their PPE. Based on their concussion history prior to entering the university, gender, and sport concussed participants were matched to a healthy control participant who had not sustained a concussion while at the institution. Prior concussion history was obtained via self-report on the ImPACT test. The ImPACT scores for each individual must have been valid.

DATA ANALYSIS

This was a retrospective cross-sectional study that analyzed the baseline concussion data of 164. The demographic variables included gender, sport, and concussion history and were used for matching the control participants. The predictor variables included total ImPACT score, scores of the four separate composites of the ImPACT test, total BESS score, total SAC score, history of ankle injury, and history of knee injury. It is important to note that with the BESS test a lower score is better, with the SAC a higher score in better, with verbal and visual memory, and processing speed on the ImPACT a higher score is better; with reaction time a lower score is better.

STATISTICAL ANALYSIS

In this study the relationship between the components of the PPE and a concussion risk was examined by performing a descriptive analysis, frequency analysis, a series of one-way ANOVAs, a receiver operator characteristic curve (ROC), and discriminant function analysis. The descriptive analysis was used to examine gender, sport, and history of previous concussion before entering the university. The frequency analysis was used to examine the numbers of each variable in the study: gender, sport, history of concussion, impulse control composite, verbal memory composite, visual memory composite, reaction time composite, processing speed composite, BESS total score, SAC total score, ankle injury history total score, knee injury total score, and any lower extremity injury history total score. In addition to examining frequencies among the whole group, both analyses were also run by group. The nine one-way ANOVAs determined differences between a dichotomous assessment of previous ankle, knee, and combines lower extremity injury as well as the four ImPACT composites: (verbal memory, visual memory, reaction time, and processing speed), the BESS total score, and the SAC total score. After determining any significant differences, a secondary analysis examined if any of the PPE components would serve as predictors of a future risk of concussion. To determine this a ROC analysis was first performed to determine cut off values of the variables included in the ANOVAs. Once the cutoff values were determined a discriminant function analysis was performed in order to show any predictive value the variables might have held. The variables were then put into the discriminant function analysis based off the determined cut off values. Lastly, sensitivity and specificity values were determined for each variable to see if it served as a predictive test. For all inferential analyses, an a-prion level of 0.05 was established.

CHAPTER 3

DOES THE PREPARTICIPATION EXAMINATION AID IN IDENTIFYING FUTURE RISK OF CONCUSSION?

RESULTS

The descriptive statistics for each group and dependent variable are presented in Table 1. (Appendix C, Table 1) The experimental participants had a significantly smaller period of time between baseline testing and inclusion in this study (329.3 $\pm$ 286.7 and 498.1 $\pm$ 367.1, days respectively, P= 0.002). There was no significant difference between groups for concussion history (0.61 $\pm$ 0.91 and 0.57 $\pm$ 1.0, previous concussions respectively, P= 0.807) There were no significant differences between groups for ImPACT composite scores verbal memory (85.7 $\pm$ 8.9 and 87.8 $\pm$ 9.7, P= 0.155), visual memory (73.1 $\pm$ 13.5 and 75.9 $\pm$ 11.6, P= 0.134), reaction time (0.577 $\pm$ 0.067 and 0.597 $\pm$ 0.076 seconds, P= 0.071), and processing speed (39.8 $\pm$ 5.9 and 39.0 $\pm$ 6.9, P= 0.398), BESS scores (12.5 $\pm$ 5.4 and 13.1 $\pm$ 5.9 errors, P= 0.483), SAC scores (27.1 $\pm$ 1.7 and 27.2 $\pm$ 2.7, P= 0.39), and previous injury history. The participant frequencies are also presented in table 2. (Appendix C, Table 2)

In determining cut off scores, the ROC analysis, reveled the following cut off scores: verbal memory, 83.5; visual memory, 81.5; reaction time, 0.63; processing speed, 33.95; SAC, 26; and BESS, 13. Area under the curve from the ROC analysis was also determined. (Appendix C, Figure 7) After the ROC analysis positive predictive values (PPV) and negative predictive values (NPV) were determined for each variable as a predictor of future sports-related concussions. (Appendix C, Table 3). PPV and NPV were found to be moderate throughout the PPE components. Finally, the discriminative function analysis revealed that none of the PPE-related variables were significant predictors of future concussion risk.

CHAPTER 4

DOES THE PREPARTICIPATION EXAMINATION AID IN IDENTIFYING FUTURE RISK OF CONCUSSION?

DISCUSSION

This study sought to identify components of the PPE as predictors of sports-related concussions. Previous literature has focused primarily on concussion recovery, but the prevention and prediction aspects of concussions have received limited attention. The main finding of this study was that there were no statistically significant differences found between groups. The second main finding of this study was that none of the variables were found to be statistically significant predictors of concussions. Therefore, the current study suggests that the PPE may not be a clinical predictor of concussions.

This study found no statistically significant differences between groups of any of the variables; the four ImPACT composites, total BESS score, total SAC score, and history of ankle or knee injury. A recent study by Swanik et al. identified a relationship between all four ImPACT composites and noncontact ACL injuries.[39] Specifically, ACL injured participants had slower reaction times, faster processing speeds, lower visual memory scores, and lower verbal memory scores than healthy matched controls.[39] The means and standard deviations of the Swanik study were similar to this study's; however, the reaction times reported were lower (better) than the ones found in the current study. The injury occurrence for ankle history was similar between groups; however, the knee injury history occurrence approached significance at 0.059; injury incidence was higher in the experimental group. It is estimated that over 3 million ankle sprains occur annually throughout the athletic population of the United States, a majority of these affect athletes between the ages of 15 and 19 and males were at a greater risk.[58] Many collegiate athletes will begin their collegiate careers with a history of two or more ankle injuries.[58] The lack of statistically significant differences between groups on lower extremity injury history suggests that other injuries may not be related to concussion injury occurrence. However, concussion history has been linked to an increased incident of lower extremity injuries.[59]

The current study suggests that the PPE, including the multifaceted concussion baseline assessment and history of lower extremity injuries, was not a clinically significant predictors of concussions. Recently, Wilkerson et al. reported that reaction time via ImPACT was a moderately sensitive significant predictor of lower extremity injuries.[28] Wilkerson found a cut off value of 0.54s for reaction time as compared to the cutoff in this study, which was 0.63s.[28] Herein, PPVs and NPVs were found to range from moderate to good, meaning an athlete within each group was just as likely to be in the experimental group and they were to be in the control group. (Appendix C, Table 3) In each ImPACT composite, the BESS test, SAC performance, and history of lower extremity injury; similar same number of athletes had scores above or below the cutoff value set for each group. There were no previous studies to compare predictive values with on any of the variables except for reaction time. However, one abstract reported that concussions predicted individuals at an increased risk of lower extremity injury.[59]

The concussion tests used in the multifaceted baseline approach in this study are the most utilized tests across sports medicine professionals.[60] It is important to compare the results of this study to published normative data. Normative scores on all 4 composites of the ImPACT test have been reported, verbal memory: 76-99; visual memory: 60-96; reaction time: 0.43-0.79; and processing speed: 30.3-49.2.[33,39,28] The ranges between the current study and previous research on ImPACT score ranges seemed to fall within the published normative values. The BESS test has been reported to have a normative range of 5-19 and was found to be 3-43 for the current study.[4,61] The reported normative range for SAC is 26-28 and was found to be 23-30 for the current study.[4,62]

Multiple risk factors that could put an individual at an increased risk of concussion have been identified in the literature. A previous history of concussion is the most well-known and accepted risk factor that increases the risk of subsequent concussions.[2,4,15] There is a dose response mechanism associated with concussions that puts an individual at a two to six times greater risk of sustaining a concussion based on the number of concussions they have already suffered.[2,16,18] Unfortunately, concussion history does not aid in predicting the first concussion. Additionally, it has been suggested that females are at a greater risk of concussion than males; however, this is not conclusive in the literature.[9,32,63,64] Specifically, it's uncertain if females actually suffer more concussions or if they are just more likely to report them.[9,65,66] It has been debated in the literature that cervical strength may be the reason why females are at a greater risk of sustaining a concussion; this may be attributed to males bracing for an incoming impact as opposed to females and males shying away from one. [14,8,9,67] If cervical strength is a significant predictor of concussion, measures should be taken to assess neck strength and incorporate targeted exercises into the strength training every athlete should already be doing. Alosco et al. has suggested that attention deficit hyperactivity disorder (ADHD) may be a contributing risk factor for future concussions.[68] He utilized ADHD self-report via ImPACT and concluded that poor motor skills, lack of coordination, and reduced balance could contribute to the increased risk.[68] The problem with these generally accepted concussion predictors is most of them don't help prevent the first concussion from occurring; neck strength could help but there are currently no accepted measures to implement this. A mechanism of concussion prediction needs to be found that would aid in the development of a clinical prediction guide.

This study had a wide variety of athletes due to a matching inability. During the matching of participants we were unable to match concussed women's soccer and cheerleading perfectly due to not having enough athletes in those sports whom meet the inclusion criteria and they were instead matched to healthy volleyball, swimming, softball, and tennis student-athletes. Similarly, during the matching process we were also unable to match football due to not having enough available matches, we had to utilize men's soccer and baseball. ImPACT subgroups have been evaluated by sport and have found minor differences between sports within the subtests.[64] The major limitation within this is that each sport has different demands placed upon the athletes, therefore, leaving athletes to have different reaction times or processing speeds based on their specific sport demands.

This study was not without additional limitations. The potentially biggest limitation of this study was the missing data sets; provided in Table 1. The data for this project was collected as part of a larger study and not all data was complete. Previous concussion history is a known predictor and it was controlled for in this study and there were no differences between groups for the concussion history. The history of concussion and history of lower extremity injury were all self-reported which has moderate reliability.[69,70] However, self-report of previous concussion history on baseline assessment is common clinical practice.[7] The investigators had no way of knowing if the participants put forth full effort into their baseline assessments, but all data was determined to be valid based of published normative values.

Future research should continue to focus on methods to identify individuals who are at an increased risk for suffering their first concussion. The ImPACT composites and other components of the multifaceted assessment did not appear to be significant predictors of concussions. However, advanced reaction time tests could be utilized like the Dynavision or Quickboard systems or simulated on-field distractions could also be useful. Additionally, a more sophisticated postural stability measure, (e.g., force plates or the SOT tests) should be explored. Further sport specific assessments could be considered as each sport is going to have distinctive normative values associated with them for the tests involved in the assessment due to different sport specific demands. For swimmers and track athletes, measuring reaction time from signal to take off could produce significant predictor results. Overall, it is extremely important for future research to focus on prediction and prevention of the first sports related concussion.

The purpose of this study was to identify the multifaceted concussion assessment and history of lower extremity injuries as predictors of future sports-related concussion. It was founded that the PPE was not statistically significant in identifying athletes who may be at an increased risk of concussion; however, clinically the PPV and NPV values were moderate; meaning each participant was at equal risk of concussion. Therefore, looking further into the composites of the ImPACT test and into the subgroups may help with concussion prediction. Finding a clinical predictor could help decrease the amount of concussions occurring annually, thereby decreasing potential late-life impairments, and potentially decreasing lower extremity injuries that occur following a concussion.

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APPENDIX A

DOES THE MULTIFACTORIAL BASELINE CONCUSSION ASSESSMENT AID IN IDENTIFYING FUTURE RISK OF CONCUSSION?

LIMITATIONS

We could not control for history of concussion or injury.

We could not control who gets a concussion so there may not be an equal amount of male and female participants.

We could not force participants to put full effort into their baseline assessment.

The ImPACT test isn't as reliable when taken in a group setting.

There were varying levels of concussion education for participants in this study.

There were varying levels of concussion media coverage for participants in this study.

All participants in this study were from the same university in southeast Georgia and participants could not be matched perfectly based off matching criteria.

One participant was missing a SAC baseline in the experimental group.

Two participants in the experimental and two participants in the control group were missing or had invalid BESS baseline scores.

Twenty-two participants in the experimental and seventeen participants in the control group were missing self-reported lower extremity injury history.

DELIMITATIONS

We chose to use the concussions already in the institution concussion database and any concussions that occur before December 31, 2013 even though some of these participants are no longer at the university.

We chose to match the control and experimental subjects based off gender and sport.

ASSUMPTIONS

Each participant put full effort into all the baseline exams (ImPACT, BESS, SAC)

Each participant was honest when filling out their PPE

RESEARCH QUESTIONS

Would a relationship exist between the components of the PPE and concussion risk?

It was hypothesized that a relationship would be found between all components of the PPE and future risk of concussion.

Would any of the PPE components serve as predictors of future concussion risk?

It was hypothesized that all components of the PPE had potential to serve as predictors of future concussions.

APPENDIX B

DOES THE PREPARTICIPATION EXAMINATION AID IN IDENTIFYING FUTURE RISK OF CONCUSSION?

LITERATURE REVIEW

Introduction

Concussions are one of the most publicized sports-related injuries in the media. They are a major health concern and possibly one of the least understood injuries as they can present differently in each individual.[13,71] The term concussion comes from the Latin word concussus, which is defined as to shake violently, and is typically defined as the immediate and transient symptoms of mild traumatic brain injury.[72,73] It was estimated in 2006 that approximately 1.6-3.8 million concussions occur annually.[1] In the same 2006 study it was reported that of the 5.3 million Americans with disabilities, approximately 54 million of them have a disability that is related to a traumatic brain injury (TBI).[1] It is also estimated that 75-80% of TBIs that occur are considered mild traumatic brain injuries (mTBIs).[71] The Zurich consensus statement defines a concussion in five parts: (1) a concussion may be caused by a direct blow to the head, neck, face or somewhere else on the body where the force is transmitted to the head, (2) they typically result in a rapid onset of relatively short lived neurological functional impairment that resolves spontaneously, (3) they may result in neuropathologic changes but the acute symptom presentation reflects a functional disturbance instead of a structural injury, (4) they result in a graded set of symptoms that may include loss of consciousness (LOC) and the resolution of these symptoms generally follows a sequential course but doesn't necessarily have to, and (5) no abnormalities are shown on standard structural neuroimaging studies.[29] In the past decade the understanding of these injuries has dramatically increased and the management has become increasingly more conservative.

Concussions are a known serious health issue and are unique because they are not seen and are difficult for the athlete to understand.[43] In the minutes to days after concussive brain injury, brain cells that aren't irreversibly destroyed remain alive, but are in a vulnerable state.[72,74,75] Giza described this altered cell state and potential cell death as a neurometabolic cascade which has been tested in rats.[75] This neurometabolic cascade is described by the pathophysiology of a concussion, which includes a sequential pattern of neuronal dysfunction due to ionic shifts, altered metabolism, impaired connectivity, and changes neurotransmission.[75] When amnesia is present it probably represents metabolic or other dysfunction in the temporal cortical and/or hippocampal areas, either through a disconnection from another brain region or from disruption in the intrinsic circuitry.[11,75] For a concussion to be managed properly an accurate diagnosis is needed; unfortunately there is a substantial discrepancy in diagnoses in emergency rooms.[71] Accurate diagnoses based on a multifaceted assessment occur when a medical professional is there for the injury, to view the mechanism, or is seen shortly after the injury.

Coup, contrecoup, or combinations of both are the common mechanisms of sports-related concussions.[76] Coup injuries are described as a forceful blow to the resting, moveable head that produces maximum brain injury to the point of cranial impact.[76] Contrecoup injuries are defined as a moving head hitting an unyielding object that produces maximum brain injury to the opposite side of cranial impact as the brain shifts within the cranium.[76] There is currently no evidence to support one occurring more than another or one being more serious than the other; unfortunately there is no way to fully prevent either from occurring.[76]

Neurometabolic Cascade

The pathophysiology of a concussion consists of, but isn't limited to, the generation and accumulation of lactic acid, decreased intracellular magnesium, free radical production, increased inflammatory responses, and altered neurotransmission.[75] Immediately following an injury to the brain, there is a disruption of neuronal membranes, axonal stretching, and an opening of voltage-dependent potassium (K^+); this leads to an increase in extracellular K^+.[77-80] The nonspecific depolarization in the neurometabolic cascade leads to an early indiscriminate release of the excitatory amino acid glutamate; which crosses the synaptic cleft and binds on the post-synaptic receptors.[75,81-83] The surrounding glial cells absorb the massive efflux of extracellular K^+.[75,81-83] As the extracellular K^+ increases neuronal depolarization is triggered which leads to further release of excitatory amino acids.[75] Energy required Sodium (Na^+)/ K^+ pumps are then activated as an attempt to restore homeostasis, which triggers an increase in usage of glucose.[84-89] There is then an increase in glycolysis which leads to an increase lactate production.[75] This increase in lactate can lead to neuronal dysfunction by inducing acidosis, membrane damage, altered blood brain barrier permeability, and cerebral edema.[90-94] This is followed by calcium (Ca^{2+}) accumulation, which is seen within hours of injury and may last for two to four days.[95-98] Excess intracellular Ca^{2+} being sequestered in the mitochondria may then cause energy failure due to an impaired oxidative metabolism.[99-101] During this process there is also a reduction in intracellular magnesium (Mg^{2+}) levels, which may last for up to four days.[102-105] While Mg^{2+} levels are low both glycolytic and oxidative generation of adenosine triphosphate (ATP) are impaired.[75] It is important to note that this process, in particular the increases in Ca^{2+}, does not always lead to cell death.[75] When a mTBI occurs the axon is also damaged. This begins with axolemmal disruption and an increase in calcium.[75] The axon then swells and eventually dies or has irreversible damage.[75] This further supports the concept that concussions are predominately a physiological injury with minimal visible symptoms.

Epidemiology

In order to help understand concussions, the epidemiology must first be understood. A common misconception is that in order to sustain a concussion, LOC must be present at the time of injury; however, many studies have shown that LOC does not need to be present for an athlete to be diagnosed with a concussion. The normal LOC rate in concussions ranges from 6 to 8.9 percent.[4,15] In fact the most common symptoms at presentation are headache, dizziness, and confusion.[15] Another misconception associated with sports-related concussions is that LOC is a predictor of the seriousness of concussion; however, it has been found through research that this is not the case.[106] Lovell found that in a non athlete population LOC had no significant impact on the recovery of a concussion; these individuals were compared by LOC, no LOC, and possible LOC.[106] Post-traumatic amnesia (PTA) occurs in 19.1 to 27.7 percent of concussions and has been shown to be a significant predictor of the seriousness of the injury.[4,15]

Concussions in sports are most commonly caused by contact with another player.[107-109] Guskiewicz found that lower level athletes such as high school and NCAA division III athletes have been found to be at a higher risk for concussion than their higher level counterparts such as NCAA DII and DI athletes.[15] High school athletes tend to have a higher rate of concussions than collegiate athletes, possibly due to the different skill levels and body compositions.[108] When comparing high school and college athletes it is important to remember that the brains of many of these high school athletes are still developing.[33]

It has been suggested that high school and college football players that have a history of concussion are at a 3-5.8 times greater risk of sustaining a second concussion.[15,18,33,106-109] This increased risk is known as dose response. This dose response relationship also states that each subsequent concussion will have a longer recovery than the previous concussion.[18,110] Marar found that concussions account for 5.9% of high school injuries and 13.2% of all sports-related injuries; however football accounted for about 47% of these. [109]

Gender Issues

Through multiple studies it has been reported that females are at approximately twice as likely to sustain concussions than their male counterparts in gender comparable sports.[65,108,109,111] It is thought that the increased participation in aggressive sports and the general increase in competitive nature has led to bigger, faster, and stronger athletes which may result in the increased velocity of collisions or increase repeating rates and the severity of head injuries in football.[15] These sex differences may be attributable to biomechanical differences between genders.[108] It is argued that male athletes could potentially be at a higher risk for concussions due to their aggressive nature and faster pace; however, female athletes are generally smaller and have weaker neck strength, which would put them at a higher risk.[65] This difference is significant because it means when a male is about to have contact with another player they are braced for it and can absorb the shock in a productive and protective manner, distributing the forces through the body and not just through the head, as opposed to when a female gets hit she tends to duck instead of bracing for the impact.[8,9,65] It should also be noted that participation in female athletics has reached a high volume and is constantly increasing.[65] In a study done by Covassin women's soccer had the highest rate of concussion and women's lacrosse had the highest inherent risk during a game.[65]

Assessment and Return to Play

It is important that clinicians are aware of the fact that sports-related concussions frequently occur without observed LOC or post-traumatic amnesia (PTA).[15,11,109] These symptoms usually indicate a more severe TBI during the acute phase of a sports-related concussion.[37] McCrea also states that even though LOC is generally a defining and essential factor of mild traumatic brain injury (mTBI), for more than thirty years the neurosciences have shown a concussion can occur without LOC.[37]

Any combination of the following symptoms can be seen in a concussion: a feeling of being stunned or seeing bright lights, brief LOC, lightheadedness, vertigo, loss of balance, headache, cognitive and memory dysfunction, tinnitus, blurred vision, difficultly concentrating, lethargy, fatigue, personality changes, inability to perform daily activities, sleep disturbances, and/or motor or sensory symptoms.[72] Headache, dizziness, and confusion are three of the most common symptoms associated with concussions occurring at a 86-94 percent rate, a 67-75 percent rate, and a 45-59 percent rate respectively.[15,109,112] There is no universal assessment battery following a concussion, but most include a symptom assessment and neurocognitive function assessment and balance assessment.[29,36] However, most clinicians agree that a baseline assessment needs to be performed and that each sports-medicine team should have protocols in place. These baseline assessments are usually done during preseason or the pre-participation exam (PPE). The fourth international consensus statement (CIS) is becoming widely accepted as the gold standard in concussion management.[29] The fourth CIS recommends a step wise protocol for recovery and a multifaceted assessment approach.

The multifaceted assessment battery is determining whether the athlete needs to be referred for further evaluation. The methods in which we as clinicians assess concussions are, however, flawed. In many assessment methods there is a known practice effect.[113] This practice effect occurs when an athlete takes a test multiple times and gets better with practice. Guskiewicz suggests that because of this practice effect when an athlete who suffered a sports-related concussion returns back to baseline scores they may not actually be fully recovered since the scores should improve with practice.[4,38,113] In other words, the athlete should be able to perform at baseline despite some neurocognitive impairment because they already know the test format due to a practice effect and repeat administration.[113] Therefore a multifaceted assessment is extremely important.[37,113] A multifaceted assessment also increases the potential for the sports-medicine professional to recognize any cognitive defects related to the mTBI. It is also important that the significance of a clinical examination is not overlooked and it is understood that this is an irreplaceable part of the assessment puzzle.[76] This multifaceted assessment should consist of neurocognitive tests, reaction time tests, balance and postural stability tests, and a self-reported symptom checklist.[29] The assessment of concussions has evolved with the increase of mTBI related research and reaffirming that postural stability is an important piece of a multifaceted approach to the management of concussions.[114]

Postural assessment is usually a key post-concussion assessment tool in sports medicine; the Balance Error Scoring System (BESS) is commonly used and recommended by the fourth CIS.[29] However, there have been multiple limitations found with this assessment tool. In a study done by Finnoff et al. it was found that intrarater and interrater reliability ranged from poor to good. (0.50-0.88; 0.44-0.83 respectively).[52] These researchers also suggested that in order to accurately conclude that point differences were not necessarily due to scoring validity; a 7.3 point difference in BESS scoring would be needed in order to conclude the athlete actually had postural impairment.[52] The double leg stances in BESS have been found to result in almost no errors.[52,114] Hunt did a study where they modified the BESS assessment, since the double leg stances rarely attribute to score variance they suggested that those stances be eliminated for a more reliable form of BESS.[114] This is important because sound instruments and measurements are a necessity in concussion assessment and management. Fox established that there should be at least a thirteen-minute rule when performing the BESS test.[115] The reasoning behind this rule is that effects of fatigue generally last for about thirteen minutes before postural control can return to the baseline measurement; it is important to make sure that postural control deficits are due to the concussion and not due to fatigue.[115] Unfortunately, waiting to assess a concussion to assure fatigue isn't playing a part is not very practical. Another factor to take into consideration when administering the BESS test is it has been shown that performance decreases when it is done in a sideline environment versus a clinical environment in healthy patients.[116] Therefore, when assessing individuals with the BESS test baseline testing should be done in a similar environment, to where they will be tested in post-injury. The most common initial presentation in concussions has been found to be a dazed facial expression and unsteady gait and the most common symptoms were headache, dizziness, and confusion.[15,109] Recent research has indicated that LOC and PTA are not great predictors of the severity of a sports-related concussion; however, the presence of these symptoms should not be overlooked. LOC and PTA are not good predictors of the recovery of a concussion because they do not occur in a large percentage of them; however, it has been found that dizziness initially may be a predictor of a prolonged recovery.[12,15] There are four symptom clusters associated with concussions, the migraine cluster, cognitive cluster, sleep cluster, and neuropsychiatric cluster.[117] The migraine cluster includes headache, dizziness, noise and/or light sensitivity, and numbness or tingling; this is most often associated with prolonged recovery.[12,17] The cognitive cluster includes fatigue, difficulty concentrating and/or remembering, and cognitive slowing. The sleep cluster includes difficulty falling asleep, sleeping less than usual, and sleeping more than usual. The last cluster, the neuropsychiatric cluster, includes being more emotional, sadness, nervousness, and irritability. The cluster that's most often associated with prolonged recovery is the migraine cluster.[12,17]

Reporting Issues/ Concussion Awareness

Concussions may arguably be the most detrimental under-reported sports-related injury. Athletes have pressure from their parents, coaches, and teammates to win and compete. Many athletes have the perception from parents that if you can't see the injury then it doesn't exist. In a recent editorial, focusing on Canadian youth hockey, a parent stated that, "he could understand the parents of players with concussions wanting to ignore their children's medically diagnosed brain injury…that parents had a significant amount of time and money invested in the child, and if there was nothing visibly wrong, he should be on the ice with his teammates."[117] McCrea et al. found that there are three main reasons why athletes don't report their concussions: (1) they didn't think it was serious enough, (2) they didn't want to sit out of participation, and/or (3) they didn't realize symptoms were concussion-related.[118]

Kaut suggested that improving knowledge of concussions might improve the reporting rate.[119] Unfortunately, we may need to educate more than just the athletes, parents, and coaches on what a concussion is and how it needs to be managed. The lack of education and awareness of concussions, their signs and symptoms, and the seriousness of the injury is a problem throughout society. In a study done by Chrisman a little over 40% of physicians stated that they were not confident in diagnosing a concussion and almost 64% said they were not confident in managing a concussion.[120] This is extremely concerning considering we all rely on physicians as part of the concussion diagnosis and concussion management programs. That being said a positive diagnosis can be challenging and should include a team approach.[29]

The importance of an accurate diagnosis cannot be underestimated.[71] With any sports-related concussion there lies a risk of complications and life-threatening injuries that the athletic trainer or other sports-medicine professionals should be constantly aware of. The time frame for these potential complications can range anywhere from minutes to days following the injury; they include subdural and epidural hematomas, which are independent of the concussion itself, and second impact syndrome (SIS).[76] Post-concussion syndrome is another possible complication associated with sports-related TBI and potentially the most likely when compared with hematomas and SIS. The athletic trainer must be aware of the signs and symptoms of these conditions and know when to refer the athlete if one of these is suspected; SIS though the rarest of the three is arguably the easiest to recognize.

A main concern of an athlete having a heightened level of activity or no rest immediately following a concussion is the risk for subsequent injury and the potential of a rare but catastrophic condition known SIS; which has a fifty percent mortality rate associated with it. In effort to prevent SIS a full recovery is necessary before returning an athlete to play. Reasoning for prescribing rest to athletes with mTBIs is prominently based off the possibility that high levels of activity can magnify the acute pathophysiology of the concussion. This concern comes from the idea of a neurometabolic cascade occurring after the initial injury that causes cell death and puts those cells that survive in a weak state, due to the K^+ influx.[75] The neurometabolic cascade was derived from a study on rats since such studies are not ethical to perform on human subjects. Majerske found that there is potential danger in delayed/prolonged recovery both extremely low and extremely high activity levels following a sports-related mTBI.[121] Even though these results were not significant to generalize to the entire athletic population, they do suggest that full bed rest, especially for more minor injuries, may not be the best treatment. It has also been found that "physical and/or mental exertion can temporarily exacerbate postconcussion symptoms at any stage of recovery (as well as elicit post-concussion-like symptoms in uninjured adults). It is unclear whether this has any long-term neuropathological or functional consequences"[122] Due to this uncertainty, most medical professionals would agree it is better to be conservative and prescribe some form of rest rather than potentially further injure the athlete.

Cumulative Effects

Concussion recovery is defined as the brain returning to a pre-morbid function level.[2,4,29,110] In accordance to this definition the concept of a no athletic exposure and recovery period until symptom free and back to baseline/normal is commonly observed.[4,6,29] Most if not all of the research points to a conservative concussion management program in order to limit any long term effects of a concussion. Conservative concussion management is also the approach recommended by the most recent international consensus statement.[29]

A history of previous concussion(s) not only poses a potential increased risk of subsequent concussion(s), but is also potentially associated with prolonged recovery of subsequent concussion.[2] A subsequent concussion is most likely to occur within seven to ten days of the first concussion; and athletes who sustain one concussion in an athletic season are three times more likely to sustain a second concussion in that same season.[2,6,15] The problem with a subsequent concussion occurring in the first seven to ten days after the first is that the first concussion may not be fully healed so the individual is at risk of suffering from the extraordinarily rare but potentially fatal SIS.[14,123] The concept of a symptom free waiting period was tested in a recent study; it was found that where the incidence of a subsequent concussion within the same sports season is low, the observation of a symptom free waiting period did not seem to influence the recovery period or reduce the risk of a subsequent concussion in the same sports season.[6]

Another problem with potential cumulative effects is that evidence in clinical practice indicates that we could underestimate the amount of time it takes to recover back to "normal" brain functions from a concussion.[124] According to Slobounov the initial two days following a concussion are the most problematic when it comes to balance and postural coordination.[124] When suffering from a concussion an athlete is likely to use a greater number of cognitive resources, likely from the occipital, temporal, and parietal, areas, to achieve normal brain function.[124] It is also important to understand that behavioral symptom resolution may not be indicative of brain injury resolution.[124] All of these factors point to the importance of a gradual and progressive RTP management program.

Post-concussion syndrome is one potential cumulative effect that arises around ten days post concussion and can last for three or more months. Typically a physician will diagnose this condition, but it is important to note that this issue is commonly misunderstood. Post concussion syndrome is when an athlete is experiencing symptoms such as headaches and dizziness for weeks or months following a concussion. Another important long term effect is chronic traumatic encephalopathy (CTE); which has only been diagnosed post-mortem but recent evidence suggests it could be diagnosed through positron emission tomography (PET) scans.[21,22,24,25] CTE is commonly misdiagnosed for depression and/or dementia, since it was traditionally only diagnosed through autopsy and dementia is part of the disease.[21,22,24,25]

Cognitive and Physical Rest

The recovery and outcome of sports-related concussions may be modified by multiple factors that may require more conservative management strategies.[7] The most recent consensus statement says that recovery must consist of both physical and cognitive rest; where cognitive rest is defined as anything that requires concentration and attention.[7] An important relationship between activity following a concussion and performance on neurocognitive tests, especially on visual memory and reaction time, has been established.[121] Even when an individual self-reports being symptom free their brain still may not be recovered, neurocognitive testing has been shown to pick up some of these deficits and also pick up minor deficits post-exercise.[121,125] Exercise has become an important aspect in most rehabilitation programs for athletic injuries; however, the understanding of rehabilitation following a TBI is fairly inconclusive. Currently rest is one of the most prescribed methods for treating a concussion.[6] For a long time it has been considered one of the best medicines for a concussion.[122] Moser found that prescribed rest is ideal in treating concussions long term and/or delayed recovery.[126] Many concussion guidelines still recommend rest as part of the concussion management/recovery program, including the Zurich Consensus guidelines for sports-related concussion.[29] This is important to note because the Zurich Consensus guidelines are arguably the most widely accepted guidelines for sports-related concussion.[29] However, there isn't a widely accepted definition of rest following a concussion. Rest can be interpreted by health care professionals and patients as anything from partial activity restriction to bed rest.[122] It is questionable as to what the duration of rest following a sports-related concussion should be, but the most widely accepted duration of rest is until the athlete is asymptomatic.[122] According to the Zurich consensus guidelines once the athlete is asymptomatic then a graded resumption of activities is the best return to play method, during this some rest is still exhibited since they don't return to full participation immediately.[7] It is important to note that an athlete may be asymptomatic but still have neurocognitive and postural/balance deficits; therefore being symptom free should not be the determining factor for returning back to activities.

Neurocognitive Functioning/ Neuropsychological Testing

Brain development processes during adolescent years high school athletes appear to have longer lasting neurocognitive effects following a sports-related TBI.[127] Before a neuropsychological testing program is implemented several issues should be considered which include, test-specific training requirements and methodological issues, the practicality of baseline testing, the reliability and validity of individual tests comprising the test battery, and the protocol for interpretation of the post injury test results.[76] The protocol for interpreting the results is important because computerized neuropsychological tests generally require a specialist to interpret the results not an athletic trainer, and sometimes is covered by state practice acts.

Neurocognitive testing is often a complex statistical process to measure recovery which is often further complicated by practice effects and other factors.[76] Therefore, we should interpret all test results in the context of all the clinical information from the multifactorial assessment and the individual's medical history.[76] In a study done by Brown et al. it was found that gender, SAT scores, alertness levels, and the sport the athlete participates in might influence performance on computerized neuropsychological tests.[64] When looking at levels of alertness, if the athlete is in-season or in preseason they will typically experience higher levels of fatigue so it may be beneficial to baseline test them before their season or preseason practices begin.[64] It has also been found that athletes can show neurocognitive defects after they report being symptom free.[128]

We know the practice effect is a major problem we face with any concussion assessment. Therefore, reducing practice effects would be a great way to make accurate RTP decisions and to increase the reliability of these tests.[128] Since it is difficult to reduce the practice effects of some of these tests it is reasonable to expect the athlete to exceed their baseline scores before considering them recovered. However, not having the athlete test on ImPACT every day post injury will help reduce this practice effect; the current recommendation through ImPACT is to test every 72 hours.

Another problem we face is that athletes are typically baseline tested in a group setting but their testing post-injury is in a solitary setting. This is an issue because the group setting score may not be reflective of how well they could actually do on baseline, based off of distractions and potentially how the directions for the exam are given.[44] For example, coaches should not be allowed in the group testing room before or during the baseline exam so they do not influence the athletes to try to intentionally do poorly. A positive thing about computerized neuropsychological testing, however, is research has found that it's very difficult for an athlete to intentionally perform poorly on their baseline testing without hitting the "red flags"/validity indicators.[44] In a study performed by Erdal athletes who have fully completed their athletic career were instructed how to intentionally "bomb" the imPACT test and were rewarded for successfully doing so; however, about ten percent.[44]

The ImPACT test has been found to be both valid and reliable. The test was found by Schatz to have a sensitivity rate of 81.9 percent and a specificity rate of

89.4 percent.[42] Another study found the specificity rate to be 80.36 percent.[43] The reliability of the ImPACT test has been done for each of the four components, motor processing speed at .76-.88, reaction time at .63-.77, visual memory at .43-.72, and verbal memory at .54-.79.[34,35,45]

Prediction of Lower Extremity Injury

When reviewing the literature, computerized neuropsychological testing has additionally been utilized in predicting lower extremity orthopedic injuries.[28,39] Swanik found that all four components of the computerized neuropsychological test, ImPACT, could be linked to an increased risk of a non-contact anterior cruciate ligament (ACL) sprain.[39] Wilkerson did a similar study looking at the reaction time of athletes via the ImPACT test and found that an elevated risk of lower extremity sprains and strains may be associated with reaction time.[28] Even though there are pros and cons to each piece of the multifactorial concussion assessment. these studies should be the foundation of multiple research studies, not only for lower extremity injuries, but for concussions as well. Once a link to predicting concussions is found, prevention strategies may be researched and set in place. The use of this has the potential to cross over to the prediction of concussions.

Swanik looked at the use of ImPACT testing and the risk of noncontact ACL injuries. He utilized a case-control design to compare four of the five composite scores of ImPACT: verbal memory, visual memory, processing speed, and reaction time, and noncontact ACL injuries that required surgery.[39] In this study a one-way analysis of variance (ANOVA) was used to analyze the neurocognitive function between the noncontact ACL injury group an the no ACL injury group, with a P value of .05.[39] Statically significant slower reaction times and processing speeds were found between groups along with significantly worse visual and verbal memory composite scores.[39]

Wilkerson looked at reaction time via the ImPACT computerized exam as a predictor of lower extremity sprains and strains in collegiate football players. A receiver operating characteristic analysis (ROC), and a 2 X 2 cross-tabulation analysis were utilized to determine a difference between the two groups in this study.[28] It was found that reaction times slower than .545 seconds left an athlete at a significantly higher risk of sustaining a slower extremity sprain or strain as compared to Swanik who found a reaction time slower than .570 left an athlete at a significantly higher risk of a noncontact ACL tear.[28,39]

Another recent study linked dynamic balance to noncontact lower extremity injuries in collegiate football athletes.[40] This study utilized the Star Excursion Balance Test to determine athletes at an increase risk of noncontact lower extremity injury.[40] A ROC curve was developed to establish a cutoff point in effort to achieve maximum sensitivity and specificity followed by the creation of a 2 X 2 table to determine relative risk.[40] It was determined that athletes with a score of 89 percent or less were at a 3.5 times greater risk of noncontact lower extremity injury.[40] These studies show the importance of neuropsychological testing and balance assessment in determining lower extremity injuries.

Recovery

It has been documented that collegiate athletes who have a history of mTBIs are more likely to report any signs and symptoms following a subsequent concussion.[32] Recovery, the understand/testing of, of a sports-related concussion is potentially one of the greatest weaknesses in the medical field. This is partially because there is no concrete way to determine when a concussion is fully healed; especially considering that athletes are known to underreport their symptoms and most tests have practice effects.[74]

It has been suggested that in clinical practice we underestimate the time it takes to fully recover from a mTBI.[124] Which leads to one of the biggest questions in concussions right now, when to encourage patients to make the transition from rest to activity resumption after a sports-related concussion.[122] Many sports-medicine professionals will agree that complete bed rest is not necessary, at least with the mild to moderate TBIs. Silverberg argues that any bed rest exceeding three days probably isn't beneficial to the athlete.[122] The Zurich consensus statement says that athletes should have a graded return to play protocol that spans over seven days and many recommendations would agree that return to play should be gradual.[29,76,129] This agrees with the window of increased risk that's associated with sustaining a subsequent mTBI. It is also known that concussions should be treated on an individual basis (adhering to professional protocols) and the clinician must understand that no concussion is the same. The question, when is the appropriate time to start an athlete on a recovery progression, is still a major topic of debate in the sports-medicine world.

In a study done by Broglio it was found that cognitive decrements extend beyond self-reported symptom resolution, which supports the notion of a conservative graded recovery process.[128] As we know a premature RTP puts the athlete at an increased risk of catastrophic injury, such as SIS.[128] However, it is important to note that some clinicians argue the existence of SIS and suggest that the same results could have occurred by the single blow/second blow that caused "so-called" SIS.[130] A premature return to play may also increase an athlete's risks of the other cumulative effects as well, such as CTE, amyotrophic lateral sclerosis (ALS), Alzheimer's disease, dementia, and/or depression. The importance is not predicting the length of recovery an individual endures but the risk of repeat injury and long term consequences.

Prevention/Prediction

In order to effectively develop preventative measures in sport-related concussions our knowledge of rates, patterns, and risk factors needs to dramatically increase.[108] An increased emphasis on athlete history would improve accurate diagnosis, would lead to increased care, and potentially an increased recovery time. Concussion history could be more accurately reported if it was more accurately defined on the pre-participation exam (PPE).[10] Unfortunately some of the population still sees a concussion and a "ding" or having your "bell rung" as being separate issues. If on the PPE an athlete was asked if they have ever sustained a concussion after being given a list of all the symptoms associated with one then the history may be more accurate.[10]

Conclusion

Overall, concussions are one of the least understood injuries in the United States, if not the world and are heavily underreported, 50 percent or more of these injuries being unreported.[4] Over the past two decades concussions have become one of the most publicized injuries in the United States. Research of these injuries has focused heavily on assessment, initial presentation, different symptom clusters, recovery, and associated risks; however, there has been extremely little research on the prediction and prevention of these serious injuries. When diagnosing and treating concussions it is important to remember that they can present in a variety of different ways and you need to take a multifaceted approach in diagnosing these injuries. It is equally important to educate the individuals that participate in high-risk activities about what a concussion is and how it can affect them.[131,132]

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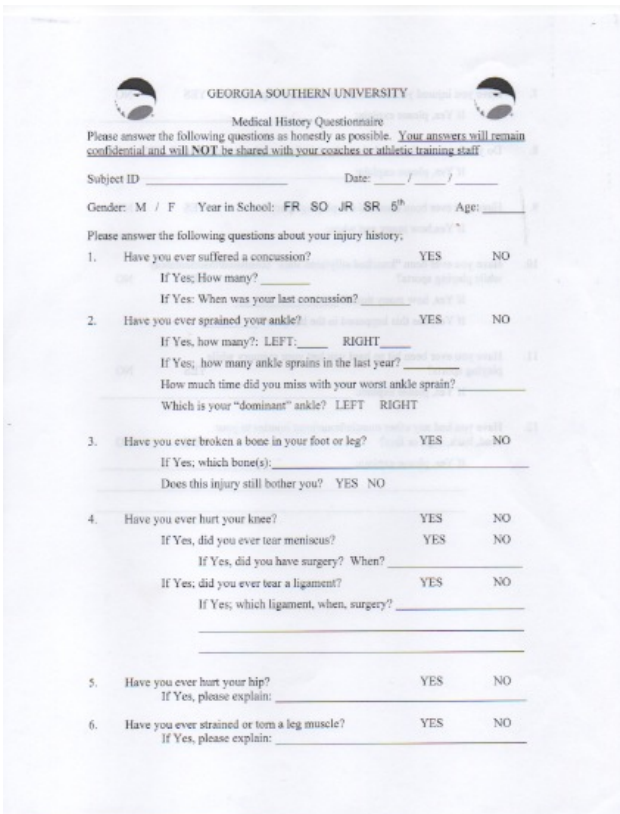
APPENDIX C

DOES THE PREPARTICIPATION EXAMINATION AID IN IDENTIFYING FUTURE RISK OF CONCUSSION?

TABLES AND FIGURES


GEORGIA SOUTHERN UNIVERSITY

Medical History Questionnaire

Please answer the following questions as honestly as possible. Your answers will remain confidential and will **NOT** be shared with your coaches or athletic training staff

Subject ID ____________ Date: ____/____/____

Gender: M / F Year in School: FR SO JR SR 5th Age: ____

Please answer the following questions about your injury history;

1. Have you ever suffered a concussion? YES NO
   If Yes; How many? ______
   If Yes: When was your last concussion? ______
2. Have you ever sprained your ankle? YES NO
   If Yes, how many?: LEFT:____ RIGHT____
   If Yes; how many ankle sprains in the last year? ______
   How much time did you miss with your worst ankle sprain? ______
   Which is your "dominant" ankle? LEFT RIGHT
3. Have you ever broken a bone in your foot or leg? YES NO
   If Yes; which bone(s): ______
   Does this injury still bother you? YES NO
4. Have you ever hurt your knee? YES NO
   If Yes, did you ever tear meniscus? YES NO
   If Yes, did you have surgery? When? ______
   If Yes; did you ever tear a ligament? YES NO
   If Yes; which ligament, when, surgery? ______
5. Have you ever hurt your hip? YES NO
   If Yes, please explain: ______
6. Have you ever strained or torn a leg muscle? YES NO
   If Yes, please explain: ______

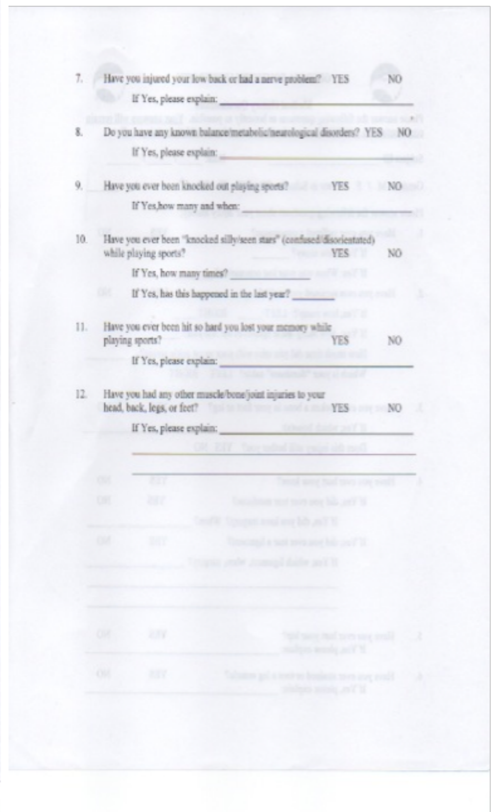

7. Have you injured your low back or had a nerve problem? YES NO
   If Yes, please explain: ______
8. Do you have any known balance/metabolic/neurological disorders? YES NO
   If Yes, please explain: ______
9. Have you ever been knocked out playing sports? YES NO
   If Yes,how many and when: ______
10. Have you ever been "knocked silly/seen stars" (confused/disorientated) while playing sports? YES NO
    If Yes, how many times? ______
    If Yes, has this happened in the last year? ______
11. Have you ever been hit so hard you lost your memory while playing sports? YES NO
    If Yes, please explain: ______
12. Have you had any other muscle/bone/joint injuries to your head, back, legs, or feet? YES NO
    If Yes, please explain: ______

Figure 1: Pre-Participation Exam Questionnaire

Word Memory					
Hits (immediate)	12				
Correct distractors (immed.)	12				
Learning percent correct	100%				
Hits (delay)	11				
Correct distractors (delay)	12				
Delayed memory pct. correct	96%				
Total percent correct	98%				
Design Memory					
Hits (immediate)	9				
Correct distractors (immed.)	7				
Learning percent correct	67%				
Hits (delay)	8				
Correct distractors (delay)	7				
Delayed memory pct. correct	63%				
Total percent correct	65%				
X's and O's					
Total correct (memory)	10				
Total correct (interference)	120				
Avg. correct RT (interfer.)	0.47				
Total incorrect (interference)	2				
Avg. incorrect RT (interfer.)	0.39				
Symbol Match					
Total correct (visible)	27				
Avg. correct RT (visible)	1.37				
Total correct (hidden)	2				
Avg. correct RT (hidden)	0.97				
Color Match					
Total correct	9				
Avg. correct RT	0.72				
Total commissions	0				
Avg. commissions RT	0				
Three Letters					
Total sequence correct	2				
Total letters correct	11				
Pct. of total letters correct	73.33%				
Avg. time to first click	1.24				
Avg. counted	24.4				
Avg. counted correctly	24.4				

Figure 2: ImPACT Composite Score Sheet

Verbal Memory Composite

***1. Average of*:** (Word Memory- Total Percent Correct)
(Symbol Match- Total Correct/Hidden)/9*100
(Three Letters- Percent Total Letters Correct)

Visual Memory Composite

***2. Average of*:** (Design Memory- Total Percent Correct)
(X's and O's- Total Correct/Memory)/12*100

Visual-Motor Speed Composite (Processing Speed)

***3. Average of*:** (X's and O's- Total Correct/Interference)/4
(Three Letters-Average Counted Correctly)*3

Reaction Time Composite

***4. Average of*:** (X's and O's- Average Correct Reaction Time Interference)
(Symbol Match- Average Correct Reaction Time/Visible)/3
(Color Match- Average Correct Reaction Time)

Impulse Control Composite

***5. Average of*:** (X's and O's- Total Incorrect/Interference)
(Color Match- Total Commissions)

Figure 3: ImPACT Mix and Match Scoring

	Exam Type	Baseline
	Word Memory	
	Hits (immediate)	12
	Correct Distractors (immediate)	12
	Learning Percent Correct	
	Hits (delay)	12
	Correct Distractors (delay)	12
	Delayed Memory Percent Correct	12
1	Total Percent Correct	
	Design Memory	
	Hits (immediate)	12
	Correct Distractors (immediate)	12
	Learning Percent Correct	
	Hits (delay)	12
	Correct Distractors (delay)	12
	Delayed Memory Percent Correct	12
2	Total Percent Correct	
	X's and O's	
2	Total Correct (memory)	12 (/12x100)
3	Total Correct (interference)	(/4) *no perfect score; 125 is very good
4	Avg. Correct RT(interference)	
5	Total Incorrect (interference)	
	Avg. Incorrect (interfernce)	
	Symbol Match	
	Total Correct (visible)	27
4	Avg. Correct RT (visible)	(/3)
1	Total Correct (hidden)	9 (/9x100)
	Avg. Correct RT (hidden)	
	Color Match	
	Total Correct	9
4	Avg. Correct RT	
5	Total Commissions	
	Avg. Commissions RT	
	Three Letters	
	Total Sequence Correct	5
	Total Letters Correct	15
1	Percentage of Total Letters Correct	15
	Avg. Time to First Click	
	Avg. Counted	
3	Avg Counted Correctly	(x3)

Figure 4: ImPACT Perfect Score Cheat Sheet

Figure 5: BESS Test

Assessment of Concussion - SAC   Form A

Name:________________________________

Team:______________ Examiner:__________

Date of Exam:________ Time:______________

Exam (Circle One): Bline   Injury   Post-Game

Follow-Up Day:______________________

Introduction:

I am going to ask you some questions.
Please listen carefully and give your best effort.

Orientation

What Month is it?	0	1
What's the Date today?	0	1
What's the Day of Week?	0	1
What Year is it?	0	1
What Time is it right now? (within 1 hour)	0	1
Award 1 point for each correct answer.		
Orientation Total Score		

Immediate Memory

I am going to test your memory. I will read you a list of words and when I am done, repeat back as many words as you can remember, in any order.

List	Trial 1		Trial 2		Trial 3	
Tiger	0	1	0	1	0	1
Orange	0	1	0	1	0	1
Puddle	0	1	0	1	0	1
Truck	0	1	0	1	0	1
Baseball	0	1	0	1	0	1
Total						

Trials 2 & 3 I am going to repeat that list again. Repeat back as many words as you can remember in any order, even if you said the word before.

Complete all 3 trails regardless of score on trial 1 & 2. 1 point for each correct response. Total Score equals sum across all 3 trials.

Do not inform subject that delayed recall will be tested.

Immediate Memory Total Score	

Exertional Maneuvers

If subject is not displaying or reporting symptoms, conduct the following maneuvers to create conditions under which symptoms likely to be elicited and detected. <u>These measures need not be conducted if a subject is already displaying or reporting any symptoms</u>. If no conducted, allow 2 minuets to keep time delay constant before testing Delayed Recall. These methods should be administered for baseline testing of normal subjects.

Exertional Maneuvers	
5 Jumping Jacks	5 Push-Ups
5 Sit-ups	5 Knee Bends

Neurologic Screening

Loss of Consciousness/ Witnessed Unresponsiveness	☐ No ☐ Yes Length:	
Post-Traumatic Amnesia? Poor Recall of events after injury	☐ No ☐ Yes Length:	
Retrograde Amnesia? Poor recall of events before injury	☐ No ☐ Yes Length:	

	Normal	Abnormal
Strength	☐	☐
Right Upper Extremity	☐	☐
Left Upper Extremity	☐	☐
Right Lower Extremity	☐	☐
Left Lower Extremity	☐	☐
Sensation - examples: Finger-to-Nose/Romberg	☐	☐
Coordination - examples: Tandem Walk/Finger-Nose-Finger	☐	☐

Concentration

Digits Backward: I am going to read you a string of numbers and when I am done, you repeat them back to me backwards, in reverse order of how I read them to you. For example, if I say 7-1-9, you would say 9,1,7.

If correct, go to next string length. If incorrect, read trial 2. 1 pt. possible for each string length. Stop after incorrect on both trails.

4-9-3	6-2-9	0	1
3-8-1-4	3-2-7-9	0	1
6-2-9-7-1	1-5-2-8-6	0	1
7-1-8-4-6-2	5-3-9-1-4-8	0	1

Months in Reverse Order: Now tell me the months of the year in reverse order. Start with the last month and go backward. So you'll say December, November…Go ahead. 1 pt. for entire sequence correct.

Dec-Nov-Oct-Sept-Aug-Jul-Jun-May-Apr-Mar-Feb-Jan	0	1
Concentration Total Score		

Delayed Recall

Do you remember the list of words I read a few times earlier? Tell me as many words from the list as you can remember in any order. Circle each word correctly recalled. Total score equals number of words recalled.

Tiger Orange Puddle Truck Baseball

Delayed Recall Total Score	

SAC Scoring Summary

Exertional Maneuvers & Neurologic Screening are important for examination, but not incorporated into SAC Total Score.

Orientation	/ 5
Immediate Memory	/15
Concentration	/ 5
Delayed Recall	/ 5
SAC TOTAL SCORE	/30

Figure 6: SAC

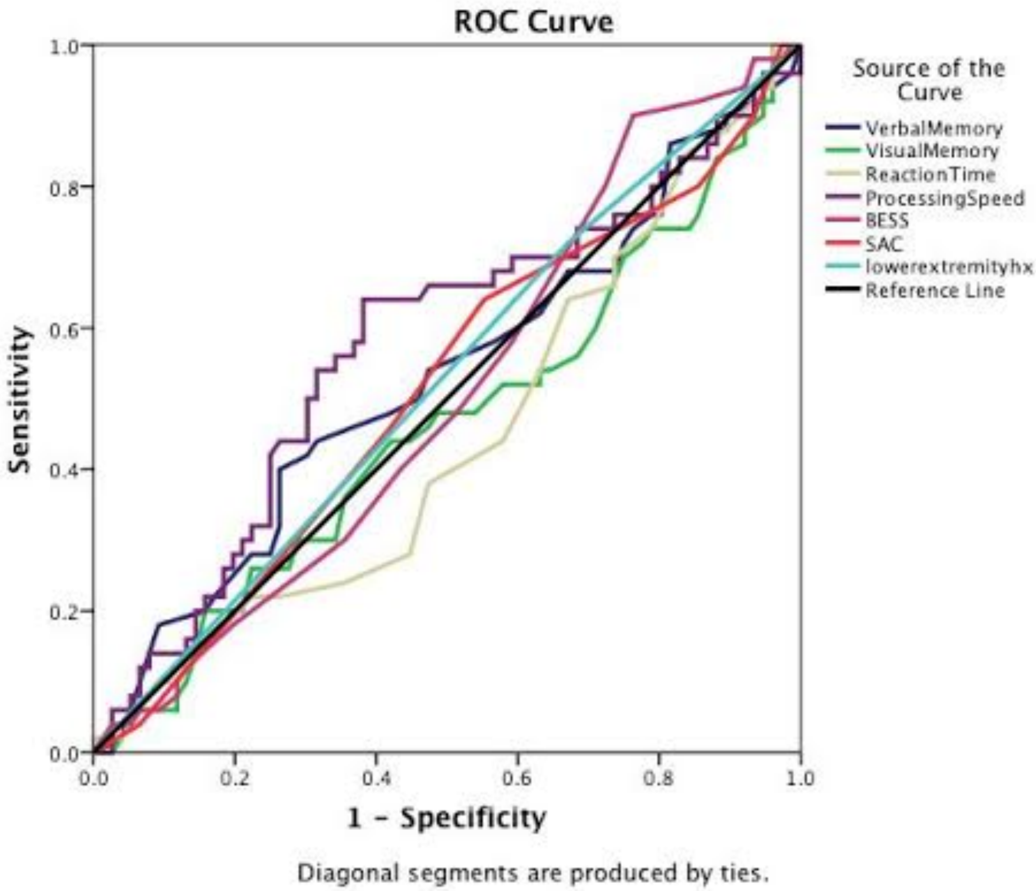


Figure 7: ROC Analysis

Sport	**Experimental Group**	**Control Group**
Football	36	20
Women's Soccer	10	5
Men's Soccer	3	12
Men's Basketball	2	2
Cheerleading	20	13
Swimming	1	7
Women's Basketball	5	2
Track	2	2
Women's Tennis	1	2
Volleyball	2	6
Baseball	0	8
Softball	0	3
Missing Variables		
SAC	1	0
BESS	2	2
ImPACT	0	0
PPE	22	17

Table 1: Participant Frequencies

Variable	N	Mean	Standard Deviation	F	P
Verbal Memory	82-E 82-C	85.7 87.8	+/- 8.9 +/- 9.7	2.0	0.155
Visual Memory	82-E 82-C	73.1 75.95	+/- 13.5 +/- 11.6	2.3	0.134
Reaction Time	82-E 82-C	0.577 0.597	+/- 0.067 +/- 0.076	3.3	0.071
Processing Speed	82-E 82-C	39.8 39.0	+/- 5.9 +/- 6.9	0.7	0.398
BESS	80-E 80-C	12.5 13.1	+/- 5.4 +/- 5.9	0.5	0.483
SAC	81-E 82-C	27.01 27.2	+/- 1.7 +/- 2.7	0.7	0.394
Ankle Injury History	36/60-E 34/65-C	n/a	n/a	n/a	0.391
Knee Injury History	25/60- E 17/65- C	n/a	n/a	n/a	0.059
Lower Extremity Injury History	45/60-E 41/65-C	n/a	n/a	n/a	0.153
Concussion History	82- E 82- C	0.609 0.573	+/- 0.913 +/- 1.006	n/a	0.567

Table 2: Descriptive data and ANOVAs

Sensitivity	0.277
Specificity	0.707
Positive Likelihood Ratio	0.947
Negative Likelihood Ratio	1.022
Positive Predictive Value	0.489
Negative Predictive Value	0.492

Table 3: PPV and NPV

APPENDIX C

DOES THE PREPARTICIPATION EXAMINATION AID IN IDENTIFYING FUTURE RISK OF CONCUSSION?

IRB

GEORGIA SOUTHERN UNIVERSITY
COLLEGE OF HEALTH & HUMAN SCIENCES
POST OFFICE BOX 8076
STATESBORO, GEORGIA 30460-8076
TELEPHONE (912) 681-0200

CONSENT TO ACT AS A SUBJECT IN AN EXPERIMENTAL STUDY

1. Title of Project: **Does the Multifaceted Baseline Concussion Assessment and History of Lower Extremity Injury Aid in Identifying Future Risk of Concussion?**

   Investigator's Name: Kassandra Johns, B.S, ATC Phone: (774) 200 - 3511

   Participant's Name ____________________________ Date:________________

   Data Collection Location: Biomechanics Laboratory, Georgia Southern University Campus

2. We are attempting to determine the link, if any, between the multifacteted baseline concussion assessment and the associate risk of a concussion. There will be approximately 300 subjects in this study. The results of this study may assist health care providers in the prediction and potential prevention of concussions.

3. If you agree to participate in this study, you will be asked to release your baseline concussion assessment scores and pre participant exam questionnaire. Your baseline concussion assessment scores will include the ImPACT test, BESS test, and SAC exam. The ImPACT test is the computerized exam that tested verbal memory, visual memory, reaction time, processing speed, and impulse control. The BESS test was the balance assessment exam and the SAC exam tested your orientation, immediate memory, concentration, and delayed memory recall.

4. There is minimal associated risk with this study. You understand that you are releasing your baseline concussion assessment scores and may withdraw this release at any time. You also understand that you are not waiving any rights that you may have against the University for injury resulting from negligence of the University or investigators. Should medical care be required, you may contact Health Services at (912) 478 – 5641.

5. You will likely receive no direct benefit for participating in this study, however you will be provided your results, if you so request. The results of this study may be used to help predict

those individuals at a great risk of sustaining a concussion and potentially prevent concussions.

6. You will not have to attend any testing sessions.

7. You understand that all data concerning myself will be kept confidential and available only upon my written request to Kassandra Johns, or other members of the research team listed below. You understand that any information about my records will be handled in a confidential (private) manner consistent with medical records.

8. If you have any questions about this research project, you may call Kassandra Johns at (774) 200-3511 or email (kj03005@Georgiasouthern.edu). If you have any questions or concerns about your rights as a research participant in this study it should be directed to the IRB Coordinator at the Office of Research Services and Sponsored Programs at (912) 478-0843 or by email at: IRB@georgiasouthern.edu.

9. You will not receive compensation for your participation in this project. You will be responsible for no additional costs for your participation in this project.

10. You understand that you do not have to participate in this project and your decision to participate is purely voluntary. At any time you can choose to end your participation by telling the primary investigator, Kassandra Johns or any other of the investigators.

11. You understand that you may terminate participation in this study at anytime without prejudice to future care or any possible reimbursement of expenses, compensation, employment status, or course grade, and that owing to the scientific nature of the study, the investigator may in his/her absolute discretion terminate the procedures and/or investigation at any time.

12. You understand there is no deception involved in this project.

13. You certify you are 18 years of age or older and you have read the preceding information, or it has been read to you, and understand its contents. Any questions you have pertaining to the research have been, and will continue to be, answered by the investigators listed at the beginning of this consent form or at the phone numbers given (912) 478 – 5268.

14. You will be given a copy of this consent form to keep for your records. This project has been reviewed and approved by the GSU Institutional Review Board under tracking number H14017

Title of Project: **Does the Multifaceted Baseline Concussion Assessment and History of Lower Extremity Injury Aid in Identifying Future Risk of Concussion?**

Principle Investigator
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02 Cone Hall
(912) 478- 0100
gwshaver@georgiasouthern.edu

______________________________ ________________
Participant Signature Date

I, the undersigned, verify that the above informed consent procedure has been followed

______________________________ ________________
Investigator Signature Date

CERTIFICATION OF INVESTIGATOR RESPONSIBILITIES

By signing below I agree/certify that:

1. I have reviewed this protocol submission in its entirety and I state that I am fully cognizant of, and in agreement with, all submitted statements and that all statements are truthful.

2. This application, if funded by an extramural source, accurately reflects all procedures involving human participants described in the proposal to the funding agency previously noted.

3. I will conduct this research study in strict accordance with all submitted statements except where a change may be necessary to eliminate an apparent immediate hazard to a given research subject.
    a. I will notify the IRB promptly of any change in the research procedures necessitated in the interest of the safety of a given research subject.
    b. I will request and obtain IRB approval of any proposed modification to the research protocol or informed consent document(s) prior to implementing such modifications.

4. I will ensure that all co-investigators, and other personnel assisting in the conduct of this research study have been provided a copy of the entire current version of the research protocol and are fully informed of the current (a) study procedures (including procedure modifications); (b) informed consent requirements and process; (c) anonymity and/or confidentiality assurances promised when securing informed consent (d) potential risks associated with the study participation and the steps to be taken to prevent or minimize these potential risks; (e) adverse event reporting requirements; (f) data and record-keeping requirements; and (g) the current IRB approval status of the research study.

5. I will not enroll any individual into this research study: (a) until such time that the conduct of the study has been approved in writing by the IRB; (b) during any period wherein IRB renewal approval of this research study has lapsed; (c) during any period wherein IRB approval of the research study or research study enrollment has been suspended, or wherein the sponsor has suspended research study enrollment; or (d) following termination of IRB approval of the research study or following sponsor/principal investigator termination of research study enrollment.

6. I will respond promptly to all requests for information or materials solicited by the IRB or IRB Office.

7. I will submit the research study in a timely manner for IRB renewal approval.

8. I will not enroll any individual into this research study until such time that I obtain his/her written informed consent, or, if applicable, the written informed consent of his/her authorized representative (i.e., unless the IRB has granted a waiver of the requirement to obtain written informed consent).

9. I will employ and oversee an informed consent process that ensures that potential research subjects understand fully the purpose of the research study, the nature of the research procedures they are being asked to undergo, the potential risks of these research procedures, and their rights as a research study volunteer.

10. I will ensure that research subjects are kept fully informed of any new information that may affect their willingness to continue to participate in the research study.

11. I will maintain adequate, current, and accurate records of research data, outcomes, and adverse events to permit an ongoing assessment of the risks/benefit ratio of research study participation.

12. I am cognizant of, and will comply with, current federal regulations and IRB requirements governing human subject research including adverse event reporting requirements.

13. I will notify the IRB within 24 hours regarding any unexpected study results or adverse events that injure or cause harm to human participants.

14. I will make a reasonable effort to ensure that subjects who have suffered an adverse event associated with research participation receive adequate care to correct or alleviate the consequences of the adverse event to the extent possible.

15. I will notify the IRB prior to any change made to this protocol or consent form (if applicable).

16. I will notify the IRB office within 30 days of a change in the PI or the closure of the study.

____________Kassandra Johns______	Kassandra Johns	7/19/13
Principal Investigator Name (typed)	**Principal Investigator Signature**	**Date**
_____Thomas Buckley___________	Thomas Buckley	7/19/13
Faculty Advisor Name (typed)	**Faculty Advisor Signature***	**Date**

***Faculty signature indicates that he/she has reviewed the application and attests to its completeness and accuracy**

CITI Collaborative Institutional Training Initiative

Human Subjects-Social & Behavioral Research - Basic/Refresher Curriculum
Completion Report
Printed on 4/15/2013

Learner: Kassandra Johns (username: kj03005)
Institution: Georgia Southern University
Contact Information Department: Kinesiology- Athletic Training
Phone: 7742003511
Email: kj03005@georgiasouthern.edu

Human Subjects-Social & Behavioral Research - Basic/Refresher: Choose this group to satisfy CITI training requirements for Investigators and staff involved primarily in Social/Behavioral Research with human subjects.

Stage 1. Basic Course Passed on 02/08/13 (Ref # 9707338)

Required Modules	**Date Completed**	
Belmont Report and CITI Course Introduction	02/08/13	3/3 (100%)
Students in Research	02/08/13	10/10 (100%)
History and Ethical Principles - SBR	02/08/13	5/5 (100%)
Defining Research with Human Subjects - SBR	02/08/13	4/5 (80%)
The Regulations and The Social and Behavioral Sciences - SBR	02/08/13	4/5 (80%)
Assessing Risk in Social and Behavioral Sciences - SBR	02/08/13	5/5 (100%)
Informed Consent - SBR	02/08/13	4/5 (80%)
Privacy and Confidentiality - SBR	02/08/13	5/5 (100%)
Conflicts of Interest in Research Involving Human Subjects	02/08/13	4/5 (80%)
Elective Modules	**Date Completed**	
Unanticipated Problems and Reporting Requirements in Biomedical Research	02/08/13	5/6 (83%)
Cultural Competence in Research	02/08/13	4/5 (80%)
Records-Based Research	02/08/13	2/2 (100%)
Research and HIPAA Privacy Protections	02/08/13	4/5 (80%)

For this Completion Report to be valid, the learner listed above must be affiliated with a CITI participating institution. Falsified information and unauthorized use of the CITI course site is unethical, and may be considered scientific misconduct by your institution.

CITI Collaborative Institutional Training Initiative

CITI Health Information Privacy and Security (HIPS) Curriculum Completion Report
Printed on 4/15/2013

Learner: Kassandra Johns (username: kj03005)
Institution: Georgia Southern University
Contact Information Department: Kinesiology- Athletic Training
Phone: 7742003511
Email: kj03005@georgiasouthern.edu

CITI Health Information Privacy and Security (HIPS) for Clinical Investigators: This course for **Clinical Investigators** will satisfy the mandate for basic training in the HIPAA. In addition other modules on keeping your computers, passwords and electronic media safe and secure are included.

Stage 1. Basic Course Passed on 02/08/13 (Ref # 9707339)

Required Modules	**Date Completed**	
About the Course	02/08/13	1/1 (100%)
Privacy Rules: Introduction to Federal and State Requirements*	02/08/13	10/10 (100%)
Privacy Rules and Research*	02/08/13	10/10 (100%)
Security Rules: Basics of Being Secure, Part 1*	02/08/13	no quiz
Security Rules: Basics of Being Secure, Part 2*	02/08/13	4/5 (80%)
Completing the Privacy and Security Course	02/08/13	no quiz
Elective Modules	**Date Completed**	
Security Rules: Protecting your Computer*	02/08/13	7/8 (88%)
Security Rules: Issues for Work/Workers Off-Site*	02/08/13	3/4 (75%)

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Paul Braunschweiger Ph.D.
Professor, University of Miami
Director Office of Research Education
CITI Course Coordinator

Return

Certificate of Completion

The National Institutes of Health (NIH) Office of Extramural Research certifies that **Kassandra Johns** successfully completed the NIH Web-based training course "Protecting Human Research Participants".

Date of completion: 02/13/2013

Certification Number: 1119342

Certificate of Completion

The National Institutes of Health (NIH) Office of Extramural Research certifies that **Thomas Buckley** successfully completed the NIH Web-based training course “Protecting Human Research Participants”.

Date of completion: 01/22/2011

Certification Number: 604801

Certificate of Completion

The National Institutes of Health (NIH) Office of Extramural Research certifies that **Thomas Buckley** successfully completed the NIH Web-based training course “Protecting Human Research Participants”.

Date of completion: 01/22/2011

Certification Number: 604801

CITI Collaborative Institutional Training Initiative

Social & Behavioral Research - Basic/Refresher Curriculum Completion Report
Printed on 2/21/2011

Learner: Jody Langdon (username: jlangdon81)
Institution: Georgia Southern University
Contact Information Phone: 9124785378
Email: jlangdon@georgiasouthern.edu

Social & Behavioral Research - Basic/Refresher: Choose this group to satisfy CITI training requirements for Investigators and staff involved primarily in Social/Behavioral Research with human subjects.

Stage 1. Basic Course Passed on 10/27/10 (Ref # 5164256)

Required Modules	**Date Completed**	
Belmont Report and CITI Course Introduction	10/27/10	3/3 (100%)
Students in Research - SBR	10/27/10	9/10 (90%)
History and Ethical Principles - SBR	10/27/10	3/4 (75%)
Defining Research with Human Subjects - SBR	10/27/10	5/5 (100%)
The Regulations and The Social and Behavioral Sciences - SBR	10/27/10	3/5 (60%)
Assessing Risk in Social and Behavioral Sciences - SBR	10/27/10	4/5 (80%)
Informed Consent - SBR	10/27/10	4/5 (80%)
Privacy and Confidentiality - SBR	10/27/10	3/3 (100%)
Workers as Research Subjects-A Vulnerable Population	10/27/10	4/4 (100%)
Conflicts of Interest in Research Involving Human Subjects	10/27/10	2/2 (100%)
Elective Modules	**Date Completed**	
Records-Based Research	10/27/10	2/2 (100%)
Research in Public Elementary and Secondary Schools - SBR	10/27/10	4/4 (100%)
Internet Research - SBR	10/27/10	4/4 (100%)
Research and HIPAA Privacy Protections	10/27/10	2/6 (33%)

For this Completion Report to be valid, the learner listed above must be affiliated with a CITI participating institution. Falsified information and unauthorized use of the CITI course site is unethical, and may be considered scientific misconduct by your institution.

Paul Braunschweiger Ph.D.
Professor, University of Miami

CITI Collaborative Institutional Training Initiative

Social & Behavioral Research - Basic/Refresher Curriculum Completion Report
Printed on 2/21/2011

Learner: Jody Langdon (username: jlangdon81)
Institution: Georgia Southern University
Contact Information Phone: 9124785378
Email: jlangdon@georgiasouthern.edu

Social & Behavioral Research - Basic/Refresher: Choose this group to satisfy CITI training requirements for Investigators and staff involved primarily in Social/Behavioral Research with human subjects.

Stage 1. Basic Course Passed on 10/27/10 (Ref # 5164256)

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Internet Research - SBR	10/27/10	4/4 (100%)
Research and HIPAA Privacy Protections	10/27/10	2/6 (33%)

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Paul Braunschweiger Ph.D.
Professor, University of Miami

CITI Collaborative Institutional Training Initiative

CITI Health Information Privacy and Security (HIPS) Curriculum Completion Report Printed on 3/14/2013

Learner: George Shaver (username: gwshaver) **Institution:** Georgia Southern University **Contact Information**Georgia Southern University

P.O. Box 8019 Statesboro, GA 30460-8019 Department: RCLD Phone: 912-478-0100 Email: gwshaver@georgiasouthern.edu

CITI Health Information Privacy and Security (HIPS) for Clinical Investigators: This course for **Clinical Investigators** will satisfy the mandate for basic training in the HIPAA. In addition other modules on keeping your computers, passwords and electronic media safe and secure are included.

Stage 1. Basic Course Passed on 03/14/13 (Ref # 9864065)

Required Modules
About the Course
Privacy Rules: Introduction to Federal and State Requirements*
Privacy Rules and Research*
Security Rules: Basics of Being Secure, Part 1*

Security Rules: Basics of Being Secure, Part 2*
Completing the Privacy and Security Course
Elective Modules
Security Rules: Protecting your identity*
Security Rules: Safer Web Surfing*

For this Completion Report to be valid, the learner listed above must be affiliated with a CITI participating institution. Falsified information and unauthorized use of the CITI course site is unethical, and may be considered scientific misconduct by your institution.

Paul Braunschweiger Ph.D. Professor, University of Miami Director Office of Research Education CITI Course Coordinator