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Examining College Student Athlete Attitudes Towards Concussion Testing and Reporting Concussions

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Abstract

Background: Examining athletes' attitudes toward concussion diagnosis, management, and treatment can lead to improved multi-faceted management of a concussion injury. Although attitudes towards concussion injuries have been studied, the examination of athletes' attitudes towards baseline computerized neurocognitive testing is understudied and is warranted.

Purpose: The purpose of this study was to examine the relationship between concussion history and athletes' effort provided during baseline testing and the utility of neurocognitive testing.

Methods: College athletes (18-23 years) completing a baseline neurocognitive test (Immediate Post-Concussion Assessment and Cognitive Test: ImPACT) were asked to complete an anonymous 33-item online survey. Survey questions included demographics and inquired about athletes' effort and utility of baseline and post-concussion neurocognitive testing. A series of chi-square analyses measured the association between sex, concussion history, and previous exposure to baseline testing on effort provided during testing and utility of the test. Level of statistical significance was $p \leq .05$.

Results: One hundred eighty-three (88 males, 95 females) athletes (M =19.1, SD = 1.2 years) completed the survey. Thirty-eight percent (70/183) reported prior concussion history and 27% (50/182) were first time test takers. Ninety-four percent (172/183) reported providing above average to maximal effort on the baseline test they completed prior to completing the survey. Ninety percent (158/176) and 87% (156/179) of the sample reported that the baseline and post-concussion test results were useful in mitigating premature return to play, respectively. There was no association between sex, concussion history, or previous exposure to baseline testing on reported effort or perceptions of utility for baseline neurocognitive testing ($p \geq .05$).

Discussion: The majority of athletes report high effort on baseline neurocognitive testing and recognize the utility of this measure for safe return to play.

Introduction

Computerized neurocognitive testing (CNT) is recognized by consensus experts as the cornerstone of the recommended multi-faceted approach to the assessment and management of sport-related concussion (SRC) (McCroy et al., 2013). It is best practice for sports medicine professionals to use CNT in a prospective manner, that compares post-injury scores to pre-injury (i.e., baseline) peformance in order to identify SRC impairment (Van Kampen, Lovell, Pardini, Collins & Fu, 2006). These comparisons provide objective data on the cognitive functioning of a concussed athlete and are valuable in making safe return-to-play decisions. Therefore, ensuring the accuracy of the baseline test is critical, and it is imperative that athletes put forth maximal effort and are motivated to do their best on this assessment.

Factors influencing the accuracy of the CNT baseline have been recently examined in the literature that include the testing environment, athletes' motivation, pre-existing learning, and hyperactivity disorders, and previous concussion history (Collins et al., 1999; Solomon & Haase, 2008). For example, there is debate in the literature if athletes can successfully "sandbag" their baseline scores to appear less impaired following a concussion and therefore expedite return to play. However, only 11% (8/59) of athletes were able to successfully lower their baseline scores without alarming validity indicators (Erdal, 2012). Similarly, Schatz and Glatts (2013) reported that 30-35% of athletes were able to avoid detection of the built in validity indicators when trying to purposely lower their baseline scores. Research has been conducted on high school athletes' perceptions, attitudes and effort towards concussion and baseline testing. In Wisconsin, only 47.3% of high school football players were found to report their concussion symptoms (McCrea, Hammeke, Olsen, Leo, & Guskiewicz, 2004). McCrea et al. (2004) revealed that the lack of reporting concussions was due to reasons such as disbelief that the injury was severe enough to seek medical attention, fear of getting suspended from the game, and absence of awareness of obtaining a concussion (McCrea et al., 2004). However, Miyashita et al. (2014) reported that 67.4% of 306 athletes are more likely to report a concussion after obtaining more information about concussions. Additional research found that improved education about concussions did not lead to improved self-reported symptoms (Kurowski, Pomerantz, Schaiper, & Gittelman, 2014). With contradicting experimental results, understanding the attitudes towards and knowledge of concussions can lead to improved athlete safety, knowledge, and management of SRCs.

The National Collegiate Athletic Association (NCAA) is changing the “concussion culture” in sports by supporting studies through funding on research and examining college athletes’ attitudes toward SRC, which may contribute to intentional poor performance on baseline CNT. For example, Szabo, Alosco, Fedor, & Gunstad (2013) reported that more than 25% of Division I football players generated invalid baseline CNT scores due to suboptimal levels of effort. However, the examination of athletes’ attitudes toward baseline CNT is understudied and is warranted. This data will inform best practices for administering baseline testing sessions and provide an increased understanding of athletes’ effort and malingering intentions on these assessments. **The purpose of this study was to examine the relationship between previous concussion and effort exerted by athletes on baseline computerized neurocognitive assessments.**

Review of literature

Sport-related concussion (SRC) continues to be a hot button issue in sports medicine. An estimated 1.6 to 3.8 million sport-related concussions occur in the United States every year (Langlois, Rutland-Brown, & Wald, 2006). The National Collegiate Athletic Association has been focusing on changing the “concussion culture” by stressing the prevalence of concussions and importance of diagnosis and management in collegiate sports. According to Langlois et al. (2006), 4 million people over 18 years old participate in sports, and during the 2009-2010 season to the 2013-2014 academic season, 6.2% of injuries were concussions (Zuckerman et al., 2015). Guskicwiez, Weaver, Padua, & Garrett (2000) reported that Division I football had a lower incident rate than Division III football with different positions experiencing the most concussions and injuries through contact with opponent, contact with teammate, contact with ground, and/or contact with equipment (Guskiewicz et al., 2000). Covassin and colleagues Another study focused on other collegiate sports, such as lacrosse, soccer, basketball, baseball, softball, and gymnastics, and found that game concussions (7.8%) occurred more frequently than practice concussions (4.2%) (Covassin, Swanik, & Sachs, 2003). Gessel, Fields, Collins, Dick, & Comstock (2007), found that collegiate sports had a higher rate of concussion than high school athletes, with the highest rate of concussion being in football (40.5%) and girl’s soccer (21.5%). Another finding included that concussion rates were higher in games (65.4%) than in practice (34.6%) (Gessel et al., 2007). However, some athlete concussions are unrecognized, and athletes often do not seek care for the concussions they do recognize (Voss, 2015). Therefore, this creates an emphasis on recognition, proper diagnostic measures, and management procedures when dealing with SRCs.

Definition, Biomechanics, and Pathophysiology of Sports-Related Concussion

A concussion, or mild-traumatic brain injury (MTBI), is a brain injury resulting from traumatic biomechanical forces that affects pathophysiological processes of the brain leading to post-concussive signs, symptoms, and decreases in cognitive, physical, emotional, and/or sleep functioning (McCrory et al., 2013). A concussion can occur in several different ways. An athlete can experience impact forces when his/her body and/or head come into contact with a solid object or when the athletes' head is struck by a moving object (Bailes & Cantu, 2001). Blows to the face, head, neck, or body that lead to a force on the head result in a concussion, causing the brain to quickly experience quickening, deceleration, and rotational forces that lead to deformation injuries to important functional components of the brain, such as cell bodies, axons, dendrites, glial cells, and blood vessels (Seifert & Shipman, 2015). These impact forces lead to further alterations in neurotransmitter release, cerebral blood flow, and synaptic dysfunction creating symptomatic problems and neurocognitive impairments within injured individuals (Seifert, & Shipman, 2015). The resulting neurological impairments lead to a neurometabolic cascade within the brain causing physical, cognitive, emotional, and sleep problems in the concussed athlete (Giza & Hovda, 2014; Weinberger & Briskin, 2013). A neurometabolic cascade causes imbalances of crucial intermediates (sodium and calcium) in metabolic pathways leading to an energy crisis in the brain. The energy crisis leads to a multitude of symptoms not easily detected by observable signs and an increased vulnerability of a repeated injury during recovery (Giza & Hovda, 2014).

Signs, Symptoms, and Impairments Related to Sport-related Concussion

Identifying and assessing the signs and symptoms of concussion is the backbone to the proper management and treatment of this injury. Symptomatology varies from athlete to athlete and likely reflects impairment of the underlying affected brain structures (e.g., visual disturbances with occipital injury). In addition, the signs and symptoms of concussion evolve following injury (Kontos et al., 2012) and include on-field (i.e., acute) symptoms and severity markers and sub-acute symptom reports.

SRCs include a wide array of on-field signs that portray both cognitive and physical impairments in an athlete. Some cognitive signs include confusion, amnesia, unaware of time date or place, and loss of consciousness (LOC). Physical signs are LOC, poor balance, easily distracted, emotional instability, vomiting, slurred speech, and decreased ability in playing. Symptoms experienced by the player include headache, dizziness, nausea, loss of balance, feeling stunned, seeing stars or lights, ringing ears, double vision, sleep disturbance, trouble concentrating, and fatigue (McCrory et al., 2013). Duration of post concussion symptoms correlates with symptom severity meaning that more severe concussions have a longer duration of symptoms and prolonged time before return-to-play in an athlete (Erlanger et al., 2003). However, Meehan, Mannix, Stracciolini, Elbin, & Collins (2013), reported that poor post-concussion symptom reports and CNT scores were associated with longer symptom duration while sex, age, LOC, and amnesia were not associated with prolonged duration. Erlanger et al. (2003) also found that cognitive impairment compared to baseline scores directly correlates with the duration of post-concussion symptoms. The sub-acute symptomatology of concussion comprises four different categories of symptoms: physical (e.g. headaches, nausea, balance issues, blurred vision, sensitivity to light or noise, confusion, and shock), cognitive (e.g. mental haziness, trouble focusing and remembering information, and delayed responses), emotion (irritability, mood swings or elevated emotions, and anxiety or nervousness), and sleep-related issues (Kontos et al., 2012).

Sports-related Concussion Management

Concussion management and assessment involves a multi-dimensional approach that consists of a clinical examination, self-reported symptom checklist, postural assessment, and neurocognitive testing (Guskiewicz et al., 2004). With symptom reports being a subjective measurement, there is a great deal of reliability on the concussed individual to accurately report their symptoms (Carone, 2015). To more accurately manage concussed patient, clinicians use an approach that includes both subjective and objective measures.

Postural assessment is an on-field examination to determine balance deficits in an athlete further indicating a concussion injury. Balance impairments occur in about 30% of sport-related concussions (Guskiewicz, 2011; Marar, Mcllcain, Fields, & Comstock, 2012). A balance impairment can be defined as the inability to stand in a upright position without deviating outside the base of support and can be caused by vestibular dysfunction in a concussed individual (Murray, Pradeep, Ambati, Contreras, Salvatore, & Reed-Jones, 2014;Marar et al., 2012). A concussed individual experiences spatial impairments caused by damage to peripheral receptors (hair cells) that leads to inaccurate acceleration senses and central nervous system damage resulting in delayed relaying of information (Mucha, Collins, & French, 2012). Some studies have shown that balance impairments in a concussed athlete resolve after seventy-two hours (McCrory et al., 2005), while other studies have shown that postural deficits have not resolved until thirty days postconcussion (Murray et al., 2014). The Balance Error Scoring System (BESS) is a common balance assessment used as a sideline test for athletes during concussion diagnosis protocol (Guskiewicz, 2011). The BESS assessment involves an athlete standing in three different stances (double leg, single leg, and tandem) with eyes open and closed for twenty seconds while the number of errors (movement outside the base of support) is recorded (Broglio, Ahu, Sopiarz, & Park, 2009). Graves (2016) found that initially there was a significant decrease in BESS scores post-concussion, but after fourteen days BESS scores returned to scores comparable to baseline scores of the athletes. Postural stability assessments provide information on vestibular deficits that directly correlates with neurocognitive deficits caused by concussion, making these assessments valuable to concussion diagnosis and management.

Neurocognitive testing procedures are object measurements that produce an onset of symptoms post-concussion after the assessments are conducted (Day & Hanson, 2012). Guskiewicz et al. (2004) stated that neurocognitive testing can be used partially to diagnosis a concussion, but is crucial and more useful in tracking the recovery of an athlete. Neurocognitive testing measures brain functions such as memory (verbal and visual), attention, reaction time, speed of information processing (visual motor speed), and impulse control (Broglio et al., 2009; Lovell, 2007). The neurocognitive impairments of a concussed athlete are monitored during the recovery period and the test results (compared to baseline assessments) are used to ensure that the athlete's neurocognitive status has returned to baseline or normative values for that individual athlete (Guskiewicz et al., 2004). Although traditional paper-pencil tests were once used computerized neurocognitive tests are becoming more popular due to benefits, such as "internet-based platforms, standardization of testing and scoring, easy accessibility to alternate test forms, and large storage data for further research on improvements" (Collie, Darby, & Maruff, 2001; Rahman-Filipiak & Wooward, 2014). Nelson and colleagues (2015), found in a study that the validity of CNTs was supported by the 73.5% of athletes producing valid scores upon retesting after producing invalid test scores. Schatz et al. (2014) also concluded that 90% of athletes retested for invalid scores produced valid scores indicating the validity of neurocognitive testing. However, cautionary measures should be taken since learning disorders produced invalid scores (25.9%), and lower GPAs were predictors for invalid CNT scores (Nelson et al., 2015). When diagnosing and managing a concussed athlete, the neurocognitive tests can help with diagnostics and most importantly recovery management, but other measures (subjective) should also be evaluated during the concussion management process.

Self-reported symptom checklists, such as Sport Concussion Assessment tool (SCAT2) are usually used in most on-field subjective assessments where the severity of multiple concussion symptoms (headaches, dizziness, nausea, fogginess, and sleep issues) are rated (Kontos et al., 2016). Although self-reported symptom checklists are extremely subjective and rely heavily on the honesty of the concussed athlete, these tests allow clinicians to construct a more individualized plan for post-concussion assessment and management (Kontos et al., 2016). The Post-Concussion Symptom Scale (PCSS) is a 22-item questionnaire that includes four different factors (cognitive, sleep problems, emotional status, and somatic factors) related to concussion impairments; this test allows the concussed athlete to report symptoms and indicate the severity of the impairments (Pardini et al., 2004). The Head Injury Scale (HIS) is another self-report symptom checklist in which the athlete reports somatic, cognitive, and neuropsychological factors. The limitation to HIS is that it lacks severity rating since it only examines the presence of absence of concussion symptoms with yes or no questions (Piland, Motl, Ferrara, & Peterson, 2003). Previous studies have shown that females tend to report more symptoms and report more severity in their concussion impairments (Broshek et al., 2005; Covassin, Schatz, & Swanik, 2007). Symptom report checklists are subjective measures allowing more personalized assessments and rehabilitation plans for each concussed athlete making them a valuable asset to the multifaceted concussion management approach.

Along with the symptom reporting checklists, baseline testing is often used to help in diagnostic and concussion management procedures. According to Nelson et al. (2015),94.7% of athletic trainers who use ImPACT, a computerized neurocognitive test, baseline test their athletes so the clinicians can take into account premorbid cognitive skills. Baseline testing scores are used to help evaluate the neurocognitive state of the concussed athlete during recovery since a concussed athlete should not return to play until postconcussion symptoms resolve and preconcussion neurocognitive functioning is obtained (McCrory , Meeuwisse, & Johnston, 2009).

Baseline testing in Sport-related Concussion Management

Baseline testing is a pre-season cognitive examination conducted by a trained healthcare professional, and the test results are used to document an athlete's pre-injury cognitive and physical function along with concussion symptoms to be compared to post-injury impairments (Guskiewicz, 2004). Baseline data are used to compare to post-concussion test results to assist sports medicine professionals with assessing impairment, determining recovery, and making safe return to play decisions. Individual differences in cognitive performance in areas of attention, memory, concentration, information processing, and reaction time make the individual baseline neurocognitive examinations necessary. Obtaining preconcussion and postconcussion neurocognitive data allows clinicians and trainers to monitor the recovery of each concussed athlete for his or her individual symptoms and issues rather than comparing the postconcussion scores to universal data (Covassin, Elbin, Stiller-Ostrowski, & Kontos, 2009).

Computerized neurocognitive tests (CNTs) are used by numerous high school, collegiate, and professional sports organizations for postconcussion objective evaluations that determine cognitive changes within a concussed individual (Covassin, et al., 2009). Computerized neurocognitive exams are designed for the assessment of SRCs using different modules to measure varying aspects of cognitive functioning that are affected by SRC including verbal memory, visual design memory, concentration, visual processing speed, and reaction time (Lovell et al., 2006; Covassin et al., 2009). Computerized neurocognitive tests are internet-based/ electronic platforms, have high standardized test management and scoring procedures, and are readily available to multiple alternate test forms, and contain centralized data storage making it possible for athletic programs to perform broad baseline testing of their athletes for post-concussion management procedures (Nelson et al., 2015). Another advantage of CNTs is that the administration, scoring, and interpretation of baseline tests do not require the presence of a licensed neuropsychologist (Resch, McCrea, & Cullum, 2013).

Factors Negatively Affecting CNTs

While there are many advantages to CNTs, there are negative factors that play important roles in the reliability of CNTs. Learning disability and attention hyperactivity disorders, previous concussions, age, sex, and testing environment (e.g., group versus individual) have been deemed to negatively affect CNT scores (Collins et al 1999). The administrators' knowledge of the test and the absence of further evaluation of scores can also play a role in invalid assessment scores (Collins et al., 1999; Covassin, Elbin, Harris, Parker, & Kontos, 2012). Factors that might negatively affect baseline scores include depression (Covassin et al., 2012), distractions (group settings) (Moser, Schatz, Neidzwski, & Ott, 2011), and computer problems (improper administration training and technical difficulties) (Schatz, Neidzwski, Moser, & Karpf, 2010).

Factors negatively affecting neurocognitive performance directly affect baseline assessment scores. These factors are dehydration, lack of sleep or fatigue (Neylan et al., 2010), and anxiety or stress (Law, Groome, Thorn, Potts, & Buchanan, 2012) during testing (Schatz et al., 2014). Learning disorders and ADD (attention-deficit disorder) directly affected the sample in the study performed by Schatz et al. (2014) because in the four samples percentages producing invalid scores were 16.9%, 12.7%, 31.1%, and 21.6%. This study also concluded that invalid scores on reassessment might indicate an individual's skills, making retesting invaluable (Schatz et al., 2014). Previous concussions are also a factor that might alter baseline scores (Collins et al 1999). Group versus individual test administration has been shown as negatively affecting baseline scores because group administration testers have produced significantly lower scores than individuals tested by themselves (Moser, Schatz, Neidzwski, & Ott, 2011). Invalid baseline scores require further validation by reassessment and evaluation of factors that could have attributed to the unacceptable scores.

ImPACT (Immediate Post-Concussion Assessment and Cognitive Test)

One of the more popular neurocognitive batteries is the Immediate Post-concussion Assessment and Cognitive Test (ImPACT). The ImPACT test assesses multiple aspects of cognitive functioning, such as attention span, working memory, response variability, non-verbal problem solving, and reaction time. Nelson et al. (2015) found that only 2.7% of the sample produced invalid test scores on ImPACT versus the invalid scores on AXON (11.3%) and ANAM (10.7%), supporting the reliability of ImPACT scores. However, to better improve specificity and sensitivity, a two-structure ("memory" and "speed" factors) scoring system was used to produce 70% specificity versus the 62% specificity produced when ImPACT composite scores were utilized (Schatz & Maerlender, 2013). Another study utilized combined discriminant function analysis when evaluating ImPACT scores and concluded that the scores correctly categorized 73.53% of concussed athletes into long term or short recovery with a sensitivity of 65.22% and a specificity of 80.36% (Lau, Collins, Lovell, 2011). The statistics further support the reliability of ImPACT as a diagnostic and management tool for concussion, but proper evaluation of scores is necessary to ensure the validity of scores.

Evaluation of ImPACT scores is necessary to properly classify, diagnose, and manage concussed athletes. ImPACT has created subscales and categories assigned to different scores allowing clinicians to determine the status of a concussed individual (About ImPACT, 2016). ImPACT "flags" athletes with baseline scores below a predefined cutoff based on specific subscales (Schatz, Moser, Solomon, Ott, & Karpf, 2012). These indicators are based on distinguishing performances 2 standard deviations below the mean, creating a space between optimal performance scores and invalid scores. This gap is a potential area in which athletes could sandbag or lower their baseline scores without indicating invalid scores or reaching the invalid threshold (Erdal, 2012). The *ImPACT Clinical Interpretation Manual* includes a description of two types of invalid scores: invalid profiles and "sandbagging" profiles (Lovell, 2007). Invalid scores indicate that an individual has not performed optimal effort, causing the results to be inaccurate. More detailed ranges are given for sandbagging profiles indicating that the athlete is intentionally suppressing his or her score to hide any impairment postconcussion without reaching the invalid threshold or "red flags" on the CNT. The sandbagging profiles have been shown to have low scores in verbal and visual memory and reaction time, showing a sense of hesitation and intentional thoughts to lower scores on tests with fairly easy tasks for even a concussed individual (Lovell, 2007).

Effort on CNTs

In addition to the objective scores provided by CNTs, effort plays a major role in the accuracy of concussion diagnosis and management. In an interview with Rick Reilly, Peyton Manning stated that he was going to intentionally do bad on his baseline test, making his postconcussion scores less extreme and less likely to affect his return to play decision (Reilly, 2011). It has been up for debate about whether or not athletes "sandbag" CNT baseline scores to alienate the suspected differences between baseline and postconcussion scores, making effort an essential part of a neuropsychological examination (Lange, Iverson, Brooks, & Rennison, 2010). Physicians treating concussed athletes have also reported that NFL players "purposely do bad on testing (baseline) to start so if they get a concussion it does not affect them" (Marvez, 2012).

Sandbagging CNTs

"Sandbagging involves underreporting symptoms or underperforming on CNTs creating a lack of reliability in concussion management. Even though previous studies have established the validity of the ImPACT CNT in the evaluation of cognitive functions and symptoms parallel to concussions (Elbin, Schatz & Covassin, 2011), lowering baseline scores has been a focus of research in order to continue to increase the validity of the ImPACT. In Erdal's (2012) experiment, 75 undergraduate athletes were instructed to attempt to do poorly on ImPACT, and the study revealed that only 11% of the sample was able to perform poorly without reaching validity indicators by using natural errors rather than calculated or blatant mistakes. However, in a study performed by Szabo et al. (2013), 27.9% of the sample had invalid ImPACT scores, without sandbagging being ruled out as a possibility. When assessing the possibility of an athlete being able to sandbag an ImPACT baseline score, Schatz & Glatts (2013), took a sample of 60 undergraduate students and created a control, naïve malingerer, and coached malingerer group. The controls were just provided with the test and told to do their best. The naïve malingerer group participants were given the same instructions as the controls but were instead told to perform poorly on the test. The coached malingerer group participants were given the same instructions as the control group and naïve malingerer group, but they were also told to perform poorly in a way to not be detected by validity indicators. The results of this study were that 30%-35% were able to avoid detecting using on the ImPACT manual indicators (Schatz & Glatts, 2013), which is consistent with Erdal's (2012) findings that it is difficult to successfully sandbag baseline ImPACT scores. An important finding of this study was that the participants attempting to sandbag their baseline tests failed to correctly recognize distractor items (Schatz & Glatts, 2013).

Individuals have been suspected for malingering on neuropsychological tests for a multitude of reasons, most resulting in an external reward. Malingering is defined as the conscious exaggeration of physical or psychological symptoms (Rogers, 1997). Defensiveness or sandbagging involves the patient concealing or minimizing impairment to attain a goal (Rogers, 1997). Negative response bias can be defined as "the deliberate exaggeration of symptoms in a clinical interview, or intentionally poor performance on psychological or neuropsychological tests (Iverson & Binder, 2000). Neuropsychological tests used to measure underperformance or poor effort usually involve an easy memory task, and sandbaggers do not usually recognize that injured patients perform well on this test, causing invalid scores to raise red flags for sandbagging (Jelicic, Ceunen, Peters, & Merckelbach, 2011). Also symptom validity tests are used to measure an exaggeration of symptoms by presenting patients with bizarre symptoms that are not usually symptoms of neurocognitive dysfunctions but in uneducated people these symptoms would appear to be legitimate (Jelicic et al., 2011). Many malingerers will appear report having these atypical symptoms that are not associated with the cognitive impairments or injury. Patients, including athletes, could possibly be coached on how to beat neurocognitive tests. Two different types of coaching are symptom coaching, which is where the coach explains the symptoms of the disorder. The other type of coach is considered test coaching, which is where the coach explains to the patient how to beat the symptom validity test without indicating red flags (Jelicic et al., 2011).

Athletes' attitudes towards concussion, concussion reporting, and baseline testing

Since there are many different factors that play a crucial role in evaluating SRCs, understanding the attitudes and influences affecting the attitudes athletes have towards the assessments and procedures is crucial regarding optimal effort and accuracy of scores. According to Kay, Welch, & McLeod (2015), the greatest positive influence on symptom reporting is knowledge of concussions and support of concussion education in schools. However, Szabo et. al. (2013) found that over 25% of college athletes received invalid tests scores (below suboptimal effort) on CNTs even after being provided with information about potential risks of concussion. Coaches' attitudes towards concussions have been noted as being both an enabler and a barricade to concussion reporting in athletes (Kay et al., 2015). In contact sports and extremely aggressive sports, the portrayal of toughness and adverse affects while sitting on the bench because of an injury negatively affect the attitudes and actuality of athletes reporting concussions or concussion symptoms (Weiese-Bjornstal, White, Russell, & Smith, 2015). The sport or team itself can exert pressure to play in a way that exhibits toughness and ability to play through an injury or return to sport sooner than expected (Weiese-Bjornstal et al., 2015). This pressure from the team, fans, and parents or family can greatly encourage an athlete to refrain from reporting a concussion (Weiese-Bjornstal et al., 2015). Delahunt, Condon, Toomey, & Blake (2014) performed a study in which 221 rugby players were questioned about issues and attitudes regarding concussions and concussion reporting. The study found that 72.5% of the sample stated that they would play in an important match even if recovering from a concussion indicating that there is a lack of awareness of the risks associated with concussion injuries and premature return-to-play (Delahunt, Condon, Toomey, & Blake, 2014). In the same study, 7.9% of the rugby players felt as if they "could not let their team down" (Delahunt et al., 2014). Another significant finding from the Delahunt et al. (2014), study was that of the 59 players that were previously been diagnosed with a concussion, 83.1% reported that they too would play an important match with a concussion or symptoms of a concussion. Another study conducted by Sye, Sullivan, and McCrory (2005), evaluated the attitudes, knowledge of concussions, and understanding of return-to-play guidelines of high school rugby players. A significant result of this study was that 76.0% (363/477) of the players believed that a teammate had played while concussed during a game, and 151 players believed a concussed teammate had also been under pressure to play (Sye et al.,2005). Some players reported inaccurate knowledge of concussion symptoms stating that, "a player had to be knocked out in order to be concussed" (Sye et al.,2005). The Sye et al. (2005), study also supported the suspicion of athletes underreporting concussion symptoms based off the expression that the down time from playing and recovery time has profound negative consequences according to the players.

While attitudes towards concussion and concussion reporting have been focused on in several studies, attitudes towards baseline concussion testing have not been thoroughly evaluated. Studies have focused on the feasibility of an athlete "sandbagging" or malingering baseline scores, but these studies did not research why an athlete would lower his/her baseline scores, athletes' attitudes towards the baseline test, and athletes' perceptions of the feasibility of malingering baseline CNTs (Erdal, 2012; Schatz & Glatts, 2013). For example, Peyton Manning discussed in an interview that he would intentionally perform poorly on his baseline tests reflecting derogative attitudes towards the effects and usefulness of baseline testing (Reilly, 2011). There are many ideas and motivations that would lead a collegiate athlete to sandbag baseline scores, but there is not an abundance of statistical data supporting the ideas, Therefore, a clear understanding of attitudes players have towards baseline CNTs, concussions, risk factors of concussions, and management of concussions is crucial in the reporting and effort put forth by a concussed athlete.

Methods

*Research Design***:** A descriptive, quantitative survey was used for this study to analyze effort exerted during baseline neurocognitive assessments. Other topics of focus in the survey was attitudes towards the utility of baseline computerized neurocognitive tests, perceptions on the utility of CNTs, and knowledge of concussions.

*Participants***:** College-aged athletes completed supervised baseline testing (ages 18 – 23) in sports including soccer, lacrosse, field hockey, softball, basketball, volleyball, cheerleading, rugby, and ice hockey.

Instrumentation: An online survey will be administered via Google forms immediately to collegiate athletes completing a widely-used CNT (ImPACT: Immediate Post-Concussion Assessment and Cognitive Test). This 33 item survey had demographic questions and inquires about athletes' effort, perceived difficulty on beating ImPACT, perceived usefulness of he baseline test for concussion management, reporting behaviors of concussion symptoms, and concussion knowledge.

Procedures: All athletes completing pre-season neurocognitive and/or post-concussion testing will be provided with a link to the survey immediately after completing testing, and informed that 1) completion of the survey is completely voluntarily, 2) failure to complete the survey will result in no consequence, and 3) results of the survey data will not be tied to ImPACT test results.

*Data Analysis***:** Descriptive statistics (e.g., means, standard deviations, percentages) were used to describe demographics and athletes' effort, honesty, speed, accuracy, and ease of tanking baseline, hiding symptoms and cognitive deficits scores based on a Likert scale. A series of chi-squares and independent samples t-tests were used to compare responses between effort and previous concussion history. All data analysis will be conducted using SPSS version 20.0 and level of statistical significance will be $p \leq .05$.

Results

Demographic Information

A total of 178 participants (*M* = 19.05, *SD* = 1.16 years; Range 18 – 23 years) completed the survey. The response rate for this survey was 178 of 189 (94%) athletes that were invited to complete the survey. The sample was 53% female (95 females, 83 males) and represented by several sports including basketball (1%, 2/178), cheer (3%, 5/178), field hockey (9%,16/178), ice hockey (8%, 14/178), lacrosse (27%, 48/178), rugby (33%, 59/178), soccer (12%, 21/178), and softball (7% 13/178). Sixty-one percent (106/173) of the sample reported zero previous concussions, 22% (38/173) reported one concussion, and 17% (29/173) had a history of two or more concussions (Range = 0 – 8). Approximately 25% (43/174) of the sample had never completed an ImPACT baseline, whereas 30% (52/174), 22% (38/174), and 24% (41/174) completed the ImPACT baseline once, two times, and three or more times prior to participating in the current study, respectively. The majority of the sample (76%, 133/175) had never completed a post-concussion administration of ImPACT. Ninety-four percent (122/130) of the sample reportedly never attempted to do poorly or “tank” a previous baseline.

Effort, Difficulty “Beating,” and Utility of the ImPACT Test

After completing the ImPACT baseline assessment, participants were asked to rate their level of effort, speed and speed of responses, and honesty in reporting their symptoms. The means and standard deviations for these 10-point Likert scale (1 = Did my worst/Inaccurate to 10 = Did my best/Accurate) items are listed in Table 1 below. In addition, participants reported their perceived level of difficulty (easy, hard) to intentionally do poorly (i.e., tank) on the baseline test and hide symptoms and the cognitive effects of concussion on the ImPACT test battery. Means and standard deviations from these responses are also presented in Table 1. Participants also reported that the ImPACT baseline (M = 8.28, SD = 1.84) and post-concussion test results (M = 8.14, SD = 1.89) are valuable in helping a sports medicine professional not prematurely return an athlete to play.

Table 1

Means, standard deviations, and ranges for effort, speed, accuracy, symptom reporting honesty, and ease of tanking, hiding symptoms and cognitive problems on the ImPACT test.

Item	Mean	Standard Deviation
Effort	9.48	.98
Speed	9.22	1.10
Accuracy	8.74	1.15
Honesty	9.60	1.09
Ease of Tanking Baseline	6.17	2.67
Ease of Hiding Symptoms	5.05	2.84
Ease of Hiding Cognitive Problems	4.31	2.56

Note: Items are a mean score on 10-point Likert Scale

Concussion History and Effort on the ImPACT Baseline Test

Differences between concussion histories on effort when taking the ImPACT baseline test were examined among the sample. Concussion history was grouped into zero, one, and two or more previous concussions. A one-way analysis of variance (ANOVA) was used to examine differences between these concussion history groups on effort score. The results of the one-way ANOVA was not significant (F [1,172] = .37, p =.69, η^2 = .02) and the means and standard deviations for effort scores across the concussion history groups are presented in Table 2.

Table 2

Means and standard deviations for effort scores among participants with zero (n = 106), one (n = 38), and two or more previous concussions (n = 29).

	Zero		One		Two or More	
	M	*SD*	*M*	*SD*	*M*	*SD*
Mean Effort Score	9.51	1.01	9.37	0.91	9.55	0.99

DISCUSSION

The purpose of this study was to examine athlete's attitude, perceptions, and knowledge toward computerized neurocognitive testing. In the sample (178 athletes), 131 athletes had previously completed a baseline neurocognitive test, and ninety-four percent of the sample (122/130) reported to have never attempted to do poorly or "tank" a previous baseline. The sample of athletes reported an average of 9.84 (on a Likert scale) on effort and an average of 9.60 honesty (on a Likert scale) during the test. On a Likert scale, the athlete sample reported lower scores for ease of tanking baseline (6.17), ease of hiding symptoms (5.05), and ease of hiding cognitive deficits (4.31). The results of this study indicated no significant relationship between the previous histories of concussion groups (one, two, and three or more) and effort (suboptimal or poor effort) on the baseline computerized neurocognitive tests. Therefore, the majority of the sample reported optimal effort and did not sandbag the baseline computerized neurocognitive test administered.

The results of this study coincide with results found from other studies that discuss the relationship between reporting concussions and previous concussions or knowledge about concussions. Miyashita et al. (2014) reported that 67.4% (206/306) of athletes are more likely to report a concussion after obtaining more information about concussions, which is inherent to previous concussions. Nelson et al. (2015) reported that athletes widespread do not exert low effort on baseline neurocognitive assessments coinciding with the exertional effort levels found in the study performed. Although our sample deemed that histories of previous concussions did not correlate with poor effort on neurocognitive tests, Collins et al. (1999) found a correlation between multiple concussions and poorer neurocognitive testing performance. Also, several studies focused on the feasibility of tanking baseline tests and found that it is difficult to sandbag neurocognitive tests in the suboptimal threshold range without reaching poor effort validity indicators (Erdal, 2012; Schatz & Glatts, 2013). Szabo et al. (2013) reported that only 27.9% of the sample produced invalid baseline neurocognitive test results with a possibility of several factors causing these low assessment results.

Some limitations to this study include missing data on the athletes' performances on the actual ImPACT test taken before the survey, leading to a lack of correlation between test performance and results of the survey. Common limitations inherent to survey research include relying on the honesty of the participants, athletes understanding the directions on the survey, different athlete interpretations of answers (a 3 on the Likert scale can be different among athletes), and lack of depth and detail in the survey.

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