Cognitive Impairment Among Collegiate African American Student-Athletes Who Have One Or More Concussions

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Abstract

The purpose of this research was to examine concussion induced cognitive impairment among collegiate athletes for a long term. This study attempted to determine if there was a significant decrease in cognitive function in student-athletes with a history of concussion after one year of concussion. Totally 46 student athletes who were qualified was included in this study. Of all the 46 student athletes, 14 are females, and 32 males from the following sports: Women's Basketball (n=3), Men's Basketball (n=2), Football (n=30), Softball (n=7), Women's Tennis (n=2), and Women's Volleyball (n=2) (Table 1). The age range was18-23 years old. Seven of them had two or more concussions Results of this study showed that while all the scores of the ImPACT test improved after one year of concussion for the student-athletes with one or more concussions, there was significant improvement only in the processing speed. For the student-athletes with two or more concussions, the processing speed score after one year of concussions was a little lower even than the score after initial concussion, but it is not statistically significant.

Keywords: Concussion, ImPACT, college student-athletes, cognitive impairment

Concussion is a health condition recently getting extensive media exposure due to its significant prevalence and negative effects in the world of athletics (Provencher et al., 2018). Concussion can cause numerous adverse consequences in its victims, including death and suicide (Costanza et al., 2021). Concussion is a brain injury and is more specifically defined as a complex pathophysiological process affecting the brain induced by biomechanical forces (McCrory et al., 2013). In other words, concussion is an alteration of brain function caused by biomechanically induced trauma which affects orientation and memory and can cause loss of consciousness (Gomez & Hergenroeder, 2013). A great deal of the literature is concentrated on concussion due to the high occurrences of the brain injury and the permanent negative effects it can cause (Murray, Salvatore, Powell, & Reed-Jones, 2014).

The Center for Disease Control (CDC) has estimated that 135,000 cases are reported to the emergency department for athletic related concussions annually (CDC, 2012). Most concussions (78.5%) occur during competition. Of these concussions, the highest occurrences for males are football related and for females are soccer related. When reviewing the sources of concussions, the most common mechanism of injury (MOI) is attributed to player-to-player contact (75%) and second is the athlete coming into contact with the playing surface (15.5%) (Laker, 2011). The MOI may also include a blow to the head, face, neck, or in any other body part that can potentially transfer the force to the head resulting in neuropathological

alterations. Onset of symptoms may occur immediately after the injury, or minutes, or hours later and have varying levels of severity (CDC, 2012).

The clinical symptoms of concussion can be graded according to severity (McCrory et al., 2013). Severity is related to the degree of functional impairment or how long symptoms persist. The symptoms related to a concussion are categorized as cognitive, affective, and somatic. These symptoms are important indicators of the effects and severity of a concussion. Cognitive symptoms may include: memory difficulties and decrease in concentration and mental processing speed. Affective symptoms may include: depression, irritability, and anxiety, while somatic symptoms may include: headache, dizziness, nausea, fatigue, sleep disturbances, blurred vision, tinnitus, hypersensitivity, and balance disturbances (Maruta, Lee, Jacobs & Ghajar, 2010; Murray, Salvatore, Powell, & Reed-Jones, 2014). Thirty percent (30%) of sport-related concussions are reported to cause balance dysfunctions (Murray et al., 2014). Symptoms may also include loss of consciousness (LOC); however LOC is not an indicator of severity (Murray et al., 2014). Severity of concussion is indicated by the length of the recovery period and the type of long-term problems sustained (Gomez & Hergenroeder, 2013)

Ninety to ninety-five percent (90-95%) of athletes in the acute stages of concussion recover within ten days of exposure to the injury, while 5-10% fail to recover as rapidly and symptoms persist for more than ten days (McCrory, Meeuwisse, Kutcher, Jordan & Gardner, 2013). In this case, the athlete is considered to be suffering from post-concussion syndrome (PCS). PCS can last up to three months or even up to one year and can potentially be linked to long-term problems. (Guinto & Guinto, 2013).

A long term problem that can be linked to PCS is chronic traumatic encephalopathy (CTE), which is more common in retired athletes (Bar & Markser, 2013). Studies citing CTE were associated with boxers and was called dementia pugilistica. This classic title of CTE is hard to define due to the lack of controlled studies during that era. The general signs reported were confusion, tremors, bradykinesia, gait disturbances, and dementia. Other studies indicated processing speed, memory, executive function, and complex attention deficits (Karantzoulis & Randolph, 2013). CTE can be related to dementia, depression, suicide, and motor neuron disease (Johnson, 2012). Additional symptoms can include Alzheimer disease, paranoia, agitation, aggression, and impairments of orientation, memory, language, and attention. It can also cause decrease in information-procession speed. Some physiological symptoms that can be found in CTE are: cerebral atrophy, enlarged ventricles, and a degreased in pigmentation of the substantia nigra and fenestration of cavum septum pellucidum (Bar & Markser, 2013). Multiple concussions are highly correlated with CTE or other conditions that classify as proteinopathies (Tartaglia et al. 2014). High impact sports athletes with a history of multiple concussions develop permanent cognitive symptoms or long-term PCS with increase in cognitive deficits and a decline of cognitive performance (Ingriselli et al. 2013).

Literature Review

Broglio, Macciocchi, & Ferrara (2007) in their study found that athletes who had a history of concussion but no longer presented concussion-affiliated symptoms still might have neurocognitive impairments. A total of 17 out of 21 athletes demonstrated impairment on at least one ImPACT variable, such as verbal memory, visual memory, reaction time, and visual-motor speed, while eight athletes (38%) were identified

as continuing to have impairment. This study confirmed that although an athlete might be asymptomatic from their exposure to concussion but there was a possibility of lingering cognitive impermanent.

Covassin, Stearne, and Elbin (2008) in a repeated measure design study reported that athletes with a history of two or more concussions suffered more neurocognitive impairment in comparison with athletes no pre-existing history of concussions. When tested the groups had no differences on day one but there was a difference on day five post-injury. The group with a history of concussions demonstrated slower reaction time and a lower verbal memory score. They concluded that athletes that had a history of concussions were subject to take longer to recover in regards to their verbal memory and reaction time when compared with athletes that had no history of a concussion.

Moser, Glatts, and Schatz (2012) investigated the positive outcomes when cognitive and physical rest was utilized in high school and college athletes after sustaining concussions. The study was conducted in a six month period and involved 49 female and male high school and college aged athletes (14-36 years) that reported at the Sports Concussion Center of New Jersey (SCCNJ). All participants were prescribed the initial first week a treatment of cognitive and physical rest. The sports related to the study were ice hockey (27%), lacrosse (18%), soccer (12%), basketball (10%), and football (8%). Participant's post-concussion symptoms deferred and the range of the injury occurrence was between 1 day and several months. Individuals were assigned to groups according to the time frame of their injury. Participants were tested using the online concussion assessment test ImPACT and a Post-Concussion Symptom Scale. Also they completed SCCNJ standard protocol. An additional 1-week of rest was prescribed to 28 participants who continued having symptoms. A MANOVA analysis showed a significant effect of prescribed rest on cognitive function and symptoms. A one-way ANOVAs analysis showed a significant difference between the group (n=28) that obtained additional rest comparing to the other group (n=21) when it came down to verbal memory, processing speed and reaction time, but not visual memory or total symptom score. The researchers indicated that the presence of cognitive and physical rest among individual who suffer of a concussion was very crucial for the proper recovery of the patient and an asymptomatic return to competition.

Webbe and Ochs (2003) investigated the correlation between the recent heading in soccer players and their neurocognitive performance. Participants included 64 male soccer players age 16-34 that competed in the high school, college, premier development and professional levels, compared to 20 active males age 16-34. The specific test administered on the soccer athletes indicated decrease in verbal learning, information processing speed and attention ability. The study supported that athletes that had recently headed a ball in moderate to high frequency had weaker neurocognitive performance.

Concussions and Gender

Gessel, Fields, Collins, Dick, and Comstock (2007) conducted a descriptive epidemiologic study investigated concussion rates among high school and college athletes on a national level. Three-hundred and nine participants that suffered from a concussion were selected from 100 high schools and 482 athletes were selected from 180 colleges. High school and college athletes participated in at least one of 9 sports (football, boys' and girls' soccer, volleyball, boys' and girls' basketball, wrestling, baseball, and softball).

Concussions constituted a total of 8.9% of the 4431 injuries suffered of the 2005-2006 school year. The majority of concussions occurred during competition (65.4%) and during practice (34.6%). The study indicated that in both high school and college sports, girls had a higher rate of concussions when compared to boys. Girls tended to have more concussions in soccer caused by either contact with the ground or the ball during defense, while boys experienced concussions more often when they had contact with another person. In basketball, girls sustained concussions while ball handling and defending, while boys sustained them during rebounding and chasing loose balls. The researchers indicated that biomechanical differences between genders might account for the higher number of induced concussions among female athletes. Female athletes tended to have more displacement and angular acceleration of their head and neck in comparison to males that exposed them to a greater disadvantage when it came to concussive forces.

Frommer, Gurka, Cross, Ingersoll, Comstock, and Saliba (2011) compared patterns in high school females and males who suffered a sport-related concussion. These patterns revolved around symptoms of the concussion, the time that the symptoms resolved and the time the athletes return to play (RTP). Participants were 812 student-athletes (202 females and 610 males) from 100 high schools who suffered a concussion within a two-year period. Data were collected from the schools' athletic trainers who reported the injuries utilizing internet-based software: Reporting Information Online (RIO). Student- athletes participated in one of the following sports: boys' football, soccer, basketball, wrestling, and baseball and girls' soccer, volleyball, basketball, or softball. During the first year, the athletic trainers recorded the primary symptoms that the athletes experienced. In contrast, in the second year all the symptoms of the student- athletes experienced were recorded. In addition, the time frame that the symptoms resolved and the RTP time frame were recorded. The primary symptom reported during year one and two, was headache. Results indicated no significant difference between sexes (males=40%, females=44% for the first year and males= 95%, females= 97% for the second year). Males more frequently reported amnesia and disorientation when compared to female athletes. However, females showed symptoms of sensitivity to noise and drowsiness when compared to males. The resolution of symptoms occurred within three days and there was no significant difference between female (66.7%) and male (72.2%) athletes. The RTP time frame was on average nine days among all athletes (64%). Male athletes (29.7%) returned to play between day seven and day nine following their exposure. In contrast, female athletes (29.7%) returned to play between day three and day six following their exposure. Results of the study indicated that there was no significant difference in symptoms resolution time and RTP time between sexes in high school athletes sustained concussions. However, there was a difference in the type of symptoms following a concussion, with females presenting more somatic and neurobehavioral symptoms and males presenting more cognitive symptoms.

Iverson and Koehle (2013) investigated normative data for balance to observe differences among age and sex. Participants included 739 males and 497 females (n= 1236) with an age range of 20-69. The study utilized the balance error scoring system (BESS) postural assessment test. Researchers indicated that participants among the ages of 20 to 49 performed better than participants 50 and 69. A correlation between sex and balance indicates that women perform worse than men. There was a significant poor performance when women were overweight.

Moore, Ashman, Cantor, Krinick, and Spielman (2010) investigated possible sex differences in cognitive function in individuals that sustained a traumatic brain injury. Participants were 83 males age range 25-81

and 75 females age range 19-79. The participants were divided into two groups: the ones that suffered a mild traumatic brain injury and the ones that suffered moderate to severe traumatic brain injury. The study indicated that there was no significant difference in cognitive functions when comparing the two groups of participants, but there was an increased performance in visual memory in females when compared to males.

Concussion and Youth

Zuckerman et al. (2012) investigated the recovery time from neurocognitive related symptoms between two different age groups following exposure to a concussion. The study included 200 adolescents and adult athletes; 100 athletes age range 13-16 and 100 athletes age range 18-22. The study utilized ImPACT cognitive test. Results of the study concluded that younger populations between the ages of 13-16 recovered more slowly from a concussion when compared to athletes between ages 18-22 years old. This study supports the normative data that indicates the age-based differences in concussive injuries and their acute response among young athletes.

Baillargeon, Lassonde, Leclerc, and Ellemberg's (2012) study examined the difference in cognitive outcomes following a concussion among three different age groups. A total of 96 male athletes were included in the study. Age group one included 32 children age 9-12, age group two included 34 adolescences age 13-16, and age group three included 30 adults. Out of the 96 athletes, half of them suffered a concussion. The study indicated that there was no significant difference in the neuropsychological test results but a slight difference in the memory test results of the adolescence group. The researchers concluded that adolescents had a high sensitivity to concussive symptoms that were persistent six months following a concussion, and were more prone to concussion side effects when compared to children and adults.

Fields, Collins, Lovell, and Maroon (2003) compared differences in symptoms and neurocognitive recovery between high school and college athletes following a sports-related concussion. The study included 370 male football and 23 female soccer Division I student-athletes. The high school participants included 22 varsity male soccer athletes and 161 varsity male football athletes. All athletes underwent baseline screening for concussion prior to the beginning of their seasons. The athletes exposed to concussions during the season were 19 high school athletes and 35 college athletes. The study reported that college athletes sustained memory impairment during the first 24 hours in comparison to high school athletes who sustained up to seven day memory impairment. The researchers concluded that there was a presence of age-related difference in concussed athletes and that health care providers should take a more conservative approach towards high school athletes' recovery.

Ingriselli, Register-Mihalik, Schmidt, Mihalik, Goerger, and Guskiewicz (2013) conducted a study to investigate a possible improvement in balance and neurocognitive performance in 15 females and 15 males who participated in collegiate recreational athletics. Students performance was compared utilizing either a single-task or a dual-task training program. Participants were randomly assigned to complete the dual-task or single-task training. Prior to the beginning of the four-week program, participants were evaluated by completing a computerized neurocognitive exam and two balance assessments. The tests were repeated at the end of the interventions. The study showed that the dual-task training participants improved in cognitive

flexibility, complex attention, executive function, and balance following both interventions. Single-task training participants showed improvement in complex attention. Researchers suggested that combinations of both tasks could be proven beneficial in individuals with concussions.

Iverson, Echemendia, LaMarre, Brooks, and Gaetz (2012) investigated the possibility of decrease in neuropsychological testing or reported any symptoms during baseline ImPACT screening in athletes that reported a history of three or more concussions. Participants included 26 male athletes age 17-22 with a history of three concussions or more and were matched with 26 male athletes who had no history of concussion. The study also matched athletes from both groups who self-reported learning problems. The study indicated that there was a decrease in memory in athletes with multiple concussions. These results suggested that athletes with multiple concussions had lingering memory deficits when compared to athletes with no history of a concussion.

McClincy, Lovell, Pardini, Collins, and Spore (2006) investigated the recovery time following a concussion among college and high school athletes utilizing the ImPACT test. The study included 104 participants (males 87.5%) from sports such as football, soccer, basketball, wrestling, hockey, and field hockey. Seventy athletes had no concussion history, 34 had a history of one concussion, and 13 had a history more than one concussion. The average age was 16.11 years. Athletes were tested post-season (baseline) and following a concussion on days two, seven, and fourteen. Analysis of the data indicated that athletes may take up to or more than 14 days to recover from a concussion and that verbal memory takes the longest to recover following a concussion.

Moser et al. (2007) indicated that professional football players had a tendency to recover from concussion more rapidly when compared to younger athletes. When compared college and high school football players the recovery time needed was different. College football players' majority recuperated within seven days and in contrast to high school football players which mostly recovered within a month. Therefore, younger populations showed a slower and different recovery configuration when compared to populations such as professional athletes and college-aged athletes.

Methods

Participants

Data used in this study was from the ImPACT test online data base of a South East historically black university in NCAA Division I. The student athletes were identified if they had one or more concussions and were African American students.

Instrumentation

Data for this research study were collected from existing data from the ImPACT test online data base. The ImPACT test is a computer administered test battery that includes six neuropsychological tests (Lovell, 1990). These tests are designed to identify different cognitive functions: attention, memory, processing speed, and reaction time. The current study generated scores for verbal memory, visual memory, processing speed (visual motor speed), and reaction time, impulse, and cognitive index. The ImPACT test has been proven to be highly effective in assessing and managing of concussion (Schatz, Pardini, Lovell, Collins &

Podell, 2006). After the test is completed, a list of 21 commonly reported symptoms is included in the assessment, known as post-concussion symptom scale (Iverson, Echemendia, LaMarre, Brooks & Gaetz, 2012). Reliability of test items is reported as follows: visual memory was 0.65, processing speed was 0.74, reaction time was 0.68, verbal memory was 0.46 and the symptom scale was at 0.43 (Schatz, 2009).

Procedures

Permission to conduct the study was obtained from the Institutional Review Board (IRB) from the university before conducting the research. Then the Head Athletic Trainer was contacted to obtain permission to utilize the ImPACT online data base. After the permission, data were collected from the ImPACT online database.

Data Analysis

The paired t-test was used to determine if there was a significant difference in cognitive functions between the means of initial concussion and one year after concussion for student-athletes with a history of one or more concussions by using SPSS. The significant level was set at .05.

Results

Participants Information

Totally 46 student athletes who were qualified was included in this study. Of all the 46 student athletes, 14 are females, and 32 males from the following sports: Women's Basketball (n=3), Men's Basketball (n=2), Football (n=30), Softball (n=7), Women's Tennis (n=2), and Women's Volleyball (n=2) (Table 1). The age range was18-23 years old. Seven of them had two or more concussions (Table 2).

Table 1

Demographic data for student-athletes with a history of one concussion or more (N=46).

Sport	Male	Female
Football	30	0
Basketball	2	3
Softball	0	7
Tennis	0	2
Volleyball	0	2

Table 2

Demographic Data for student-athletes with a history of two concussions or more (N=7).

Sport	Male	Female

Football	6	0
Basketball	0	1
Softball	0	0
Tennis	0	0
Volleyball	0	0

Paired t-test was used to determine if there was a significant difference between initial concussion and one year after the concussion of the student athletes with a history of one or more concussions on the ImPACT tests (Table 3). While all the scores after one year of concussion improved, significant difference was only found in processing speed ($p<.044$).

Table 3

Initial and follow-up concussion paired t-test on cognitive functions of student-athletes with a history of one or more concussions (N=46).

	Mean	SD	P value
Verbal Memory 1	84.54	7.713	0.071
Verbal Memory 2	87.57	10.28	
Visual Memory1	73.43	11.76	0.578
Visual Memory 2	74.48	15.3	
Processing Speed1	37.77	7.027	0.044
Processing Speed2	39.17	6.326	
Reaction Time 1	0.619	0.901	0.661
Reaction Time 2	0.613	0.73	
Impulse 1	5	4.158	0.545

Impulse 2	5.37	3.75	
Cognitive Index 1	0.298	0.107	0.268
Cognitive Index 2	0.322	0.156	

Only 7 student athletes had two or more concussions in this study (Table 4). No significant difference was found between the means of initial concussion and one year after the concussion. While the verbal memory, visual memory, and cognitive index scores were all improved, the processing speed score was reduced. The reaction time was also increased.

Table 4

Initial and follow-up paired t-test on cognitive functions of student-athletes with a history of two or more concussions (N=7).

	Mean	SD	P value
Verbal Memory 1	85.14	7.403	0.301
Verbal Memory 2	89.86	9.651	
Visual Memory 1	74.71	8.261	0.28
Visual Memory 2	79.29	11.75	
Processing Speed1	42.49	8.187	0.808
Processing Speed2	41.96	6.214	
Reaction Time 1	0.564	0.043	0.42
Reaction Time 2	0.584	0.039	
Impulse 1	5.29	2.138	0.593
Impulse 2	4.57	3.552	

Cognitive Index 1	0.36	0.104	0.743
Cognitive Index 2	0.372	0.105	

Discussion

The purpose of this research was to examine concussion induced cognitive impairment among collegiate athletes for a long term. Student-athletes experiencing concussion can develop short and long term cognitive deficits that can potentially lead to negative effects on their academic and athletic performance. This study attempted to determine if there was a significant decrease in cognitive function in student-athletes with a history of concussion after one year of concussion. Results of this study showed that while all the scores of the ImPACT test improved after one year of concussion for the student-athletes with one or more concussions, there was significant improvement only in the processing speed. For the student-athletes with two or more concussions, the processing speed score after one year of concussions was a little lower even than the score after initial concussion, but it is not statistically significant.

Broglio et al.'s (2007) study also reported an impairment in processing speed (visual-motor speed). In their study, however, they also indicated impairments in verbal memory, visual memory, and reaction time in some student-athletes. Potential cause of differences between these two studies can be attributed to number of data collected. In the Broglio et al.'s (2007) study the total number of participants (n=21) was significantly less than the number of participants in the current research study (n=46). Another reason can be the fact that Broglio et al.'s (2007) follow-up data was conducted after 72 hours following the student-athletes' injuries and then another follow-up was conducted when the student-athletes reported of being asymptomatic. In the current research study, the follow-up data collected was obtained in the following academic year after the student-athletes experienced a concussion. That factor could have potentially allowed for more time of cognitive recover comparing to the other study.

Covassin et al. (2008) indicated cognitive impairment in verbal memory and reaction time in student-athletes who suffered two or more concussions. In contrary, with the small group of student-athletes (n=7) who suffered two or more concussions in this study there was no significant difference in any aspect of the ImPACT. Potential cause of differences when comparing the two studies can be the time frame the data was collected. Covassin et al.'s study (2008) indicated cognitive impairment when the data was analyzed the fifth day following the injury and there was no follow-up during a longer time frame post-concussion. In contrary, the data that were analyzed in the current study were obtained within a longer time frame following an exposure to a concussion. Another factor that could affect the outcome of the results could be the number of the data analyzed. Covassin et al.'s study had a greater number of data to compare with the total of 57 student-athletes with a history of concussions and more specifically 21 student-athletes with a history of two or more concussions.

Student-athletes with concussion can develop short and long term cognitive deficits that can potentially lead to negative effects on their academic and athletic performance (Broglio, Macciocchi, & Ferrara, 2007). Consequences of concussion exposure may negatively affect academic progress, athletic performance, and general health and well-being. The results of this study may be significant for athletic administrators,

current concussed student-athletes and future student-athletes. Athletic administrators may benefit by better understanding the nature of concussions and may become more conscious of the needs of their student-athletes. Therefore, administrators can provide resources to develop and improve preventative, educational, and health services that will benefit current, currently concussed, and future student-athletes.

There was only 7 student-athletes with two or more concussions in this study. The small number of subjects in this category greatly limited the power of the t-test analysis in this study. It is suggested to collect more data of student-athletes with two or more concussions in the future to see if there is any significant decrease in their cognitive functions compared to student-athletes with only one concussion. Another suggestion is to increase the frequency of the baselines data collection. Instead of waiting for a yearly data collection, the university can perform ImPACT baselines for the student-athletes within six months and have a follow-up every six months.

Conclusion

This study showed that processing speed was significantly improved after one year of concussion for student-athletes with one or more concussions. Although no significant deficit in cognitive functions was found for student-athletes with two or more concussions in this study, it is still an area that is worth more studies.

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