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CTE And The Effects Of Multiple Concussions On College Athletes

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CTE AND THE EFFECTS OF MULTIPLE CONCUSSIONS ON COLLEGE ATHLETES

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Abstract

The purpose of this research was to determine if signs and symptoms of Chronic Traumatic Encephalopathy (CTE) could be detected in college athletes who have suffered multiple concussions. College athletes are likely to be at an increased risk of suffering a concussion, due to the high-impact trauma that is often seen in contact sports. This question was explored through the use of a survey, cognitive test, known as the Mini Mental State Examination (MMSE), and the Beck Depression Inventory. The questions on the survey included necessary background information (i.e. age and sex), as well as more personal information including: number of concussions and organized sports played. The Beck depression inventory quantified the research subject's level of depression, which is associated with CTE. The Mini Mental State Examination is another clinical test used primarily with Alzheimer's disease patients to examine cognitive degeneration. We found no notable differences in cognition between members of the control group and members of the experimental group. However, the results of the Beck Depression Inventory displayed a significant difference between the two groups. The average score for the control group was a 5.5, which is considered normal, whereas, the average score of the experimental group was an 18, which would be considered borderline clinical depression. This would suggest that college athletes who have suffered multiple concussions may be more likely to be diagnosed with clinical depression, and some signs of CTE may be detectible in college athletes.

Table of Contents

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Tables and Figures

Page

Introduction

Traumatic brain injuries (TBI) occur very often and can be life-threatening in both the short-term and long-term survival of an individual. A traumatic brain injury results when the head makes contact with another object, resulting in the normal processes of the brain becoming disrupted (CDC 2017). About one in every 300 Americans is admitted to the emergency department each year for treatment of a TBI (CDC 2016). These TBIs are generally divided into categories based on the severity of the injury. Concussions are one type of mild TBI that are quite common, especially among athletes in contact sports. A concussion is the result of the brains jolted movement inside of the skull caused by impact with an object. In many cases, the brain makes a traumatic impact with one part of the skull and then a second impact opposite to the first, resulting is what is known as a coup-countercoup injury, causing far greater injury than the point of impact (Northeastern 2010; Medline 2017).

Chronic brain trauma can result from multiple different sources, some of the most common being car accidents, contact sports, and explosive blast impact (Taylor et al. 2017; Goldstein et al. 2012; Seichepine et al. 2013). Some of the most commonly affected individuals are athletes involved in contact sports and military personnel who have been exposed to explosive blasts (Goldstein et al. 2012; Seichepine et al. 2013). The repeated trauma to the brain, caused by any of the previously mentioned events or any other traumatic brain injury, can result in, over time, the degeneration of the individual's brain or chronic traumatic encephalopathy (BU 2017).

Chronic traumatic encephalopathy (CTE) is a condition which results from repeated trauma to the head. It is often correlated with multiple concussions, and as a result, it is also often correlated with athletes involved in contact sports. It is a condition which, in recent years, has been thrust into the spotlight as a result of national media attention. A movie, "Concussion" was produced about the man who first uncovered CTE's connection to concussions suffered by players participating in football (ESPN 2017). It has also become a significant issue for the National Football League (NFL), as increasing numbers of deceased veterans of the NFL have been diagnosed with the condition at autopsy. In very recent news, former New England Patriot, Aaron Hernandez, was revealed to have been suffering from an advanced case of CTE. His brain was examined post-mortem, and it was determined that his case was quite advanced, especially for someone at a relatively young age (CNN 2017).

There is not enough currently known regarding the biochemical development of CTE, though tau proteins and amyloid-beta plaques are believed to play a large role, as they do in other forms of dementia. Tau proteins are found on the microtubules of neurons and when they behave and/or degrade abnormally, it can lead to abnormal or no functionality of neurons. These chronic conditions are known as taupathies (Edwards et al. 2016). It is believed that these tau proteins degrade as a result of hyperphosphorylation, a process which causes the phosphate groups that bind to tau to bind in abnormally high quantities. The reason for this event is not known, however the result is the formation of neurofibrillary tangles (NFTs), long fiber-like formations that do not degrade properly (Edwards et al. 2016; The Dana Foundation 2013). Alzheimer's

disease (AD) results from another type of taupathy, as NFTs have been observed in AD infected brains, as well (Sen et al. 2017). Amyloid-beta plaques have also been observed in individuals diagnosed with CTE, and are believed to be the primary cause of Alzheimer's disease (Sen et al. 2017). Although the pathogenesis of AD is not fully understood, recent research appears to point toward a lack of normal breakdown of amyloid-beta proteins. The current belief is that natural amyloid-beta proteins, for some reason, develop an abnormal protein structure, leading to dense clusters of the protein which form plaques (Sen et al. 2017). Observing that NFTs and amyloid-beta plaques are found in both AD and CTE, one could hypothesize that although the pathogenesis of the two conditions is different, the results lead to the same outcome. The only discrepancy between the two conditions may be the stimuli that initiate the pathogenetic process, the abnormal aging process in AD and repeat trauma in CTE (Sen et al. 2017; Seichepine et al. 2013).

The symptoms that have been observed in correlation with a diagnosis of CTE are depression, suicidal thoughts, behavioral changes, and cognitive issues (Goldstein et al. 2012). In the field of CTE, a common issue exists among most of the collective research performed, it is primarily targeted at identifying CTE in the brains of deceased athletes. By this point, the results of this research have quite limited clinical significance, as it does not assist a clinician in maintaining the health of a patient. Currently, as is with AD, a true diagnosis of CTE cannot be made until a postmortem examination is performed on the brain. Although, recently published research has shown that it may be possible to use radiological imaging to identify signs of CTE in a living person (Omalu et al. 2017).

Either way, there are identifiable symptoms which could be used to formulate a tentative diagnosis for a patient, perhaps then confirm a radiological diagnosis, while it will still be of value to them. Most importantly, early detection of the condition would allow clinicians to provide advice to an individual on how to avoid additional damage to the brain and prevent worsening of the disorder. Using established methods in following the progression of AD, this research takes a similar but less-traveled approach by evaluating college athletes for these identifiable symptoms.

The high school and college age demographic (15-24 years) is the second largest age demographic admitted to the emergency department for TBI (CDC 2016). Presumably, if an individual has suffered from multiple concussions, then he/she would be more likely to display cognitive and emotional symptoms of dementia, correlated with development of CTE (i.e. depression, suicidal thoughts, emotional changes, and cognitive issues). The emotional changes that an individual may display include: anger, irritability, and abrupt mood changes. Cognitive issues expressed by individuals affected by CTE may include: problem-solving difficulty and poor memory or memory loss. This research aims to examine if those symptoms can be identified at an early stage of CTE in an individual and could ultimately be used to diagnose and treat individuals affected by CTE.

Methods

This research was approved by the Salem State University Institutional Review Board. Informed consent was obtained from all participants prior to the start of each

research interview. We performed research interviews with 8 individuals, all of which were between the ages of 18-25 years. The participants were divided into two groups, a research group containing two individuals who were current or former college athletes and had suffered one or more diagnosed concussions, and a control group of six individuals who were never involved in college athletics, three of which had never before suffered a concussion, and three others who had been diagnosed with a concussion.

Research interviews began with a survey designed to obtain necessary background information, as well as a brief medical history regarding concussions. Background information collected included: age, sex, history as a collegiate athlete, history as a high school athlete, number of diagnosed concussions, number of concussions related to contact in a sport, history of blackouts, and history of undiagnosed concussions. The survey was administered as a written form which was filled in by each test subject.

The Beck Depression Inventory was used to obtain a quantitative analysis of each test subject's depression level. The test form was borrowed from the United States Navy Bureau of Medicine and Surgery. This test was not altered from its original form, which is used clinically to examine patients for depression. The test is based around emotional feelings and behaviors, such as: sadness, guilt, self-worth, decision-making, weight changes, health concerns, and sleep quality. The test was administered in the same way as the survey, as a written form, filled in by each test subject. The scale of the test ranges from 0 to 63. A score ranging from 0 to 10 indicates a normal condition, without significant mood disturbance. A score ranging from 11 to 16 indicates a mild mood

disturbance. A score ranging from 17 to 20 indicates borderline clinical depression. A score ranging from 21 to 30 indicates moderate depression. A score ranging from 31 to 40 indicates severe depression. Finally, a score of 40 or more indicates extreme depression.

The Mini Mental State Examination (MMSE) was used in the research interviews, but was altered slightly from its original form. The MMSE is designed to be used clinically, to examine patients for signs and symptoms of dementia. The original MMSE form was borrowed from storrsuk.com, and we made the decision to add the "clock drawing test (CDT)." The original exam is used on its own, as well as part of another cognitive evaluation known as the mini-cog test. For this test, the patient or test subject is asked to draw an analog clock with all 12 numbers and label it at a specific time. We replaced the final part of the MMSE, which involves drawing two intertwining pentagons, with the CDT. Past research has shown that the CDT can be a useful tool for analyzing executive functioning, a vital part of cognition, and it is best used as part of a larger group of tests (Paula et al. 2013). Also, we believed that the CDT would provide a more easily quantifiable representation of cognitive issues. When scoring the CDT, points could be deducted for missing numbers, incorrect order, incorrect placement, and incorrect time.

The MMSE was administered verbally to each test subject, and scored by the researcher. The scoring system for the MMSE ranges from 0 to 30. A score from 24 to 30 indicates normal cognitive function. A score from 18 to 23 indicates mild dementia. A score from 10 to 17 indicates moderate dementia. Finally, a score below 10 indicates severe dementia. With that said, the MMSE is traditionally used in a progressive

evaluation. The value of the MMSE does not lie in one score, but rather how that score changes over a period of time, within the same individual. But it can offer a snapshot examination of the current cognitive function in subjects with a history of concussions.

Participants

Subjects involved in this study were between the ages of 20-25 years. The control group consisted of six individuals (5 male; 1 female), and the experimental group consisted of two individuals (both female). The divide between sexes was merely a result of random chance, as well as willingness to volunteer.

Both subjects included in the experimental group were involved in sports for several years prior to attending college, and continued as student athletes for, at least, some of their college education. The sports which subjects were involved in during their high school and/or college years included: ice hockey, volleyball, basketball, softball, and track and field.

None of the subjects in the control group were involved in any organized sports at the collegiate level, though they may have had some involvement in athletics prior to attending college.

Concussions

The number of diagnosed concussions that a participant may have suffered ranged from 0-5. Half the subjects in the control group had never been diagnosed with a concussion, while the other half had suffered between 1-2 diagnosed concussions, with

the average being about 0.67. Both subjects involved in the experimental group had suffered five diagnosed concussions prior to their research interview. (*Table 1; Figure 1)*

Participant Group	# of Concussions
Control 1	0
Control 2	0
Control 3	0
Control 4	2
Control 5	1
Control 6	1
Control (Average)	0.67
Athlete 1	5
Athlete 2	5
Athlete (Average)	5

Table 1. *Score on the MMSE and Beck Depression Inventory for each test subject.*

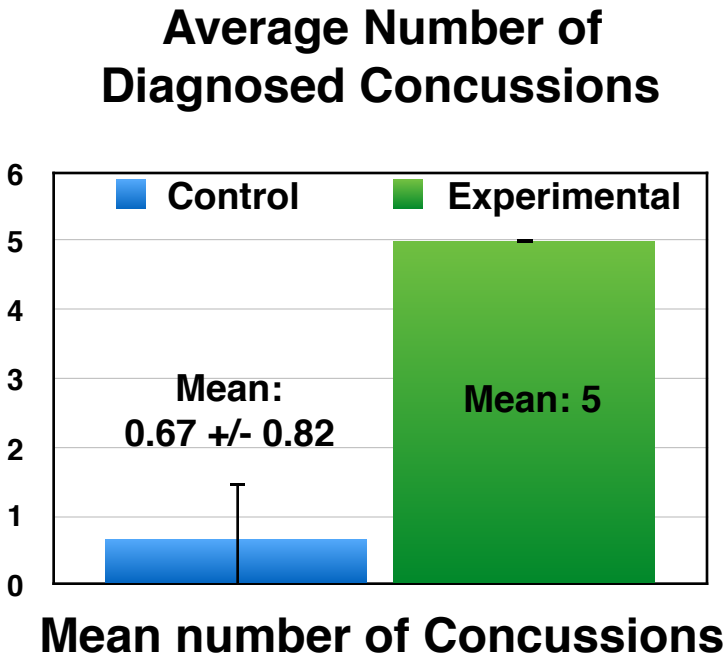

Figure 1. *Average number of diagnosed concussions (Control-Blue; Experimental-green) (Mean Value +/- Standard Deviation)*

Out of the ten total diagnosed concussions in the experimental group, six were suffered as a direct result of contact while participating in organized sports. Although it is subjective, it is also noteworthy that one member of the experimental group (Athlete 1) believes that they had suffered three additional, undiagnosed, concussions. In addition, both subjects also reported that they recall having "blacked-out" at least one time, as a result of contact during an organized sport.

Results

Mini Mental State Examination (MMSE)

The average score of the control group on the MMSE was a 29 out of a possible 30 points. Comparatively, the average score for the experimental group was a 29.5 out of a possible 30 points ($p = 0.27$). Both of these averages are well within the "normal" range from 24 to 30. (*Table 2; Figure 2*)

Participant Group	Beck Score	MMSE Score
Control 1	10	27
Control 2	7	28
Control 3	0	29
Control 4	7	30
Control 5	5	30
Control 6	4	30
Control (Average)	5.5	29
Athlete 1	15	29
Athlete 2	21	30
Athlete (Average)	18	29.5

Table 2. *Score on the MMSE and Beck Depression Inventory for each test subject.*

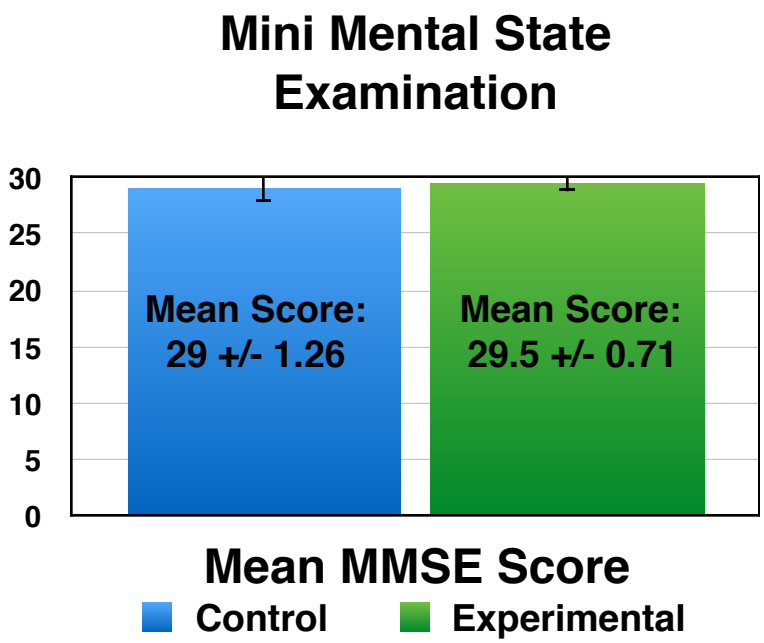

Figure 2. *Average score on the Mini Mental State Examination (Control-Blue; Experimental-green) (Mean Value +/- Standard Deviation)*

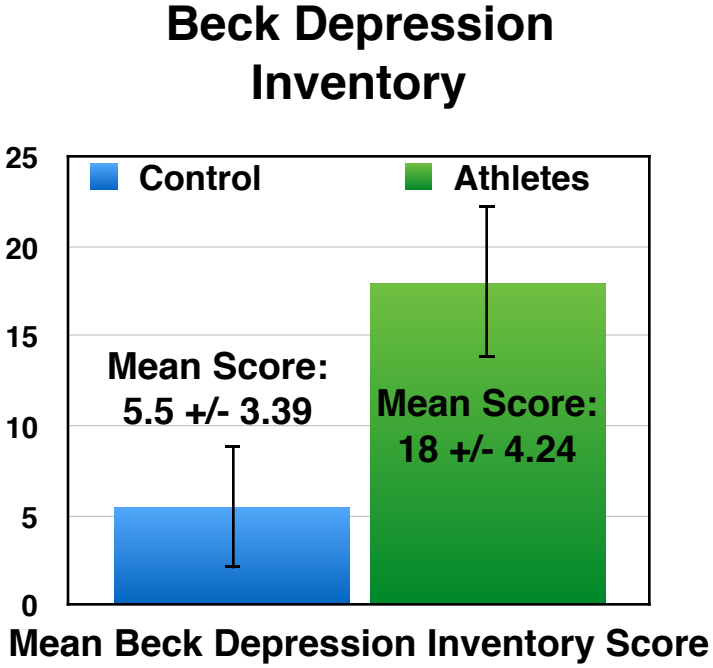

Figure 3. *Average score on the Beck depression inventory (Control-Blue; Experimental-green) (Mean Value +/- Standard Deviation)*

Beck Depression Inventory

The average score of the control group on the Beck Depression Inventory was a 5.5 out of a possible 63 points. This average would be considered within the "normal" range, which ranges from 1 to 10. Comparatively, the average score for the experimental group was an 18 ($p = 0.05$). This average is considered to be borderline clinical depression. (*Table 2; Figure 3*)

Discussion

The findings of this research, in combination with past studies and medical knowledge, would suggest that some early symptoms of CTE may be detected in college-age athletes who have suffered multiple concussions. It would also suggest that these same athletes may be at a higher risk of developing clinical depression, when compared to the general population.

The results of the Beck Depression Inventory produced, with about 95% confidence, the conclusion that individuals who are involved in college athletics and have suffered from multiple concussions are likely to score higher on a depression evaluation, and may also be more likely to develop clinical depression. There was a noticeably drastic difference between the average score of the control group versus the average score of the experimental group in this part of the study.

That being said, this research would also suggest that it would be unlikely that cognitive disruption could be detected in athletes who are a part of this age group (18-25 years). Though the results of the MMSE did not reach statistical significance, there

appeared to be no discernible difference between the cognitive capabilities of an individual who was not a college athlete and one who was a college athlete. With that being said, the MMSE is generally used as a progressive test, rather than as a snapshot at one moment in time. Though the results of just one Beck Depression Inventory could indicate clinical depression, the first MMSE test would usually be used as a baseline for tracking the progression of an individual's score, but it can also display current cognitive impairment in an individual. In the case of this study, the MMSE was limited to a snapshot at one moment in time, and therefore did not meet the ideal criteria for the most effective MMSE results.

Finally, this study would suggest that individuals who are involved in athletics have a much higher risk of suffering a concussion ($p < 0.01$).

The research presented here could open the door to additional research, increasing the validity of the many questions surrounding CTE, concussions, and athletes. Perhaps a study could be conducted using brain scans or another method to evaluate these same athletes for depression and other additional neurological changes. A study could also be designed to evaluate former college athletes for cognitive difficulties and disfunction later in their lives.

In conclusion, while the results of this study are quite intriguing, it was conducted using a very small sample size. The results are largely supported by the the literature written about past studies and current medical knowledge. However, a much larger and more diverse sample size would be necessary in order to support the conclusions of this study.

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