The Relationship Between Traumatic Brain Injury and Aggression in College Football Players

Jessica Winslow

North Carolina Wesleyan College

Abstract

Extant literature shows that traumatic brain injury has been linked to aggressive behavior. Repeated concussions, a type of mild traumatic brain injury, and sub-concussive impacts over time can lead to neurodegenerative brain diseases like chronic traumatic encephalopathy, the symptoms of which often include violent and aggressive behavior. With as many as 3.8 million concussions occurring in the U.S. every year, understanding the role that mild traumatic head injury may play on aggression is an important research topic. In this study, 56 North Carolina Wesleyan College football players were administered two questionnaires: one to assess aggression and one to assess history of head injury. Four sub-types of aggression: physical aggression, verbal aggression, anger, and hostility, as well as total aggression, were correlated with three ways of quantifying concussions: diagnosed concussions, treated concussions, and suspected lifetime concussions, which was the number of concussions players reported having suffered in their lifetime regardless of whether the impact was diagnosed or treated. Both physical and verbal aggression correlated significantly with suspected lifetime concussions. These results show that, on average, players that reported experiencing more lifetime concussions scored higher on physical and verbal aggression measures than players that reported fewer lifetime concussions. No significant differences were found between any of the aggression subscale measures or any of the concussion measures based on player position.

Traumatic brain injury (TBI), defined by the CDC, is "a disruption in the normal function of the brain that can be caused by a bump, blow, or jolt to the head, or penetrating head injury" (Traumatic Brain Injury and Concussion, 2019). Given the prevalence of TBI, which affects millions of people each year ("What is a Concussion," 2018), its effect on brain functioning and behavior is an important area of research. A great deal of current research links TBI with a host of executive brain functioning deficits including, but not limited to, impairment in regulating emotions, recruiting appropriate emotional input in decision making, understanding and responding to punishment, learning from previous mistakes, controlling impulses, and in social functioning (Bannon, Salis, & O'Leary, 2015). Cognitive deficits caused by TBI, in turn, affect behavior. One type of behavior that recent literature has linked to TBI is aggression. This literature review seeks to show that TBI and aggression are positively correlated and reviews the incidence of TBI in football player populations.

Aggression

Aggression can be defined as a social behavior that is intended to harm another person who would seek to avoid this harm, and it may be physical or verbal (Lane, Kjome, & Moeller, 2011). Being a natural human trait, some aggression is considered positive, or necessary, such as when aggression is used for protection, survival, healthy competition, or used to produce other various advantages to the aggressor. This type of aggression is called instrumental aggression. Another type of aggression is hostile, or negative, aggression, wherein the purpose is to inflict harm on another person with little or no advantage to the aggressor (Liu, 2004). Negative aggression is also referred to as excessive or inappropriate aggression. Although some levels of both types of aggression are natural in humans, persistently high and socially disruptive levels of aggression, particularly hostile aggression, are indicative of psychopathology and often come

with many social consequences, which may include rejection from peers, or if aggression escalates to violence—physical harm to the aggresse or aggressor, or confrontations with law enforcement. (Lane et al., 2011). Additionally, Arnold Buss and Mark Perry identify four valid subtypes of aggression in their 1992 Aggression Questionnaire: physical aggression, verbal aggression, anger, and hostility, with anger describing a general propensity towards becoming angry and hostility describing resentment and suspicion towards the motives of others. The critical social consequences of aggression highlight the importance of research on the possible neuropsychological causes of high levels of aggression.

Support for the relationship between TBI and aggression

The purpose of this research project is to determine if traumatic brain injury positively correlates with aggression in college football players, with a hypothesis that the two variables are related. Numerous studies support this hypothesis. Rosenbaum and Hoge (1989) linked head injury to intimate partner violence (IPV), finding that closed head injury, in which there was no open wound or gash, was present in 61.3% of 31 partner violence perpetrators. Rosenbaum et al. created a similar study in 1994 with a larger sample size of 53 partner-abusive men, 45 maritally satisfied men, and 32 maritally-discordant men and discovered that 51% of male spouse abusers in their sample had suffered from head injury compared to 25% of non-violent maritally-discordant men and 16% of maritally-satisfied men. In this study, men with a history of head injury reported an increased loss of temper and control, more difficulty communicating verbally, and arguing with others. Another study found that IPV perpetrators had a significantly higher weighted average of TBI (53.6%) than the general population of men (38.5%) (McKinlay, Grace, Horwood, Ridder, MacFarlane, & Fergusson, 2008). Existing research on head injury and IPV also explores the extent to which severity of head injury plays a role. In a study by Turkstra,

Jones, and Toler (2003), twenty men convicted of domestic violence were compared to twenty men without a criminal background that were matched for age, race, and socioeconomic status. They found that over half the participants in both groups had experienced a traumatic brain injury, but the participants in the IPV perpetrator group had experienced significantly more severe damage as determined by the persistence of post-injury changes in activities, behavior, and emotional control. These studies show how head injury and aggression are related in intimate partner violence populations.

Head injury is also associated with a "broad risk for criminal behavior among both violent and nonviolent individuals" (Bannon et al., 2015). A study conducted in New Zealand by Barnfield and Leathem (1998a) found that 86.4% of prisoners in the study, both violent and nonviolent offenders, had experienced at least one significant head injury, while 56.7% reported experiencing multiple significant head injuries. Additionally, another study conducted by Diamond, Harzke, Magaletta, Cummins, and Frankowski (2007) found that out of 107 male and 118 female offenders across three prison security levels, 88% of the prisoners had experienced at least one significant head injury. Compared to the general population, violent and nonviolent offender groups have elevated frequencies of lifetime experience of multiple head injuries with frequencies of 61.1% for violent offenders and 46.2% for nonviolent offenders (Leon-Carrion & Ramos, 2003).

The studies above demonstrate the correlation between traumatic brain injury and aggression by examining head injury in intimate partner violence perpetrator populations and more general criminal populations. Although a causal relationship between TBI and aggression cannot be determined from correlational studies, other studies suggest that TBI may lead to increases in aggression. McKinlay, Brooks, Bond, Martinage, and Marshall (1981) interviewed a

close relative of 55 severely head injured adults three, six, and twelve months after their injuries and found that family members commonly reported a host of cognitive changes in their loved one post-injury. The most commonly reported problems include slowness, tiredness, irritability, poor memory, impatience, tension and anxiety, bad temper, personality change, and depressed mood. Irritability was reported in 63% of patients at three months post-injury, 69% at six months post-injury, and 71% at twelve months post-injury, while bad temper was reported in 48%, 56%, and 67% of patients at three, six, and twelve months respectively. A much less commonly reported behavioral change, violent and inappropriate social behavior was reported in approximately 20% of patients at each stage. Though this behavioral change was not nearly as common as other cognitive symptoms, family members reported that violent and inappropriate social behavior had not been present in the patient before the injury, or that such behavior had been markedly less frequent (McKinlay et al, 1981). Another study found that 31% of caregivers for TBI patients reported moderate or severe aggressiveness toward themselves in the two years following the injury. These caregivers also reported more complaints with the head injured individuals' behavior over time, specifically noting increasingly severe temper outbursts (Hall, Karzmark, Stevens, Englander, O'Hare, & Wright, 1994). These studies not only show how TBI and aggression are related, but also suggests that TBI may lead to increases in aggression. However, more research must be conducted to fully support this. If TBI causes aggression to increase, research will show that the more traumatic brain injury a person receives, the higher he or she should score on a measure of aggression.

TBI's physiological effects on the brain

Research shows that traumatic brain injury may lead to increases in aggression by negatively affecting the brain circuitry implicated in emotion regulation and impulse control.

This circuit includes limbic structures such as the amygdala, hippocampus, hypothalamus, and anterior cingulate cortex (ACC), and several regions of the frontal lobe (Davidson, Putnam, & Larson, 2000). Figure 1 below exhibits a diagram of these areas.

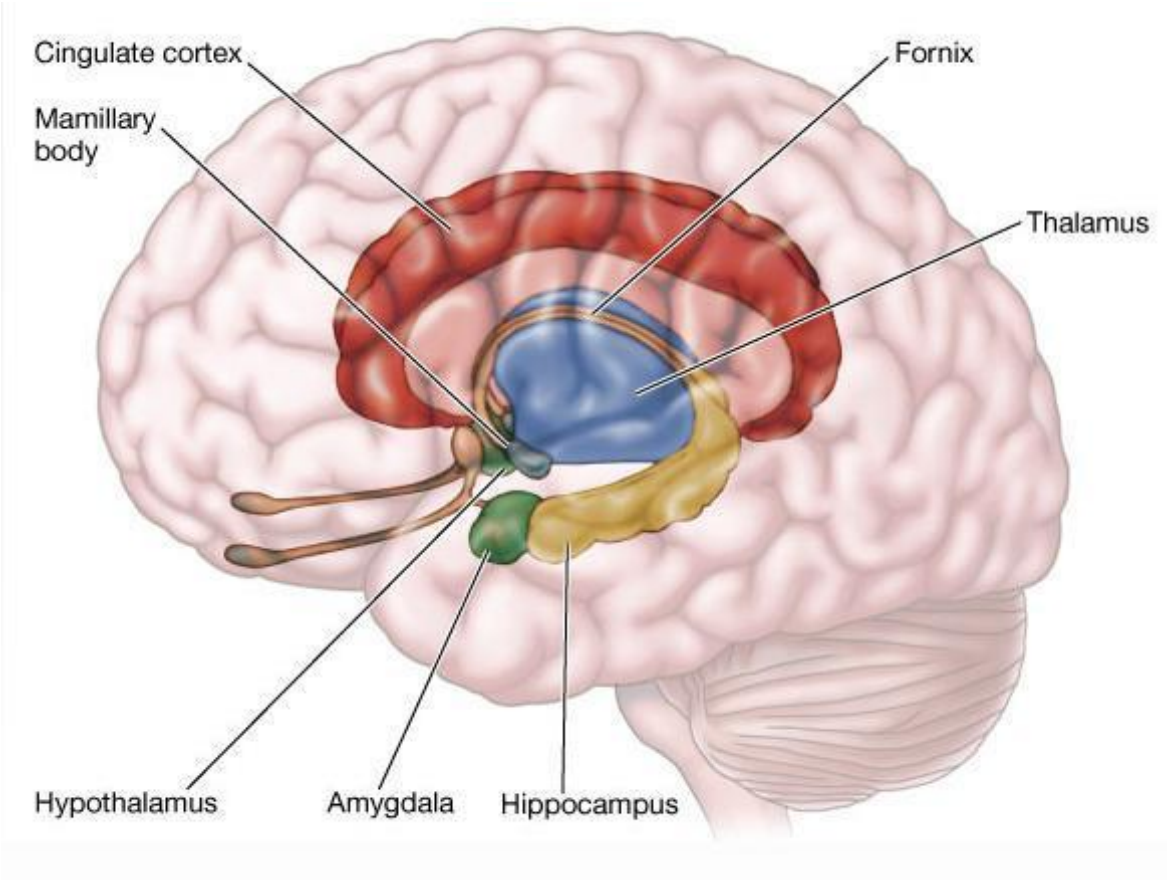

Figure 1. Areas of the Limbic System (2018)

Damage to any of these areas or the interconnectedness between them may result in a loss of proper functioning, which in turn may lead to an increase in aggressive thoughts and behavior because of a decreased ability to regulate emotions, make rational decisions, and control impulsivity (Bannon et al., 2015). Damage to the dorsolateral prefrontal cortex, orbitofrontal cortex, ventromedial prefrontal cortex, and medial frontal cortex in particular are the brain regions most associated with anger, irritability, and violence. Studies on brain lesions of these

areas, defined as any abnormality of brain tissue that results from trauma or disease, offers evidence as to how damage to these brain regions can lead to aggressive behavior (Bannon et al, 2015). In a study by Brower and Price in 2001, researchers studied the frontal lobe function in aggressive and antisocial participants. They found strong evidence for a correlation between both frontal lobe dysfunction on a broad level and orbitofrontal injury on a specific level and violent behavior. Additionally, Bechara, Damasio, and Damasio (2000) found that patients with inferior frontal lobe damage have an impaired ability to understand the consequences of their actions." This evidence points to increased violence and aggression as a result of impulsivity. Patients that are unable to fully comprehend the consequences of their behavior may lean towards acting in ways that will grant immediate rewards.

Seguin (2009) argued that although frontal lesions may not directly cause increased aggression, they often significantly impair psychosocial functioning, emotional decision making, and the ability to attend to informational cues from the environment, which may increase the tendency to turn to aggression or violence under conditions of stress or frustration. Evidence shows that the right ventromedial prefrontal cortex (VMPFC) may play an important role in decision making and emotional processing (Bannon et al, 2015). One famous case of ventromedial prefrontal lesion is that of Phineas Gage in 1848. Before his accident, which sent a 3-cm-thick, 109-cm-long iron rod through his face, skull, and brain, Gage was described as a "responsible, intelligent, and socially well-adapted individual, a favorite with peers and children" (Damasio, Grabowski, Frank, Galaburda, & Damasio, 1994). Although he recovered from the accident fairly quickly, friends and family members reported a significant change in his personality soon after. Once a very socially adapted individual, he soon became consistently irritable and often offended those around him; where he was once a hard-working, responsible

individual, he was soon fired from his job from a lack of being able to be trusted to perform work responsibilities. Doctors determined that his frontal lobe injury was the cause of his sudden, irritable, change in personality (Damasio et al, 1994). Although this is only one case study, Tranel, Bechara, and Denburg conducted a study in 2002 comparing individuals with right amygdala focal lesions to those with left amygdala focal lesions. Researchers found that the individuals with right amygdala damage showed not only significant disruption in social and interpersonal behaviors, but had "reduced anticipatory skin conductance" during a gambling task that involved risk and reward decisions (Tranel et al, 2002). Further, most participants with right VMPFC lesions met the criteria for "acquired sociopathy." This diagnosis involves an inability to learn from previous mistakes, a significantly decreased ability to understand and respond to punishment, and a decreased ability to feel negative emotions. Incredibly, the left VMPFC lesion group showed normal social and emotional processing—markedly different from the right VMPFC lesion group (Tranel et al, 2002). Overall, this study supports the claim that individuals with damage to certain areas of the frontal cortex cannot recruit appropriate emotional information when making decisions, meaning these individuals often tend to make decisions that favor immediate rewards. Although brain lesions are a more severe form of brain injury, other types of traumatic brain injury can lead to the same type of cognitive decline and changes in behavior, such as changes in aggression, if similar brain regions as the ones described above are affected. Varying degrees of severity of TBI lead to a range of levels of abnormal brain functioning.

TBI is classified into three levels of severity: mild, moderate, or severe, with each level differentiated by observable signs and symptoms at the time of injury. Mild TBI (mTBI) is defined by a loss of consciousness ranging anywhere from 0-30 minutes and an altered state of

consciousness lasting less than 24 hours. Loss of consciousness in moderate TBI may last between 30 minutes and 24 hours, with an altered state of consciousness lasting more than 24 hours, but less than 7 days. Lastly, severe TBI is defined by a loss of consciousness for over 24 hours and altered consciousness lasting over 7 days (Buckley, Kaye, Stork, Heinze, & Eckner, 2017). On the mild end of the spectrum lies concussion, a term often used interchangeably with mTBI. The research presented here focuses on concussions, particularly how college athletes, like football players, are affected by concussion, and how these concussions may correlate to aggression.

Concussions and their effects

Concussions are "a type of traumatic brain injury caused by a bump, blow, or jolt to the head or by a hit to the body that causes the head and brain to move rapidly back and forth" ("What is a Concussion," 2018). Because concussions cannot always be observed through brain imaging like X-rays, CT scans, or MRI scans, they are identified by the emergence of any number of a wide range of symptoms (Buckley et al, 2017). Symptoms include, but are not limited to, loss of consciousness, problems with balance, amnesia, confusion, dizziness, nausea or vomiting, memory problems, and difficulty completing mental tasks. These symptoms typically fall into four major categories: physical symptoms, cognitive symptoms, sleep symptoms, and emotional symptoms, and symptoms normally fully resolve within a couple of weeks. As many as 3.8 million concussions occur in the U.S. every year, and although they are generally not life-threatening, concussions can still cause brain damage that impairs brain cell functioning, especially when not treated properly ("What is a Concussion," 2018). Some studies show that many concussions remain unreported, and therefore untreated, among athlete populations (Meehan, Mannix, O'Brien, & Collins, 2013; Delaney, Lacroix, Leclerc, &

Johnston, 2002). In a 2013 study of 486 people who had suffered a sport-related concussion, 30.5% reported a previously undiagnosed concussion as determined by answering "yes" to the question "Have you ever sustained a blow to the head which was not diagnosed as a concussion but was followed by one or more of the signs and symptoms listed in the Post-Concussion Symptom Scale." Additionally, the undiagnosed concussions were associated with higher post-concussion symptom scale scores and higher loss of consciousness rates for future concussions as compared to athletes that did not report a previously undiagnosed concussion (Meehan et al., 2013).

Repeated blows to the head that don't meet the concussion threshold, but still shake the brain, have been shown to lead to a decline in proper brain functioning over long periods of time as well (Gavett et al. 2011; Baugh et al. 2012; "Subconcussive Impacts," 2018). These less-severe blows are called sub-concussive impacts. Understanding the full effects of concussions and sub-concussive impacts and how they affect the brain is critical in learning how to prevent and cure degenerative brain diseases like chronic traumatic encephalopathy (CTE). CTE is caused by a history of repetitive brain trauma, including both concussive and sub-concussive impacts, and is largely found in contact sport athletes and men and women with a history of military combat, but has also been linked to physical abuse victims and epileptics (Baugh et al, 2012; Gavett et al, 2011). The emergence of CTE typically occurs in midlife over a period of years or decades of head trauma and is characterized by a host of behavioral, cognitive, and mood-related symptoms. Symptoms that have been documented in CTE patients include learning and memory problems, impulse control problems, irritability, increased anger and violence, apathy, paranoia, depression, and suicidality. As CTE progresses over time, some patients

eventually develop dementia as well (Baugh et al, 2012; Gavett et al, 2011). Most relevant to this research is the increases in aggression and violence that is often observed in patients with CTE.

The number of blows to the head over time is thought to be more significant in the development of CTE than the severity of the blows (Baugh et al., 2012; "What is CTE," 2019). Contact sport athletes such as football players are often victims of CTE because of the incredible amount of sub-concussive impacts they are subjected to. A study of 314 football players from three colleges reported a median of 420 head impacts received by individual players during a single season, with a maximum of 2492 head impacts. These data were collected by having participants wear Riddell VSR-4, Revolution, or Speed football helmets instrumented with an accelerometer-based device to gauge and record head impacts and their location on the head, and this impact data includes the number of impacts in both practices and games (Crisco et al., 2011). These repeated blows to the head over a prolonged period of time cause aggregates of phosphorylated tau protein to build up in the form of neurofibrillary tangles and glial tangles (Gavett et al, 2011; Baugh et al, 2012). Although the pathologic mechanism that ties mild head injuries to the formation of neurofibrillary tangles is still largely unknown, it may involve a series of diffuse axonal injuries (DAI). DAI describes the stretch or tearing of axons when head impacts cause the brain to shift and rotate within the skull. This axonal injury can result in "alterations in axonal membrane permeability, ionic shifts including massive influx of calcium, and release of caspases and calpains that might trigger tau phosphorylation, misfolding, truncation, and aggregation" (Gavett et al, 2011, p. 181). Research on Tau's involvement in frontotemporal degeneration diseases concludes that the phosphorylation, truncation, and aggregation of tau leads to neurodegeneration. Although the tau protein build-up starts multifocally around small blood vessels in the brain, over time it eventually spreads to larger

brain regions to cause neurodegeneration on a larger scale (Gavett et al, 2011). Currently, CTE can only be diagnosed post-mortem, but the emergence of CTE symptoms combined with a history of repetitive brain trauma can be good indicators of this disease ("What is CTE," 2019).

Recent studies on the brains of deceased former professional football players show that CTE is a critical issue. In the time span of February 2008 to June 2010, 321 professional American football players died. Of these 321, the brains of 12 players underwent post-mortem examination at Boston University Center for the Study of Traumatic Encephalopathy, where all 12 brains examined showed evidence of CTE. This suggests an estimated lifetime prevalence of at least 3.7% in professional football players (Gavett, Stern, & McKee, 2011). In 2017, another study on the prevalence of CTE examined the brains of 202 football players whose brains were donated for research. Out of the sample of 202 players, 177 total (87%) were neuropathologically diagnosed with CTE. Included in the sample were players across a range of playing levels and of these different groups, 0 of 2 pre-high school players, 3 of 14 high school players (21%), 48 of 53 college players (91%), 9 of 14 semiprofessional players (64%), 7 of 8 Canadian Football League players (88%), and 110 of 111 National Football League players (99%) were diagnosed with CTE (Mez et al, 2017). Even accounting for the sample bias in this study, assuming that the brains were likely donated because the players showed signs and symptoms of CTE, this study demonstrates how research on concussions and sub-concussive impacts in all athletes, but particularly football players, is a critical issue.

As previously discussed, evidence shows that TBI may play an important role in increasing aggression. Although concussion is on the mild end of TBI, is it possible to find a correlation between the number of concussions and level of aggression in college football players? The research presented here seeks to answer this. Research was conducted on North

Carolina Wesleyan College football players by administering surveys to assess aggression levels and history of head injury, and then the data was analyzed to determine if the two variables correlated. Finding a correlation between the variables is not sufficient to assume a causal relationship between TBI and aggression, however, the results of this research, combined with numerous other studies that suggest a very strong association between TBI and aggression, seek to offer some additional insight into the relationship between the two variables.

Methods

Participants

Participants of this study included 56 North Carolina Wesleyan College football players between the ages of 18 and 25.

Measures

Two surveys were used in this study: The Aggression Questionnaire, and a short compilation of questions created by the researcher to assess history of head injury. Both questionnaires are located in Appendix A. The Aggression Questionnaire, created by Arnold Buss and Mark Perry (1992), is a 29-item survey that tests for four factors of aggression: physical aggression, verbal aggression, anger, and hostility. For each item, participants were asked to rate how the statement applied to them on a scale of 1 (extremely uncharacteristic) to 5 (extremely characteristic). An internal reliability analysis for The Aggression Questionnaire determined that Cronbach's Alpha = .910 for total aggression, meaning that the survey has excellent reliability. Each individual sub-type of aggression also tested high in internal reliability. With 9 survey items, physical aggression tested at .717 in an internal reliability

analysis. Additionally, verbal aggression, with 5 items, tested at .759, anger, with 7 items, tested at .799, and hostility, with 8 items, tested at .862. To assess history of head injury, there was an additional nine question survey administered with The Aggression Questionnaire. These questions asked the age of the participant, year in college, primary position in football, number of years playing football in both college and high school if applicable, as well as the total number of years playing organized tackle football, the number of concussions the participant had been treated for, the number of concussions the participant had been diagnosed with, and the number of concussions the participant estimated he had suffered in his lifetime, regardless of whether he sought treatment for or reported the concussion. To assure that participants understood what a concussion is, the definition of concussion was clearly defined on the survey. The concussion and aggression data for each football player was only compared to other players. If an athlete reported few concussions, the number of concussions was only considered low in comparison to the number of concussions of the other players on his team, rather than those of the general population.

Procedure

The Aggression Questionnaire and the head injury questionnaire were administered to members of the NCWC football team to correlate concussion incidence to aggression on February 19th, 2020. Before beginning this study, approval to conduct research was obtaining by North Carolina Wesleyan College's Institutional Review Board. The surveys were administered during a football meeting on the NCWC campus and all players were informed beforehand that their participation was completely voluntary. To assure that players did not feel pressured to participate or not participate, the researcher asked all coaches present to temporarily step out of the room while research was being collected. Before administering the surveys, all participants

signed two identical consent forms (see Appendix B), one of which was returned to the researcher. Permission to administer the surveys was granted by the football coaches and athletic director. To assure anonymity from both the researcher and others, participants were instructed not to write their names on the surveys and asked to place their own completed surveys in a folder at the front of the room. Completion of both surveys took approximately 10-15 minutes.

After the surveys were administered and collected, Pearson correlation coefficients were calculated to correlate physical aggression, verbal aggression, anger, hostility, and total aggression with diagnosed, treated, and suspected lifetime concussions. Basic descriptive statistics were also computed for all aggression subscales and concussion measures. Finally, a multivariate analysis of variance was conducted to investigate any possible differences in aggression subscale scores or diagnosed, treated, or suspected lifetime concussions between player positions.

Results

Pearson correlation coefficients were calculated to correlate all four different dimensions of aggression plus total aggression with three ways of quantifying concussions. Assuming that players may not have reported or been treated for all sustained concussions, concussion data was broken up into three groups on the head injury questionnaire: diagnosed concussions, treated concussions, and suspected lifetime concussions. Suspected lifetime concussions describes the total number of concussions each player suspected that he had suffered in his lifetime based on a given definition of concussion. Correlation coefficients are reported in Table 1.

Table 1

Prevalence of Concussions Correlated with Subtypes of Aggression

	Diagnosed Concussions	Treated Concussions	Suspected Lifetime Concussions
Physical Aggression	.132	.121	.352**
Verbal Aggression	.208	.186	.391**
Anger	.288	.311	.098
Hostility	.254	.263	.068
Total Aggression	.237	.257	.235

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

r = Pearson correlation coefficient

Two significant relationships were found. Both physical aggression ($r = .35$, $p<.01$) and verbal aggression ($r = .39$, $p<.01$) correlated significantly with suspected lifetime concussions, but not with diagnosed or treated concussions. Anger, hostility, and total aggression showed no significant correlations to any of the concussion measures. Figure 1 shows the relationship between physical aggression and suspected lifetime concussions on a graph. A linear regression analysis was conducted to determine the linear regression line for the graph, which shows the significant positive correlation between physical aggression and suspected lifetime concussions. Figure 2 shows the significant positive correlation between verbal aggression and suspected lifetime concussions. A linear regression analysis was conducted to determine the linear

regression line for Figure 2 as well. For both Figures 1 and 2, aggression scores increase as the number of concussions increases.

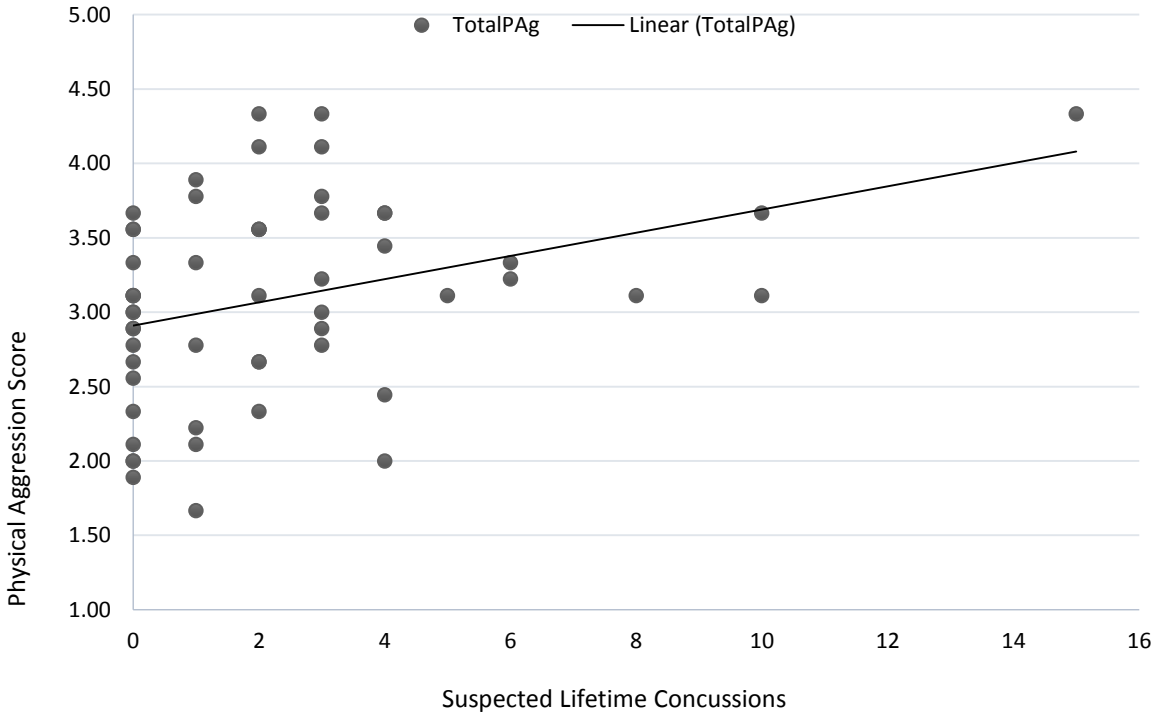

Figure 1. Physical aggression vs. suspected lifetime concussions. As shown by the linear regression line, players that reported more lifetime concussions also tended to score higher on the physical aggression measure. Physical aggression was correlated wi

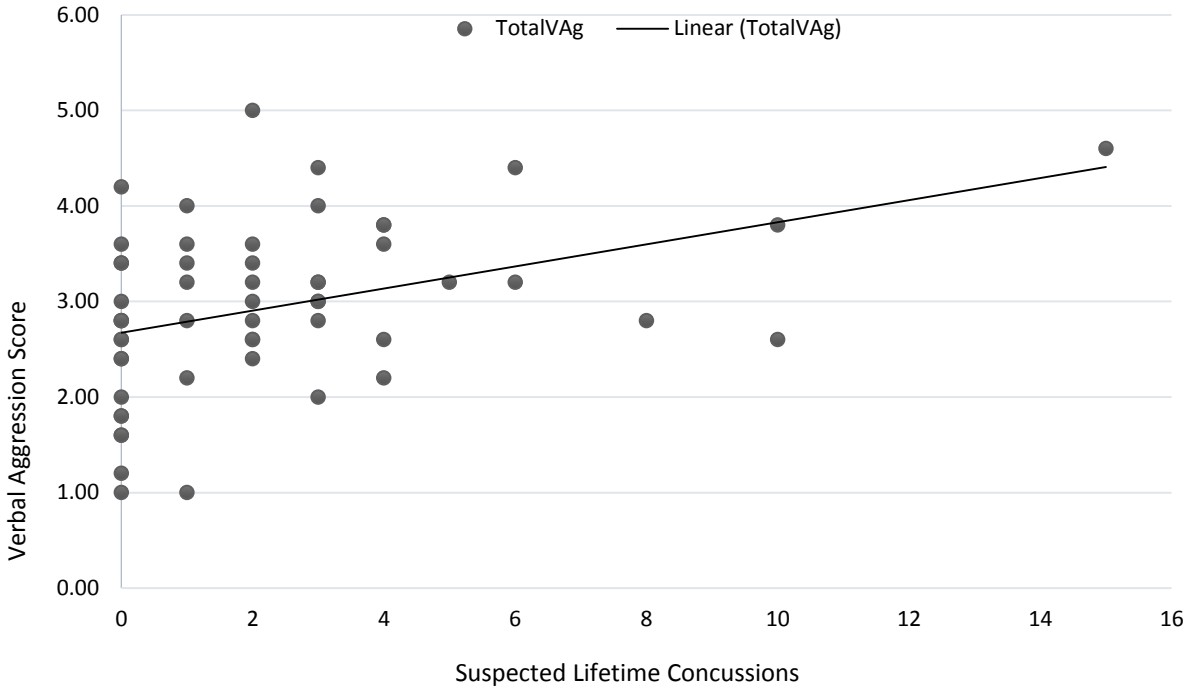

Figure 2. Verbal aggression vs. suspected lifetime concussions. As shown by the linear regression line, players that reported more lifetime concussions also tended to score higher on the verbal aggression measure. Verbal aggression was correlated with sus

The set of data in Table 2 below summarizes the mean and standard deviation of each aggression subscale score based on the three different categories of player primary position. Basic descriptive statistics for each aggression subscale were computed to find the means and standard deviations. Additionally, a multivariate analysis of variance was conducted to investigate any differences in the aggression measures between position categories. No significant differences were found between the scores of any of the aggression subtypes based on position. As the table shows, the sample sizes varied widely between positions.

Table 2

Mean and Standard Deviation of Aggression Subscale Scores Based on Position

	Quarterbacks/Running Backs/Kickers			Offensive Linemen/ Defensive Linemen/ Linebackers			Receivers/Defensive Backs/Tight Ends		
Variables	N	Mean	SD	N	Mean	SD	N	Mean	SD
Physical Aggression	5	.5200	.1487	33	.6431	.1293	16	.5861	.1270
Verbal Aggression	6	.5867	.1378	33	.6255	.1808	16	.5050	.1503
Anger	5	.5086	.2113	26	.5593	.1947	8	.4964	.1534
Hostility	6	.5583	.0785	26	.5135	.2263	8	.4469	.1430

The subsequent graphs in figures 3, 4, 5, and 6 exhibit the mean scores and standard deviations of each individual subscore of aggression: physical aggression, verbal aggression, anger, and hostility, respectively, based on the player position categories. The gray bars show the means, while the error bars represent the standard deviations. None of the positions reported significantly different aggression subscale scores than any of the other positions.

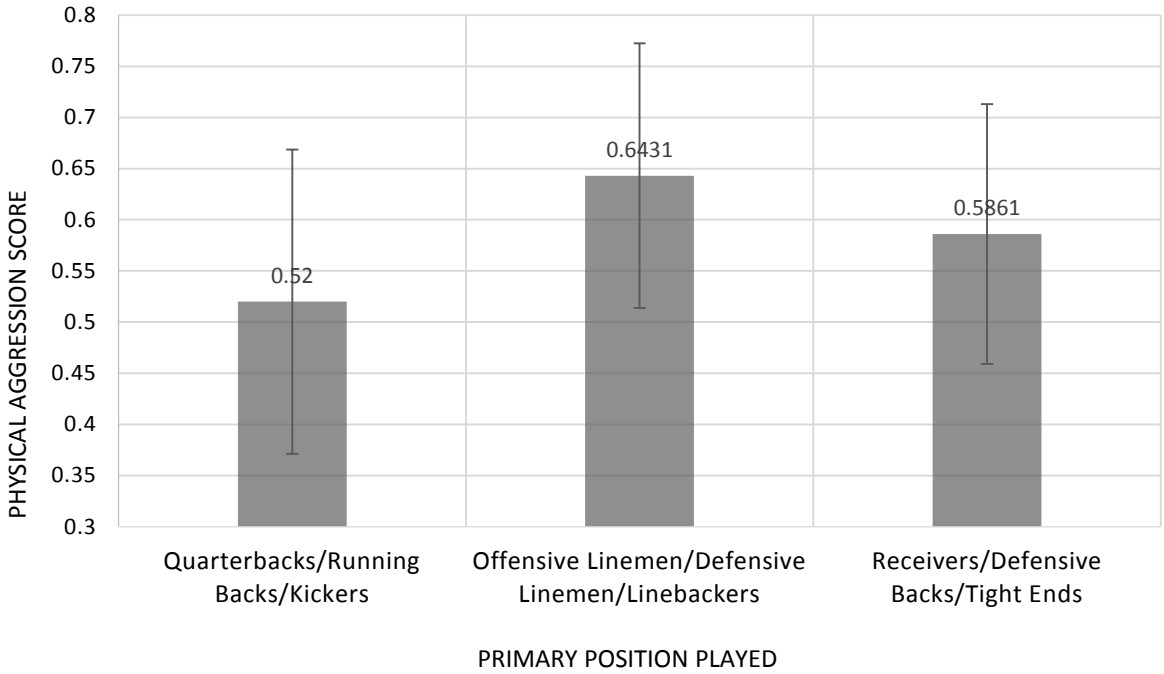

Figure 3. Mean and standard deviation of physical aggression scores by position. The gray bars show the mean physical aggression scores reported by each position category, while the error bars represent standard deviations. No significant differences in p

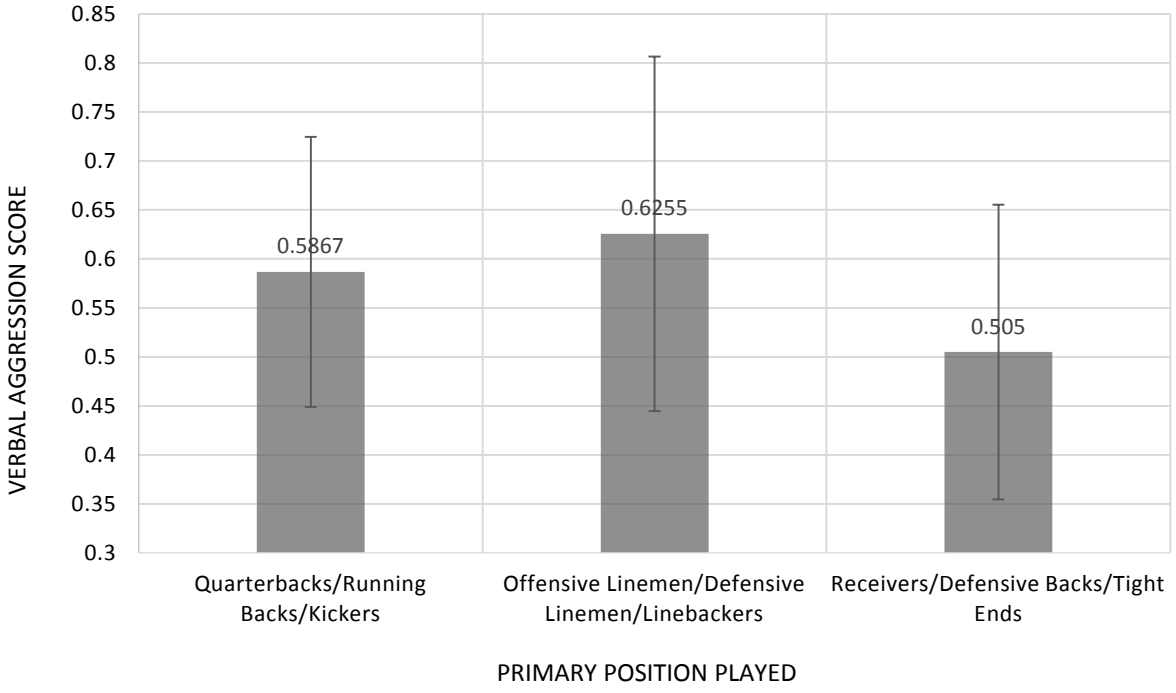

Figure 4. Mean and standard deviation of verbal aggression scores by position. The gray bars show the mean verbal aggression scores reported by each position category, while the error bars represent standard deviations. No significant differences in verba

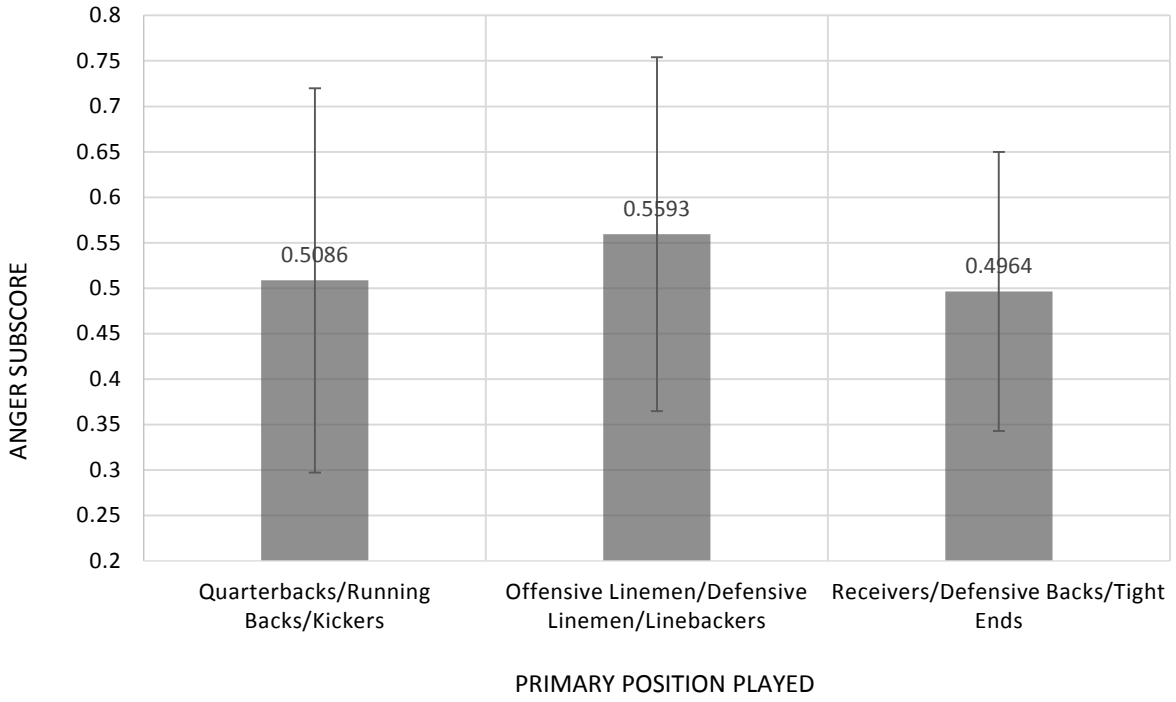

Figure 5. Mean and standard deviation of anger scores by position. The gray bars show the mean anger scores reported by each position category, while the error bars represent standard deviations. No significant differences in anger scores were found betwe

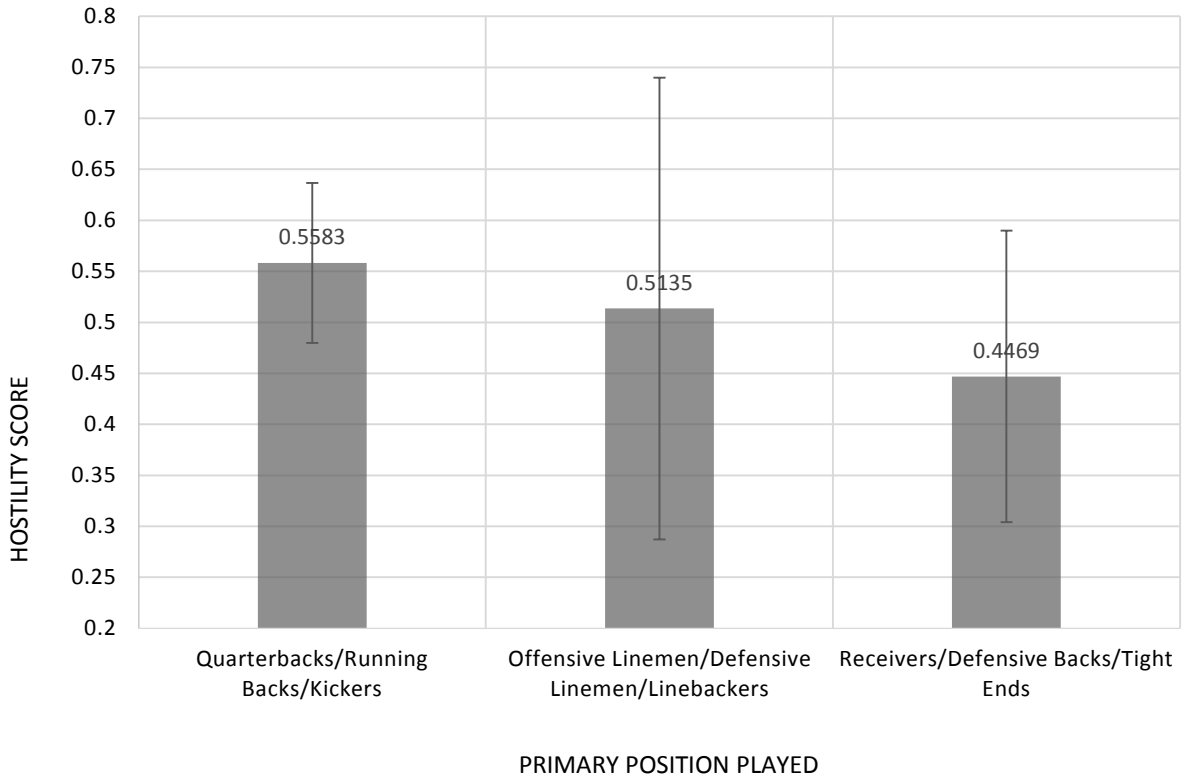

Figure 6. Mean and standard deviation of hostility scores by position. The gray bars show the mean anger scores reported by each position category, while the error bars represent standard deviations. No significant differences in anger scores were found b

The mean and standard deviation of diagnosed concussions, treated concussions, and suspected lifetime concussions based on player position is summarized in Table 3. Basic descriptive statistics for the three concussion measures were computed to find the means and standard deviations. A multivariate analysis of variance was conducted as well to investigate any differences in the concussion measures between position categories. No significant differences

were found between the number of concussions reported on the survey for any of the concussion questions based on position

Table 3

Mean and Standard Deviation of Concussion Scores Based on Position

	Quarterbacks/Running Backs/Kickers			Offensive Linemen/ Defensive Linemen/ Linebackers			Receivers/Defensive Backs/Tight Ends		
Variables	N	Mean	SD	N	Mean	SD	N	Mean	SD
Diagnosed Concussions	6	1.17	.983	33	.55	.938	16	.56	.933
Treated Concussions	6	1.17	.983	33	.48	.795	16	.44	.629
Suspected Lifetime Concussions	6	2.00	1.549	32	2.88	3.563	16	1.31	1.702

Figures 7, 8, and 9 show the mean and standard deviation of each individual measure of concussion—diagnosed, treated, and suspected, based on the three categories of player positions. In Figures 7 and 8, quarterbacks, running backs, and kickers reported the most diagnosed and treated concussions by almost twice that of the other two position categories. However, in Figure 9 offensive lineman, defensive lineman, and linebackers reported the most suspected lifetime concussions.

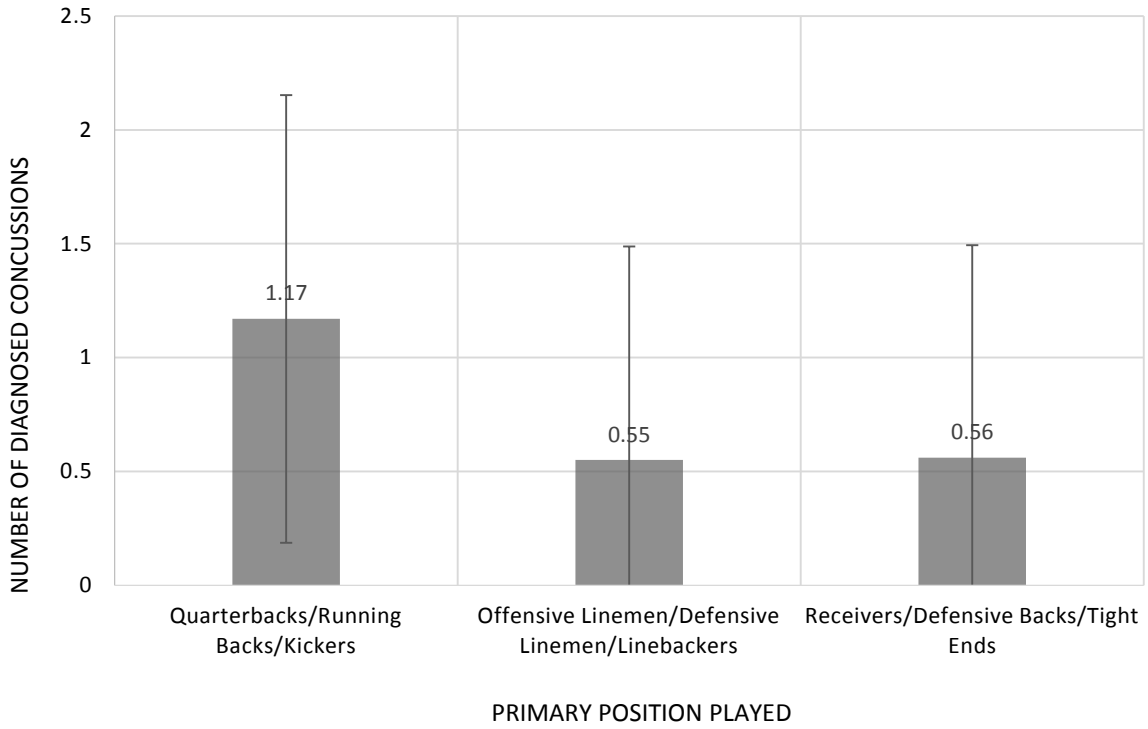

Figure 7. Mean and standard deviation of diagnosed concussions by position. The gray bars show the mean number of diagnosed concussions reported by each position category, while the error bars represent standard deviations. No significant differences in n

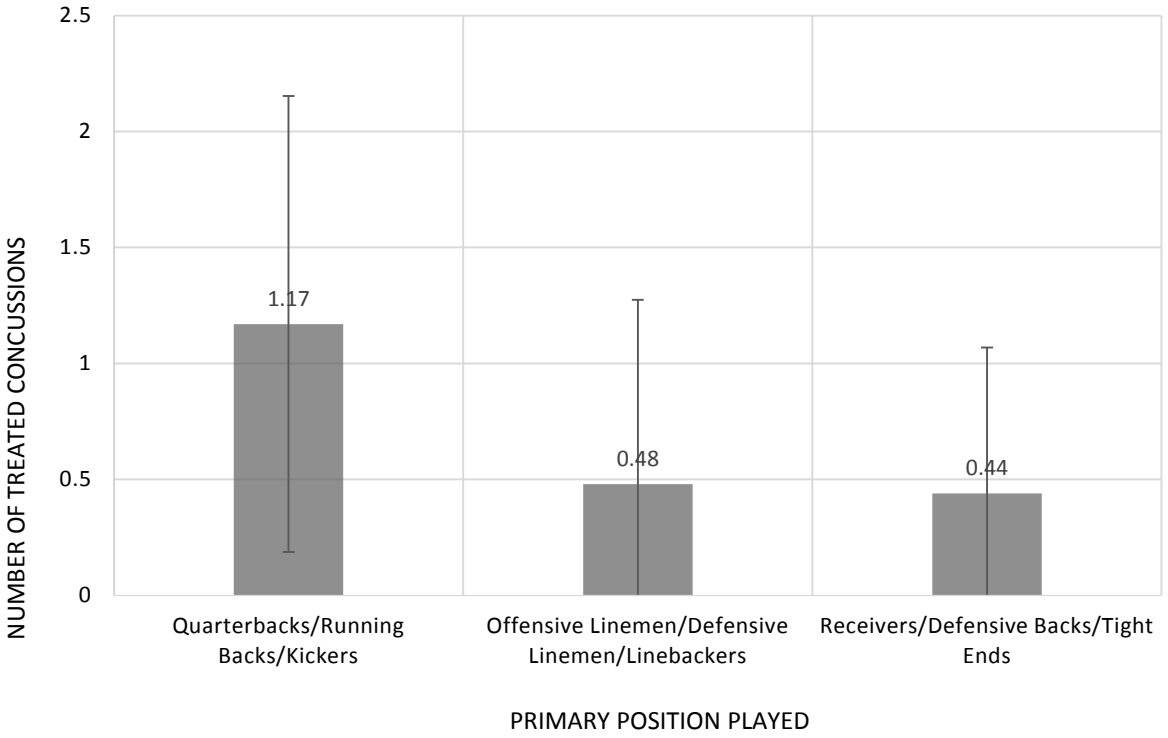

Figure 8. Mean and standard deviation of treated concussions by position. The gray bars show the mean number of treated concussions reported by each position category, while the error bars represent standard deviations. No significant differences in numbe

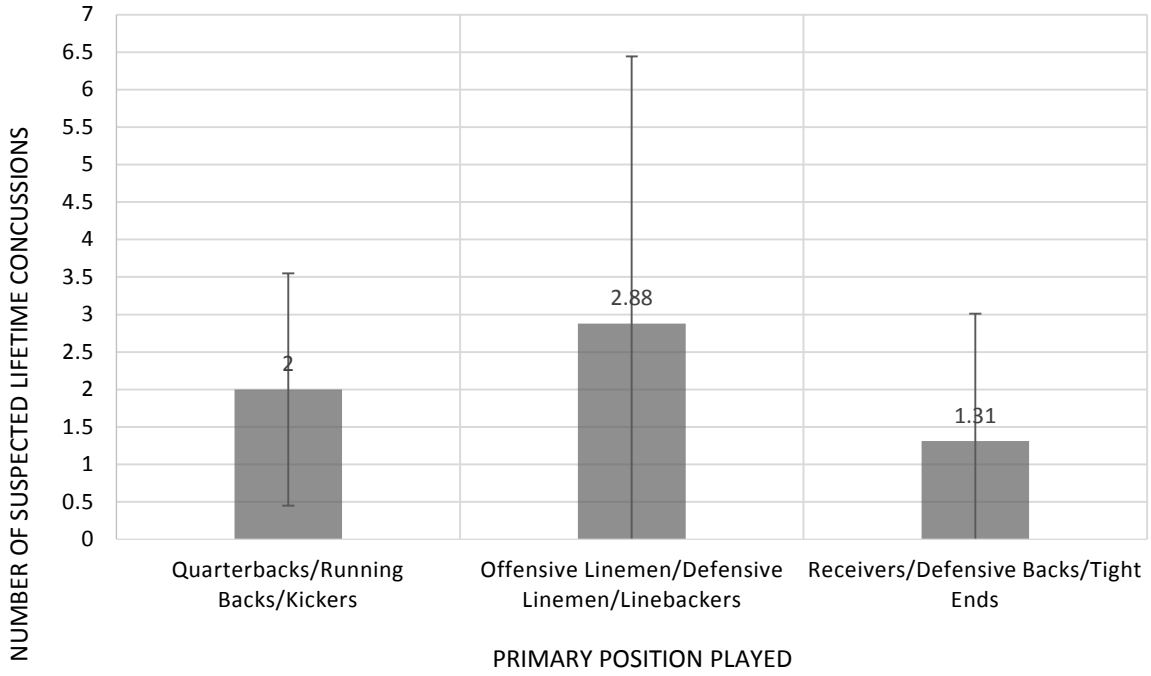

Figure 9. Mean and standard deviation of suspected lifetime concussions by position. The gray bars show the mean number ofsuspected lifetime concussions reported by each position category, while the error bars represent standard deviations. No significant

Although there are some variations in the data between positions for graphs 7, 8, and 9, none of these differences were statistically significant.

Discussion

Based on the increasing awareness of the dangers of mild traumatic brain injury and the potential negative effects associated with repeated head injury, like aggression, the purpose of this study was to examine the prevalence of mTBI in a college football population and its correlation to aggression scores. This study sought to determine if aggression scores from The Aggression Questionnaire would correlate with reported concussion data from the head injury

questionnaire created by the researcher with a hypothesis that the two variables would show a positive correlation. These data were also used to explore whether aggression scores or questionnaire-reported concussions would vary significantly between three different categories of player positions.

The results show that physical aggression and verbal aggression both significantly correlate with the number of suspected lifetime concussions players reported, but not in the number of diagnosed or treated concussions. This means that players that reported higher concussions also scored higher, on average, on the physical and verbal aggression measures. Additionally, anger, hostility, and total aggression score showed no correlation between any of the concussion measures. These results have a few possible interpretations. One interpretation as to why only physical and verbal aggression were significant is that the total number of concussions a player has suffered in his lifetime directly increases physical and verbal aggression. Another interpretation is that men that are naturally more physically and verbally aggressive play football more aggressively and therefore are prone to suffering more lifetime concussions. Additionally, it is also possible that a third, unknown factor could cause both physical and verbal aggression and frequency of head injury to increase.

Existing research supports the idea that head injury may lead to increases in physical and verbal aggression. In a previously discussed study, McKinlay et al (1981) found that relatives of head injured adults reported violent and inappropriate social behavior in 20% of 55 patients at three, six, and twelve months post-injury, where this behavior had not been present in the patient prior to the injury, or had been markedly less frequent. Irritability was also reported in 63%, 69%, and 71% of patients at three, six, and twelve months after the injury, as well as bad temper in 48%, 56%, and 67% of patients at three, six, and twelve months post-injury. In another study

by Hall et al (1994), 31% of caregivers for TBI patients reported moderate or severe aggressiveness toward themselves by two years after the injury, with patients' behavior, specifically in regard to temper, worsening over time. These studies support the idea that physical and verbal aggression may increase after head injury; however, they also support the idea that general anger and hostility may increase after head injury as well, which is not supported by this research.

One reason why only physical and verbal aggression were significantly correlated with lifetime concussions, and not anger and hostility, could be due to poor sample size for the anger and hostility measures. As shown in Table 2, the sample of players that completed the anger and hostility aggression subtype questions was significantly less than the sample size for those that completed the physical and verbal aggression subtype questions. The reason for this is because some players started to answer the aggression questionnaire but did not complete it, with many players skipping the anger and hostility questions. This means that less data were collected on the anger and hostility aggression subtypes than physical and verbal aggression. These uncompleted questionnaires also prevented researchers from computing a total aggression score for those surveys.

Additionally, it is possible that only suspected lifetime concussions showed significant correlations with physical and verbal aggression, and not diagnosed or treated concussions, because players do not report or seek treatment for all concussions. In this case, the number of total suspected lifetime concussions for any of the positions would be higher, on average, than the number of diagnosed or treated concussions for those positions. Comparing Figure 9, which shows the mean and SD for suspected lifetime concussions, with Figures 7 and 8, which show the means and SDs for diagnosed and treated concussions, respectively, shows that all group of

players reported suffering more lifetime concussions, on average, than they were diagnosed with or treated for. However, this difference was not tested for significance. In a previously discussed study, Meehan et al discovered that 30.5% of a study of 486 athletes reported suffering a previously undiagnosed concussion. Although the research with NCWC football players was not focused on the prevalence of unreported and untreated concussions, it is possible that additional research may show differences between lifetime concussions and diagnosed and treated concussions, given that the data seem to vary between these concussion measures.

As shown by Table 3, there were also no significant differences in the number of any of the concussion measures between positions, meaning none of the position categories reported significantly more diagnosed, treated, or suspected lifetime concussions than any of the other position categories. The data seem to show slight differences, but these potential differences were not statistically significant and therefore could have been caused by unrelated factors. However, it is interesting that in Figures 7 and 8, quarterbacks (QBs), running backs (RBs), and kickers (Ks) reported twice the amount of diagnosed and treated concussions as the other two player categories. In Figure 9, however, offensive linemen (OL), defensive linemen (DL), and linebackers (LBs) reported the most concussions. In a study of 314 football players by Crisco et al (2011), running backs and quarterbacks were found to receive the greatest magnitude of head impacts while offensive linemen, defensive linemen, and linebackers received the most frequent impacts. QBs and RBs reporting more diagnosed and treated concussions, on average, than other players in the NCWC research may reflect a greater severity of head impacts, and therefore a greater need for those impacts to be diagnosed and treated. OL, DL, and LBs reporting more suspected lifetime concussions, on average, may reflect a higher frequency of overall sustained concussions, which is supported by Crisco's research. Given the low and unequal sample sizes

between each category of player position, it is possible that this study may show significant results if repeated with a larger sample size. Overall, a greater sample size for the whole study, and a more equal sample size between player positions, would greatly improve this study.

Although significant results were found between suspected lifetime concussions and physical and verbal aggression, a causal relationship cannot be determined between the two variables by this study alone. It is possible that mild traumatic brain injury, like concussions, could lead to increases in aggression. It is also possible, however, that high aggression could cause football players to play more aggressively, therefore resulting in more concussions. Additionally, it is possible that a third, unknown factor causes increases in both concussive impacts and aggression. To help clarify the possible causal relationship between TBI and aggression in football player populations, more longitudinal studies must be conducted in which players are studied over a period of years across their football career. To determine if aggression increases in individual players as a function of concussion frequency, aggression measures would have to be administered to players at least twice: at the beginning of the study and after a period of time in which players may happen to sustain additional football-related concussions. The two aggression scores could then be compared to determine if aggression changed over time as the number of concussions sustained increased.

Areas of improvement

One issue with this research study is that self-report data is not always reliable. Both surveys administered, the aggression questionnaire and the head injury questionnaire, relied on self-report data. There is no way to verify that participants answered honestly on the surveys or that participants were able to accurately judge the number of suspected lifetime concussions that they had suffered. Because participants were asked to report the number of concussions they

thought they had experienced over their lifetime based on a given definition of concussion, some participants may have overestimated or underestimated the actual number of concussions suffered because of faulty perception or memory of past blows to the head. Football players often suffer many blows to the head; it is highly possible that players could not remember all blows that resulted in concussion symptoms, therefore underreporting or overreporting the actual number of concussions. Additionally, because traumatic brain injury can affect memory, the concussions that any of the players may have suffered could have further caused faulty memory of past blows to the head.

Another issue with this research is that sample sizes were relatively low. A total of 56 NCWC football players participated in the study, but because these players were split up into three position categories the sample sizes of each individual category were much smaller. Additionally, the sample sizes across position categories were not equal. Thirty-three offensive lineman, defensive linemen, and linebackers participated in the study while only sixteen receivers, defensive backs, and tight ends, and only six quarterbacks, running backs, and kickers participated in the study. To be able to accurately compare data across position categories, much larger sample sizes are needed within each position category, as well as more equal sample sizes between positions.

References

[Areas of the Limbic System]. (2018). Retrieved from https://www.studyblue.com/notes/note/n/chapter-3-the-brain-and-the-nervous-system/deck/140031

Bannon, S. M., Salis, K. L., & O'Leary, K. D. (2015). Structural brain abnormalities in aggression and violent behavior. *Aggression and Violent Behavior, 25*(Part B), 323-331.

Barnfield, T. V., & Leathem, J. M. (1998a). Neuropsychological outcomes of traumatic brain injury and substance abuse in a New Zealand prison population. *Brain Injury, 12*(11), 951-962.

Baugh, C. M., Stamm, J. M., O'Riley, D., Gavett, B. E., Shenton, M. E., Lin, A., Nowinski, C. J., Cantu, R. C., McKee, A. C., & Stern, R. A. (2012). Chronic traumatic encephalopathy: Neurodegeneration following repetitive concussive and subconcussive brain trauma. *Brain Imaging and Behavior, 6*, 244-254.

Bechara, A., Damasio, H., & Damasio, A. R. (2000). Emotion, decision making and the orbitofrontal cortex. *Cerebral Cortex, 10*(3), 295-307.

Brower, M. C., & Price, B. H. (2001). Neuropsychiatry of frontal lobe dysfunction in violent and criminal behavior: A critical review. *A Journal of Neurology, Neurosurgery, and Psychiatry, 71*(6), 720-726.

Buckley, L., Kaye, S. A., Stork, R. P., Heinze, J. E., & Eckner, J. T. (2017). Traumatic brain injury and aggression: A systematic review and future directions using community samples. *Aggression and Violent Behavior, 37*, 26-34.

Buss, A. H, & Perry, M. (1992). The aggression questionnaire. *Journal of Personality and Social Psychology, 63*(3), 452-459.

Crisco, J. J., Wilcox, B. J., Beckwith, J. G., Chu, J. J., Duhaime A., Rowson, S., Duma, S. M., Maerlender, A. C., McAllister, T. W., & Greenwald, R. M. (2011). Head impact exposure in collegiate football players. *Journal of Biomechanics, 44*(15), 2673-2678.

Damasio, H., Grabowski, T., Frank, R., Galaburda, A. M., & Damasio, A. R. (1994). The return of Phineas Gage: Clues about the brain from the skull of a famous patient. *Science*, 246(5162), 1102-1105.

Davidson, R. J., Putnam, K. M. & Larson, C. L. (2000). Dysfunction in the neural circuitry of emotion regulation—A possible prelude to violence. *Science, 289*(5479), 591-594.

Delaney, J. S. Lacroix, V. J., Leclerc, S., & Johnston, K. M. (2002). Concussions among university football and soccer players. *Clinical Journal of Sport Medicine, 12*, 331-338.

Diamond, P. M., Harzke, A. J., Magaletta, P. R., Cummins, A. G., & Frankowski, R. (2007). Screening for traumatic brain injury in an offender sample: A first look at the reliability and validity of the traumatic brain injury questionnaire. *The Journal of Head Trauma Rehabilitation, 22*(6), 330-338.

Gavett, B. E., Stern, R. A., & McKee, A. C. (2011). Chronic traumatic encephalopathy: A potential late effect of sport-related concussive and subconcussive head trauma. *Clinics in Sports Medicine, 30*, 179-188.

Hall, K. M., Karzmark, P., Stevens, M., Englander, J., O'Hare, P., & Wright, J. (1994). Family stressors in traumatic brain injury: A two-year follow-up. *Archives of Physical Medicine and Rehabilitation, 75*(8), 876-884.

Lane, S. D., Kjome, K. L., & Moeller, F. G. (2011). Neuropsychiatry of aggression. *Neurologic Clinics, 29*(1), 49-64.

Leon-Carrion, J., & Ramos, F. J. C. (2003). Blows to the head during development can predispose to violent criminal behavior: Rehabilitation of consequences of head injury is a measure for crime prevention. *Brain Injury, 17*(3), 207-216.

Liu, J. (2004). Concept analysis: Aggression. *Issues in Mental Health Nursing, 25*(7), 693-714.

McKinlay, A., Grace, R. C., Horwood, L. J., Ridder, E. M., MacFarlane, M. R., & Fergusson, D. M. (2008). Prevalence of traumatic brain injury among children, adolescents and young adults: Prospective evidence from a birth cohort. *Brain Injury, 22*(2), 175-181.

McKinlay, W. W., Brooks, D. N., Bond, M. R., Martinage, D P., & Marshall, M. M. (1981). The short-term outcome of severe blunt head injury as reported by relatives of the injured persons. *Journal of Neurology, Neurosurgery, and Psychiatry, 44*, 527-533.

Meehan, W. P., Mannix, R. C., O'Brien, M. J., & Collins, M. W. (2013). The prevalence of undiagnosed concussions in athletes. *Clinical Journal of Sport Medicine, 23*(5), 339-342.

Mez, J., Daneshvar, D. H., Kiernan, P. T., Abdolmohammadi, B., Alvarez, V. E., Huber, B. R., Alosco, M. L., Solomon, T. M., Nowinski, C. J., McHale, L., Cormier, K. A., Kubilus, C. A., Martin, B. M., Murphy, L., Baugh, C. M., Montenigro, P. H., Chaisson, C. E., Tripodis, Y., Kowall, N. W., Weuve, J., McClean, M. D., Cantu, R. C., Goldstein, L. E.,

Katz, D. I., Stern, R. A., Stein, T. D., & McKee, A. C. (2017). Clinicopathological evaluation of chronic traumatic encephalopathy in players of American football. *Journal of the American Medical Association, 318*(4), 360-370.

Rosenbaum, A., & Hoge, S. K. (1989). Head injury and marital aggression. *The American Journal of Psychiatry, 146*(8), 1048.

Rosenbaum, A., Hoge, S. K., Adelman, S. A., Warnken, W. J., Fletcher, K. E., & Kane, R. I. (1994). Head injury in partner-abusive men. *Journal of Consulting and Clinical Psychology, 62*(6), 1187.

Seguin, J. R. (2009). The frontal lobe and aggression. *European Journal of Development Physchology, 6*(1), 100-119.

Subconcussive Impacts. (2018, May 31). Retrieved from https://concussionfoundation.org/CTE-resources/subconcussive-impacts

Tranel, D., Bechara, A., & Denburg, N. L. (2002). Asymmetric functional roles of right and left ventromedial prefrontal cortices in social conduct, decision-making, and emotional processing. *Cortex, 38(*4), 589-612.

Traumatic Brain Injury and Concussion. (2019, March 4). Retrieved from https://www.cdc.gov/traumaticbraininjury/index.html

Turkstra, L., Jones, D., & Toler, H. I. (2003). Brain injury and violent crime. *Brain Injury*, *17*(1), 39-47.

What is a concussion? (2018, October 10). Retrieved from https://concussionfoundation.org/concussion-resources/what-is-concussion.

What is CTE? (2019, November 14). Retrieved from https://concussionfoundation.org/CTE-resources/what-is-CTE.

Appendix A

Head Injury Questionnaire

1. Age _____
2. Year in college _____
3. Please indicate the category that best describes your primary position in football:

   ☐ Quarterback/running back/kicker

   ☐ Offensive/defensive lineman/linebacker

   ☐ Receiver/defensive backs/tight end
4. How many years have you been playing college football? _____
5. Did you play football in high school? If yes, for how many years?

   ☐ Yes, _____ ☐ No
6. How many total years have you been playing organized tackle football? _____
7. How many concussions have you been diagnosed with in your lifetime?

   _____
8. How many concussions have you been treated for in your lifetime? _____
9. Based on the definition of concussion below, how many concussions do you suspect you have suffered in your lifetime, from any cause, regardless of whether the concussion was diagnosed and/or treated? _____

A concussion is an injury to the brain caused by a bump, blow, or jolt to the brain that results in temporary loss of normal brain function. One or more of the following symptoms following a blow to the head constitutes a concussion:

- Prolonged headache
- Vision disturbances

- Dizziness
- Loss of consciousness
- Nausea or vomiting
- Impaired balance
- Confusion in the form of:
    - ❖ Inability to maintain a coherent stream of thought
    - ❖ A disturbance of awareness with heightened distractibility
    - ❖ Inability to carry out a sequence of goal-directed movements
- Memory loss
- Ringing ears
- Difficulty concentrating
- Sensitivity to light
- Loss of smell or taste

Concussion. (2019). Retrieved December 7, 2019, from https://www.aans.org/Patients/Neurosurgical-Conditions-and-Treatments/Concussion.

THE AGGRESSION QUESTIONNAIRE

Rate each of the following items in terms of how characteristic they are of you. Use the following scale:

1	2	3	4	5
Extremely uncharacteristic of me		Neither uncharacteristic nor characteristic		Extremely characteristic of me

_____ 1. Once in a while, I can't control the urge to strike another person.

_____ 2. Given enough provocation, I may hit another person.

_____ 3. If someone hits me, I hit back.

_____ 4. I get into fights a little more than the average person.

_____ 5. If I have to resort to violence to protect my rights, I will.

_____ 6. There are people who pushed me so far that we came to blows.

_____ 7. I can think of no good reason for ever hitting a person.

_____ 8. I have threatened people I know.

_____ 9. I have become so mad that I have broken things.

_____ 10. I tell my friends openly when I disagree with them.

_____ 11. I often find myself disagreeing with people.

_____ 12. When people annoy me, I may tell them what I think of them.

_____ 13. I can't help getting into arguments when people disagree with me.

_____ 14. My friends say that I'm somewhat argumentative.

_____ 15. I flare up quickly but get over it quickly.

_____ 16. When frustrated, I let my irritation show.

_____ 17. I sometimes feel like a powder keg ready to explode.

_____ 18. I am an even-tempered person.

_____ 19. Some of my friends think I'm a hothead.

_____ 20. Sometimes I fly off the handle for no good reason.

_____ 21. I have trouble controlling my temper.

_____ 22. I am sometimes eaten up with jealousy.

_____ 23. At times I feel I have gotten a raw deal out of life.

_____ 24. Other people always seem to get the breaks.

_____ 25. I wonder why sometimes I feel so bitter about things.

_____ 26. I know that “friends” talk about me behind my back.

_____ 27. I am suspicious of overly friendly strangers.

_____ 28. I sometimes feel that people are laughing at me behind my back.

_____ 29. When people are especially nice, I wonder what they want.

Buss, A. H. & Perry, M. P. (1992). The Aggression Questionnaire. Journal of Personality and Social Psychology, 63, 452-459.

Appendix B

North Carolina Wesleyan College (NCWC) Consent to Participate in a Research Study Adult Participants

Consent Form Version Date: January 21, 2020
Title of Study: The Relationship Between Head Injury and Aggression
Principal Investigator: Jessica Winslow
Principal Investigator Department: Psychology
Principal Investigator Phone number: 252-217-1996
Principal Investigator Address: 3400 N. Wesleyan Blvd, Rocky Mount, NC
Principal Investigator Email Address: Jw239696@my.ncwc.edu
Co-Investigators: Dr. John Temple

What are some general things you should know about research studies?
You are being asked to take part in a research study. To join the study is voluntary. You may refuse to join, or you may withdraw your consent to be in the study, for any reason, without penalty.

Research studies are designed to obtain new knowledge. This new information may help people in the future. You may not receive any direct benefit from being in the research study. There also may be risks to being in research studies. Deciding not to be in the study or leaving the study before it is done will not affect your relationship with the researcher, your instructors, or North Carolina Wesleyan College.

Details about this study are discussed below. It is important that you understand this information so that you can make an informed choice about being in this research study.

You will be given a copy of this consent form. You should ask the researchers named above, or staff members who may assist them, any questions you have about this study at any time.

What is the purpose of this study?
The purpose of this study is to determine if a relationship exists between head injury and aggression.

Are there any reasons you should not be in this study?
You should not be in this study if you do not play football at NCWC or are under the age of 18.

How many people will take part in this study?
If you decide to be in this study, you will be one of approximately 100 people in this research study.

How long will your part in this study last?
Your part in this study will take approximately 10-15 minutes to complete.

What will happen if you take part in the study?
If you decide to take part in this study, you will be asked to complete two surveys: an aggression questionnaire and a questionnaire assessing history of head injury. Both surveys will be kept anonymous and will not be shared with anyone but the researcher.

What are the possible benefits from being in this study?
This research is designed to benefit society by gaining new knowledge. You will not benefit personally from being in this research study.

What are the possible risks or discomforts involved from being in this study?
The contents of the two surveys may include sensitive information about the participant's levels of aggression and history of head injury. This information may result in negative social consequences if the data is accidentally disclosed.

How will information about you be protected?
Responses to both questionnaires will remain completely anonymous. To ensure anonymity, participants will be instructed not to write their names on either questionnaire. After both questionnaires have been completed, each participant will place his own surveys in a manila envelope located at the front of the room. Individual responses will not be shared with anyone but the principal investigator and project director and all materials associated with this study will be destroyed after the research is completed.

What if you want to stop before your part in the study is complete?
Your participation in this study is voluntary and you can withdraw from this study at any time, without penalty. The investigators also have the right to stop your participation at any time.

Will you receive anything for being in this study?
You will not receive any compensation for participating in this study.

Will it cost you anything to be in this study?
Participants will not incur any costs in this study.

What if you are a NCWC student?
You may choose not to be in the study or to stop being in the study before it is over at any time. This will not affect your class standing, grades at NCWC, or your relationships with your instructors or the college. You will not be offered or receive any special consideration if you take part in this research.

What if you are a NCWC employee?
Taking part in this research is not a part of your college duties and refusing will not affect your job. You will not be offered or receive any special job-related consideration if you take part in this research.

What if you have questions about this study?

You have the right to ask, and have answered, any questions you may have about this research. If you have questions about the study (including payments), complaints, concerns, or if a research-related injury occurs, you should contact the researchers listed on the first page of this form.

What if you have questions about your rights as a research participant?

All research on human volunteers is reviewed by a committee that works to protect your rights and welfare. If you have questions or concerns about your rights as a research subject, or if you would like to obtain information or offer input, you may contact the Institutional Review Board Chair, Dr. Gregory Preuss at (252) 985-5255 or by email to gpreuss@ncwc.edu.

Participant's Agreement:

I have read the information provided above. I have asked all the questions I have at this time. I voluntarily agree to participate in this research study.

_____ _____

Signature of Research Subject Date

_____

Printed Name of Research Subject

_____ _____

Signature of Research Team Member Obtaining Consent Date

_____

Printed Name of Research Team Member Obtaining Consent