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An Issue Worth Tackling:
Chronic Traumatic Encephalopathy in the National Football League

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Introduction

From religion to politics to occupations to geographical locations, there are so many ways in which individuals can identify themselves in order to connect with others who share the same values and beliefs. The group that is arguably at the top of this list, however, is sports. Over the past century and a half, sports have become engrained into the psyche of America. They play an integral role in cultivating unity and promoting wellness among many other benefits. However, there are significant repercussions associated with participation in sports and various recreational activities. In further detail throughout this review, we will look into sports-related head injuries with a focus on American Football—specifically at the professional level. What are both the short and long-term risks associated with traumatic brain injury, and do they outweigh the numerous benefits of investing in such activities?

Traumatic brain injury is an umbrella term for traumas such as concussions and is defined as “an impulsive force transmitted to the head resulting from a direct or indirect impact to the head, face, neck, or elsewhere” (Daneshvar et al. 2017). Approximately 1.6 to 3.8 million sports-related traumatic brain injuries (TBIs) occur in the United States annually (Vos et al. 2018). This equates to a staggering 7,397 brain injuries every single day. This statistic includes data from all age ranges and all activity levels, but TBIs are most commonly connected to contact and high-impact sports such as football, soccer, rugby, boxing, and hockey. The indirect and direct costs associated with these TBIs total around 76.5 billion dollars each year (Vos et al. 2018). This works out to about 209.6 million dollars spent daily on treating injuries of this nature. It is important to keep in mind that this information was gathered from TBI cases that have been reported to coaches, trainers, and healthcare professionals. A large number of concussions and head trauma sustained by athletes often go unreported. The quick onset of symptoms which

include, but are not limited to, loss of consciousness, behavioral changes, and cognitive issues; the possible lack of symptoms present; and the investment in the sport as well as drive to compete all have the potential to contribute to missed TBI diagnoses.

The National Football League has become a monopolizing organization in the United States—fans travel across the country to see their teams play and fork out an estimated 14 billion dollars per year for tickets, merchandise, and television deals (Huddleston 2017). However, science is a force to be reckoned with and has put this dominating industry under intense scrutiny. Due to a breakthrough scientific discovery in 2002, an immense amount of light has been shed on the life-threatening effects of enduring multiple head injuries—specifically as a result of playing American football. Chronic traumatic encephalopathy, or more commonly referred to as CTE, is the topic of this heated and on-going discussion. CTE is a progressive and incurable neurological disease most likely found in athletes who have experienced repetitive head injuries (Merriam-Webster’s Medical Dictionary 2016). To understand the evolution of this disease, its life-long implications, and how it is currently impacting our sports-centered culture, I will begin by explaining the history of American Football. This will give context to the discovery of CTE which will set the stage for explaining the symptoms and pathophysiology of the disease. I will briefly examine the effects of playing pre-professional football before dissecting what it means to play in the National Football League and why the stakes are so high. This will lead into how the governing bodies of the NFL are handling the scientific evidence of CTE and the impact it has on the industry. To close, I will propose various ways this issue can be tackled by looking into prevention through league education and regulations, current therapeutic treatments to alleviate symptoms, and redesigned protective gear in an attempt to decrease the number of cases of this fatal disease.

History of American Football

Football has given baseball a run for its money in terms of owning the title of “America’s Game”. For a sport that was once on the verge of implosion, football’s popularity increased exponentially over the past sixty years. In 1870, just two years after the birth of baseball, a soccer/rugby hybrid was becoming popular which would later become modern-day American football. The first set of rules for this new sport were implemented just six years after its inception, but the formation of the league as we know it did not begin taking shape until the 1920s. After years of semi-organized chaos, people argued for concrete rules, the issue of uniforms for each team, and a fair selection process for drafting players. As a result of these concerns, the first official meeting took place in 1920 in Canton, Ohio—the current home of the Pro Football Hall of Fame—which led to the creation of the American Professional Football Association (APFA). The APFA only lasted for two years until it was renamed to the National Football League, or NFL, which consisted of a total of twenty-two teams at the time (Grant 2000). This would mark the beginning of a formidable era that is still on the rise today despite a couple of inevitable setbacks.

The Great Depression caused an abundance of economic and financial turmoil, and the NFL was harmed in the process. In 1932, the number of teams in the league dwindled down to just eight. Joe Carr, the current president of the league, worked tirelessly to keep the organization in business due to the amount of potential he saw in the game (Grant 2000). At the end of the 1930s, World War II was America’s top priority; the NFL was on the brink of survival once again as rosters were depleting due to men being drafted. In May of 1942, 112 of the 346 current NFL players were required to enroll in the armed forces (MacCambridge 2015). This left the league scrambling for players to stay afloat.

After a couple of decades of rebuilding, a Harris Survey published in 1965 showed that football was more favorable over baseball, 41% to 38%, for the first time ever and has been “America’s Sport” ever since. Additionally, the increasing demand of television contracts to broadcast games sky-rocketed during this time period and is still on the rise. In 1962, the NFL and CBS agreed to a 4.6 million dollar deal which increased to 14.1 million dollars just two years later. In 1989, four major networks consisting of CBS, ABC, NBC, and ESPN signed a four-year television contact for 3.6 billion dollars. Currently, less than thirty years later, those same four major networks agreed to a four-year 8.8 billion dollar contract to broadcast all of the NFL games (Huddleston 2017). It seems as if the popularity of football has been on an upward trend since the mid 1960s (Grant 2000). However, scientific findings and advanced research have inflicted a nationwide concern regarding the safety of the game which has affected the reputation of the league.

The nature and pace of the game has heightened over the years as athletes have become bigger, faster, and stronger due to starting play at a younger age and more efficient training regimens. In 1994, the NFL created the Mild Traumatic Brain Injury (MTBI) committee to address the increased number of injuries sustained by players. The chair of the committee, Dr. Elliot Pellman, told *Sports Illustrated* that “concussions are part of the profession, an occupational risk”. In 1999, Mike Webster, a former Pittsburgh Steelers center, claimed that playing football led to his dementia-like symptoms and filed for disability. Later in that same year, Dr. Pellman explained how the majority of the 180 TBIs per year in football are minor injuries (Ezell 2013). While the NFL was appeasing teams, players, and the public by the creation of this committee, it would not be until 2002 when the truth would come crashing down in what has been named “the autopsy that changed football” (Breslow 2013).

Discovery of Chronic Traumatic Encephalopathy

Mike Webster, also known as Iron Mike, played in 220 NFL games—the most for any player in Pittsburgh Steelers history. He was elected to the Pro-Bowl nine times, donned four Super Bowl rings, and was inducted into the Pro Football Hall of Fame. Webster had an incredible career that will forever be overshadowed by his life’s depressing end at the young age of fifty from a heart attack. A couple of years before his death in 2002, he began showing signs of dementia—he was confused, he would wander through the streets of Pittsburgh, he began sleeping in his car, he forgot to eat, his teeth began falling out, and he had to tase himself just to fall asleep (Laskas 2015). Dr. Bennett Omalu, a neuropathologist, was assigned to the autopsy of Mr. Webster. He was expecting Webster’s brain to show signs of Alzheimer’s disease; however, Dr. Omalu was shocked when he opened the skull and the brain was not visibly atrophied or shriveled but rather looked completely normal. Dr. Steven DeKosky, a well-known neurologist specializing in Alzheimer’s research, verified the idea that Webster’s brain did not physically show signs of this neurodegenerative disease usually found in people over the age of sixty. Dr. Omalu had the brain mounted on slides and spent months studying them, reviewing literature, and scratching his head at what caused Mike Webster’s unexplainable symptoms prior to his death (Kirk 2013).

Harrison Martland, a New Jersey based forensic pathologist, is credited for first classifying symptoms closely related to those of CTE. Martland studied boxers and published an article in *Journal of the American Medical Association* in 1928 titled “Punch Drunk”. He believed that punch drunk syndrome resulted from “definite brain injury due to single or repeated blows on the head or jaw” that caused those affected to display signs analogous to Parkinson’s, Alzheimer’s, and dementia (Perrine et al. 2017). His hypothesis was not backed up until 1973

when British neuropathologist Dr. John Corsellis autopsied the brains of fifteen former boxers. Dr. Corsellis described the first neurodegenerative disease associated with repetitive brain injury as “damaged tissue with irregular folds in irregular patterns” which he coined dementia pugilistica (Laskas 2015). These findings would resurface to help Dr. Omalu in the discovery of modern-day CTE.

After months of deliberation, Dr. Omalu discovered “neurofibrillary tangles in the nerve cells of the frontal and temporal cortex” in Webster’s brain caused as a result of the buildup of phosphorylated tau proteins. Dr. Corsellis’s autopsy results described how, when looking at the brain with the naked eye, it was clearly battered and bruised. The major difference with Omalu’s findings was that Webster’s brain looked completely free of harm—until it was carefully observed under a microscope (Laskas 2015). Additionally, the neurofibrillary tangles were found in different locations and patterns than what is seen in Alzheimer’s and dementia (UC Davis Health). Dr. Omalu published his findings and gave it a descriptive name—chronic traumatic encephalopathy or CTE. This is defined as “a progressive neurological disease found especially in athletes who have experienced repetitive injury to the brain and is characterized by memory loss, depression, confusion, and cognitive issues among other symptoms” (Merriam-Webster’s Medical Dictionary 2016).

Although Dr. Omalu’s predecessors—Drs. Martland and Corsellis—did research that helped formulate his diagnosis in Webster, Dr. Omalu’s findings are significant in that it was the first time CTE was distinguished from other neurodegenerative diseases as well as the first time it was discovered in a former NFL player (Budson et al. 2017). The Nigerian-born doctor who knew nothing about football when he began Webster’s pivotal autopsy naively thought that the NFL would embrace his research which prompted him to present it to them. Dr. Omalu’s goal in

publishing this information was to enhance the game and the lives of the players, save money on the costs of TBIs suffered by players, and prevent families from being torn apart by the devastating results of this disease (Kirk 2013). Rather than using Dr. Omalu's scientific evidence for its intended purposes, the NFL did the exact opposite; they violently attacked his research on a public stage and even went as far to demand his publications be retracted from medical literature (Breslow 2013). While the NFL's response significantly affected Dr. Omalu and his family to the point of moving across the country, it was no surprise to Dr. DeKosky. Prior to Dr. Omalu's discovery, Dr. DeKosky and his colleagues asked the NFL Hall of Fame for permission to conduct a lengthy series of studies that would track ex-NFL players who were showing signs of memory loss. However, their proposition went completely unacknowledged by the league (Laskas 2015). The NFL was, and still is to an extent, afraid of the overwhelming science behind this serious issue.

Pathophysiology of CTE

Since Dr. Omalu's breakthrough, a plethora of research has been conducted in order to draw the amount of attention to this issue that it deserves. Dr. Ann McKee is the chief of neuropathology at the Veterans Affairs Boston Healthcare System as well as the director of the Boston University Chronic Traumatic Encephalopathy (BU CTE) Center in Massachusetts. She is one of the lead doctors on the largest CTE research study in the world. In Dr. McKee and her colleague's book, they explain how there are two defining traits of CTE that make it different from other neurodegenerative diseases. The first unique trait is that abnormal tau protein bundles deposit around blood vessels; the second hallmark characteristic is that the tau protein build-up occurs in the crevices and depths of the sulci particularly in the frontal and temporal cortexes (Budson et al. 2017). These different lobes are responsible for a variety of functions including

memory, judgement, impulse control, and behavior. The tau protein build-up in these areas is responsible for the death of the healthy cells and tissue that aid in the everyday functions listed above (Laskas 2015).

Dr. McKee and other scientists at the BU CTE Center have classified the progressive pathologies and symptoms associated with CTE into four stages which can be seen in figure 1. Stage 1 CTE is clinically diagnosed by the presence of small bundles of tau proteins. The least advanced stage of this disease is accompanied by either a lack of physical symptoms or minor ones such as headaches or mild depression. Stage 2 CTE shows evidence of an increased number of isolated tau proteins and is characterized by symptoms such as more severe depression and short-term memory loss. Diagnosis of stage 3 CTE is classified by similarly isolated tau proteins with the addition of age-related tau protein layers in the affected and surrounding areas. Symptoms of stage 3 CTE progress to include executive dysfunction and cognitive impairment. Stage 4 CTE is the most advanced and shows the presence of an abundance of tau protein bundles found mainly in the sulci of the frontal and temporal cortexes of the brain. This stage includes all of the other stage's symptoms in addition to dementia-like behavior, difficulty using words, and unnecessary aggression (Iverson et al. 2015; McKee et al. 2012). If a current or former football player dies and is diagnosed with CTE after an autopsy is performed, the stage of their CTE is significantly correlated with age at death and duration of exposure to football (Budson et al. 2017). While children are encouraged to begin participating in organized sports and activities at a young age, signing up for football and other contact sports such as soccer, wrestling, and hockey should be given heavy consideration. The amount of well-established data showing correlation between duration of football exposure and the severity of a potential CTE diagnosis is alarming.

Pre-Professional Football

Organized athletics are a big part of growing up for most children; they promote communication skills, help kids understand the value self-esteem, and highlight the importance of a strong work ethic. Childhood years are meant for the youth to try a variety of sports and be part of a team. However, in today's sports-driven society, some young kids are encouraged to choose one or two sports that they like the best. This approach is intended to narrow the focus onto a select sport for that individual to excel in rather than being average in a multitude of sports. This intense and repetitive activity is referred to as "sport specialization" and is intended to maximize athletic success. In fact, some people are convinced that sport specialization is necessary to produce professional athletes—but it comes with a multitude of risks. Immense amounts of pressure, being overworked, and increased injury are all consequences of specializing in sports at such a young age (Jayanthi et al. 2013).

To no surprise, the long-term effects of sport specialization are no exception to football. The longer exposure a tackle football participant has to the sport increases the number of TBIs they might sustain which is positively correlated to their likelihood of developing CTE. There is an ongoing debate that argues what age children should be allowed to begin playing tackle football—or if they should be able to at all. A study conducted at the BU CTE Center discovered "an association between participation in youth tackle football before age twelve and impaired mood and behavior later in life". The participants of this long-term study consisted of 214 former American football players—43 of which played only through high school, 103 who played through college, and the remaining 68 played professionally. Those who started tackle football prior to turning twelve showed an "increase risk of problems with behavioral regulation, apathy, and executive functioning by two-fold and increased the risk of clinically elevated

depression scores by three-fold”. These findings are attributed to the fact that the brain, especially in males, experiences tremendous growth and development during the ages of ten to twelve (Belson 2017).

While this information is both startling and convincing, participation in youth tackle football has not decreased tremendously. However, the safer alternative of flag football is gaining popularity (Belson 2017). Young boys who start tackle football at a young age often dream of achieving the ultimate goal of performing at the most elite level in the National Football League. In order to obtain this professional status, athletes have to be dedicated to the game throughout high school and college. Although the nature and pace of the game at these levels is not as intense as it is in the NFL, every hit—regardless of the magnitude—adds up over the years. Additionally, most NFL players make it as far as they do because of how invested they are in the sport which, for most of them, means beginning prior to the age of twelve.

National Football League

The Road to the NFL

Making it big on football’s most prestigious stage is extremely harder than the general population thinks. A handful of players come from poverty, broken homes, or disadvantaged upbringings and use football as their motivating factor to make better lives for themselves. Every year, there are about 1.05 million high schoolers who participate in tackle football, but only a mere 0.02% of them will go on to play in the NFL. The breakdown of that percentage is as follows: of the 73,063 collegiate football players in 2017, only 253 of them were selected into the league during the NFL draft that year (NCAA 2018). As these statistics illustrate, it is extremely difficult to advance up the football ladder. Only the top-tier athletes who pour endless time and dedication into the sport will fulfill their dreams of playing at the highest level.

There is no denying that it is an incredible feat to make the cut to get into the NFL—but it is another thing to make a name for one's self once there. This slim chance of making it to the big leagues is one of the biggest reasons NFL players work around the clock and often brush off the risks associated with the game. They are the best of the best and football quickly becomes, if it has not already been, their full-time jobs. The players commit themselves to being students of the game who will do everything they can to help their teams find ways to be victorious each Sunday during the seven-month season. While the NFL is competitive amongst the league, there is also competition within each team.

Players need to continually work hard to stay on the active roster because nothing is guaranteed. In late July of every year, ninety men report to their respective teams for training camp. Training camp runs for about three weeks and consists of rigorous practices, workouts, and trainings multiple times per day. Before the season officially starts in early September, a fifty-three-man roster needs to be created; this means that thirty-seven of those ninety athletes at training camp for each team will lose their jobs before the season even starts. Of the 2,880 players that report to training camp each summer, only 1,696 of them, or 58.8%, will be on the active rosters when kick-off day rolls around (Kane 2018). While some of these players who get cut will be moved to the team's practice squad or become free agents within the league, a lot of them will have lost their positions in the NFL in the blink of an eye. Another reason NFL athletes are so competitive and driven is because football is their occupation and therefore their source of income. With these extremely large salaries comes the risk of having them taken away without warning if the players are not constantly competing at the highest level they possibly can. There is always someone just as qualified on the bench ready to take their spot—and their paycheck.

League Salaries

Players work so hard and diligently in both practice and games because their performance has the potential to impact their earnings. They cannot be worried about playing it safe out on the field to avoid injury because that could result in being cut from the team. Quarterbacks are the highest paid players in the league where as tight ends are the lowest paid; rest assured, however, no one is struggling to make ends meet. In 2018, rookies, or first-year players, are required to receive a minimum salary of \$480,000. The NFL has a wage scale which requires veterans, players who have been in the league for at least seven years, to earn a minimum salary of \$915,000 (Kane 2018).

To understand the progression of pay in the league, we will look at Aaron Rodgers, the quarterback for the Green Bay Packers. He was drafted in 2005 at the age of twenty-one; at this time, his annual base salary was \$620,000 to be the second-string quarterback. Fast-forward thirteen years, eight playoff berths, six Pro-Bowl nominations, two league-MVP awards, and a Super Bowl ring, and he claimed the title of the league's highest paid player this year. He will rake in 67 million dollars this season alone after he signed a contract extension in August (Gaines 2018). To put these numbers into perspective, Rodgers will earn approximately \$184,000 per day or \$7,700 per hour for this year. Additionally, none of these figures include player endorsements and sponsorships. I think it is safe to say that if players were making \$50,000 per year, there is a good chance the NFL might not exist. The players themselves would not be able to justify the health risks they are taking for such a "small" paycheck. One of the reasons so many players are willing to risk injury and sustain repetitive blows to the head is because of the money involved. While there is no doubt that professional athletes in all sports are extremely passionate about what they do, money is a large motivating factor for NFL players to

stay disciplined in their strict practice, training, and nutrition regimens for as long as they physically and mentally can. However, this comes at a cost that has been scientifically proven to be greater than any string of numbers following a dollar sign.

Injuries—Particularly Concussions

Majority of NFL players have a “football first, life later” mindset. They have blinders on during their careers because of the grit, perseverance, and sacrifice it took to get to where they are today. If a player gets hurt during a game, they often try to shake it off and convince the medical staff they are fit to get back on the field. The most devastating thing in all of sports is seeing an athlete put in endless hours of practice only to suffer a serious injury that sidelines them for an extended period of time. What is even more gut-wrenching, however, is watching players sustain blow after blow to the head that have the potential to create negative effects that last a lifetime.

The number of concussions sustained by NFL players in the 2017 season was up to 291, a 16% increase from the 250 concussions reported in 2016. Part of the reason for this eye-opening statistic could be due to more players self-reporting their concussions. Additionally, various protocols that have made concussion detection more sensitive have been introduced since the league started publishing injury data in 2012 (Stluka 2018). For example, there are referees up in the booths at every game who carefully watch every player on each snap. If they suspect a player experienced a concussion at any point in the game, they can call down to the field referees and have that player removed from the game to be evaluated. Regardless of the reason, the NFL is not happy with this jump in the number of head injuries during the season and claim to be doing various studies in order to determine what is contributing to it. They are looking into things such as what types of plays routinely increase athletes’ risk of sustaining a concussion and have even

talked about banning such plays (Taylor 2015). While the players need to know when to put their health above their drive to be out on the field, the league also needs to do their part to recognize the severity of this concussion epidemic and its lasting effects.

“League of Denial”

The National Football League is a monopolizing empire that produces an estimated 14 billion dollars’ worth of revenue every year from ticket sales, merchandise, and television deals. To put this colossal number in perspective, 38.4 million dollars is spent *every single day* on the NFL—way more money than most people will have in their *lifetimes*. NFL Commissioner Roger Goodell predicts that the annual revenue will almost double to 25 billion dollars by 2025 (Huddleston 2017). However, the league has been on the hot seat since the early 2000s due to the discovery of chronic traumatic encephalopathy by Dr. Bennett Omalu which unveiled a terrifying concussion epidemic in American football. The National Football League has continually denied the link that playing football and developing CTE are connected even though the science overwhelmingly states otherwise (Ezell 2013).

When Dr. Omalu presented the league with his initial research on Mike Webster, they dismissed the science. However, Dr. Omalu paved the way for breakthrough research that is making it impossible for the NFL to keep denying it. In 2017, Dr. Ann McKee and her team at the BU CTE Center published findings from the largest study on CTE. The study examined the brains of a total of 202 former football players including high school, college, semi-professional, NFL, and Canadian league players. A shocking 177 of the 202 samples displayed signs of CTE. Out of the 202 brains in this study, 111 belonged specifically to former NFL players; 110 of the 111 brains showed signs of CTE—an astounding 99% (Budson et al. 2017; Mez et al. 2018). Dr. McKee acknowledged there was a selection bias in the sample size due to the method in which

the tissues were collected. Families who saw symptoms of CTE in a loved one prior to them passing away had to be willing to donate their brain to the BU CTE Center for this study. Despite this bias, however, the numbers and evidence are still appalling and reiterate why CTE should not be taken lightly.

It was not until eight years after Omalu's findings that the NFL first publicly recognized concussions and CTE as a major concern for football players. In 2010, the league donated 30 million dollars to the National Institutes for Health to fund research on the disease. In 2013, the National Football League Players Association (NFLPA) provided funds for a 100 million dollar study at Harvard (Ezell 2013). While the NFL still has a tendency to beat around the bush about this issue, they have been promoting safer tackling techniques in an attempt to reduce head-to-head collisions (Belson 2017). They have also spent 1 million to promote flag football in the younger populations to keep kids interested in the game without suffering from the long-term effects of early exposure. Additionally, an HBO/Marist poll from 2017 revealed that 44% of parents with sons under the age of 18 were less likely to allow them to play tackle football (Huddleston 2017). This was a reality check for the league because the youth become their next elite athletes. The NFL has no choice but to act on this issue if they do not want to see their enterprise fade in popularity.

How to Tackle CTE

This review has worked in an attempt to reveal the multiple layers that make up this existential crisis that has plagued the sport of football. The science gathered on this topic matches a referee's uniform—it is black and white. However, the big area of question lies in how we approach the science; what can we do to tackle the large, scary, and controversial issue of chronic traumatic encephalopathy?

Prevention & League Education

The biggest thing the league can currently do to help alleviate the issue of CTE diagnoses in former football players is to work on prevention which should start with the younger population. Families should be educated before they decide if their child will play football during their formative years. Additionally, players at the professional level need to be thoroughly and continually educated of the lifelong risks associated with the game (Kane 2018). The NFL needs to continue to implement rules and regulations with the players' safety and health at the forefront of their minds regardless of how the fans feel about the changes.

The NFL Competition Committee has created and modified a number of rules in recent years in an attempt to better protect the athletes. For example, contact practices involving tackling have been limited to one time per week. In a game setting, if a player lowers their head and initiates contact with the helmet, they will most likely be penalized through substantial fines and disciplinary action. In terms of concussions, individual players as well as entire teams can be fined if they fail to comply with the concussion protocol (Tharmaratnam et al. 2018). While all of these advancements in player safety are in the right direction, education is still lacking. Additionally, monetarily fining players is not always effective because as discussed earlier, they make a significant amount of money. Although some fans get bent out of shape about the new rules claiming it takes away from the nature and pace of the professional sport, the Competition Committee must ignore the critics. The committee must keep both short and long-term player safety in mind as they continue to create rules and regulations in an attempt to reduce TBIs.

Therapeutic Treatments

There is currently no cure for CTE, and the disease can only be diagnosed post-mortem through an autopsy. The use of therapeutics has been researched with the main goal of increasing

the quality of life in those who are suffering from CTE. One scientist and his team expressed the difficulty in developing therapeutic remedies is mainly due to a lack of understanding of the mechanism of the disease. They cannot pinpoint how and why the tau proteins phosphorylate and create bundles in certain areas of the brain which has led to minimal advancements (Pearn et al. 2017). Another study used mice to research possible detection methods as well as ways to stop the progression of the disease through drug usage. TBIs were inflicted upon a group of mice to mimic what happens to football players after years of repetitive head injuries. Various imaging methods were tested on the mice in an attempt to find a detection method in living people. Additionally, the mice were given different drugs in an effort to inhibit the progression of the disease once symptoms are present (Tharmaratnam et al. 2018). Although neither of these approaches were successful, they are still paving the way for future studies on both the mechanism and progression of the disease. There is still a long way to go in terms of therapeutic remedies for CTE, but it is definitely not something to be quickly dismissed as it has the potential to be very helpful.

Innovative Protective Gear

The most promising thing that has been developed for current prevention of CTE is the VICIS ZERO1 helmet. VICIS is a sports technology company based out of Seattle, Washington that is focused on improving player safety without compromising performance. The company was founded by engineers, neurologists, and physicians who are “on a mission to keep the game of football around while reducing the lasting health effects it has on the players”. The NFL has even granted the company money to collaborate on research with the goal of making this the best and safest helmet for a football player to step out on the field in. The VICIS ZERO1 helmet has been in the works since approximately 2014 and has just started being used at the collegiate and

professional levels. The helmet is unique in that it has multiple layers intended to slow the impact of collisions as well as mitigate linear and rotational impact forces. The Lode Shell is the outermost layer; it is similar to a car bumper and has some give to it as opposed to a standard helmet which leaves the brain to absorb the force from an impact. The next layer is the VICIS RFLX layer. This is made of one and a half inch thick columns that compress, twist, bend, and shift to absorb impact from all directions and speeds. The RFLX layer is what makes the ZERO1 extremely unique. The innermost layers are the Arch Shell and the Form Liner which help in absorption of impact as well as comfort. While the ZERO1 is extremely customizable, the baseline price is right around \$1,000—but safety should not be sacrificed for cost. This helmet is the first of its kind and is extremely promising on the quest to make player protection a priority (VICIS 2018).

The ZERO1 drew national attention when it ranked first out of thirty-three helmets in the NFL/NFLPA biomechanical laboratory helmet performance studies in both 2017 and 2018. The main goal of the test is to determine which helmets best reduce the severity of head impacts and collisions (Play Smart Play Safe 2018). A handful of players from 28 of 32 NFL teams currently wear this helmet and all feedback has been positive thus far. Additionally, the Notre Dame football team is the first program at any level to primarily outfit the team with the VICIS ZERO1 helmet. The Notre Dame coaching staff took it upon themselves to implement this helmet during the 2018 season because they consider themselves a “gold standard” in terms of player safety (Lemire 2017). While it will take a while to gather long-term data from the implementation of what has been ranked the safest football helmet, the future is looking promising in terms of protective equipment. Hopefully, we will see an entire league sporting the VICIS ZERO1 helmet in the very near future.

Conclusion

Amidst all of this denial and controversy, however, I think one thing most people would agree on is the fact that sports have become a cultural identity and monopolizing enterprise in our society. The National Football League has single-handedly taken over the day that used to belong to the church; we plan our days around our team's schedule, we travel near and far to cheer them on, and we glorify those on the field. However, we often lose sight of the extreme dangers and risks associated with playing in the NFL—the players we idolize are putting their health and longevity on the line for *a game*. We often forget about their lives after they hang up the cleats. We often forget about their families who also have to deal with the lasting health effects of playing a contact sport. We often forget that football is just a phase of their lives in the grand scheme of things.

As mentioned earlier, there is currently no cure for CTE. To help decrease the number of cases of CTE reported in deceased football players, we can do a number of things. The league can continue implementing rules and regulations while making player education a top priority. While therapeutic remedies are a work in progress, they can offer promising diagnostic features as well as preventing progression. The league can also require better protective gear designed to help alleviate the issue such as the very promising and well-designed VICIS ZERO1 helmet. No one wants to see football disappear completely, but if we want it to stick around, some interventions need to be made, and CTE must be tackled after all.

We need to lose the “football first, life later” mindset. While we love watching football every Sunday, life still has to go on after the glory days are over and that is something we cannot forget. Successful men are falling victim to this disease. Families are being ripped apart. Children are losing fathers. As much as I hate to admit it, we—the league, players, and fans—need

to remember that football is *just a game*. The science published in regard to CTE is a force to be reckoned with, and it is our responsibility to illuminate the severity of this issue even if it means changing the way football is played. At the end of the day, the long-term well-being of the athletes we idolize is far more important than the score when the clock hits zero, the history books, or any number of Lombardi trophies.

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Appendix

