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Addressing One of Football's Greatest Issues: CTE, A Discussion on the Neurology Behind the Life-Changing Disease

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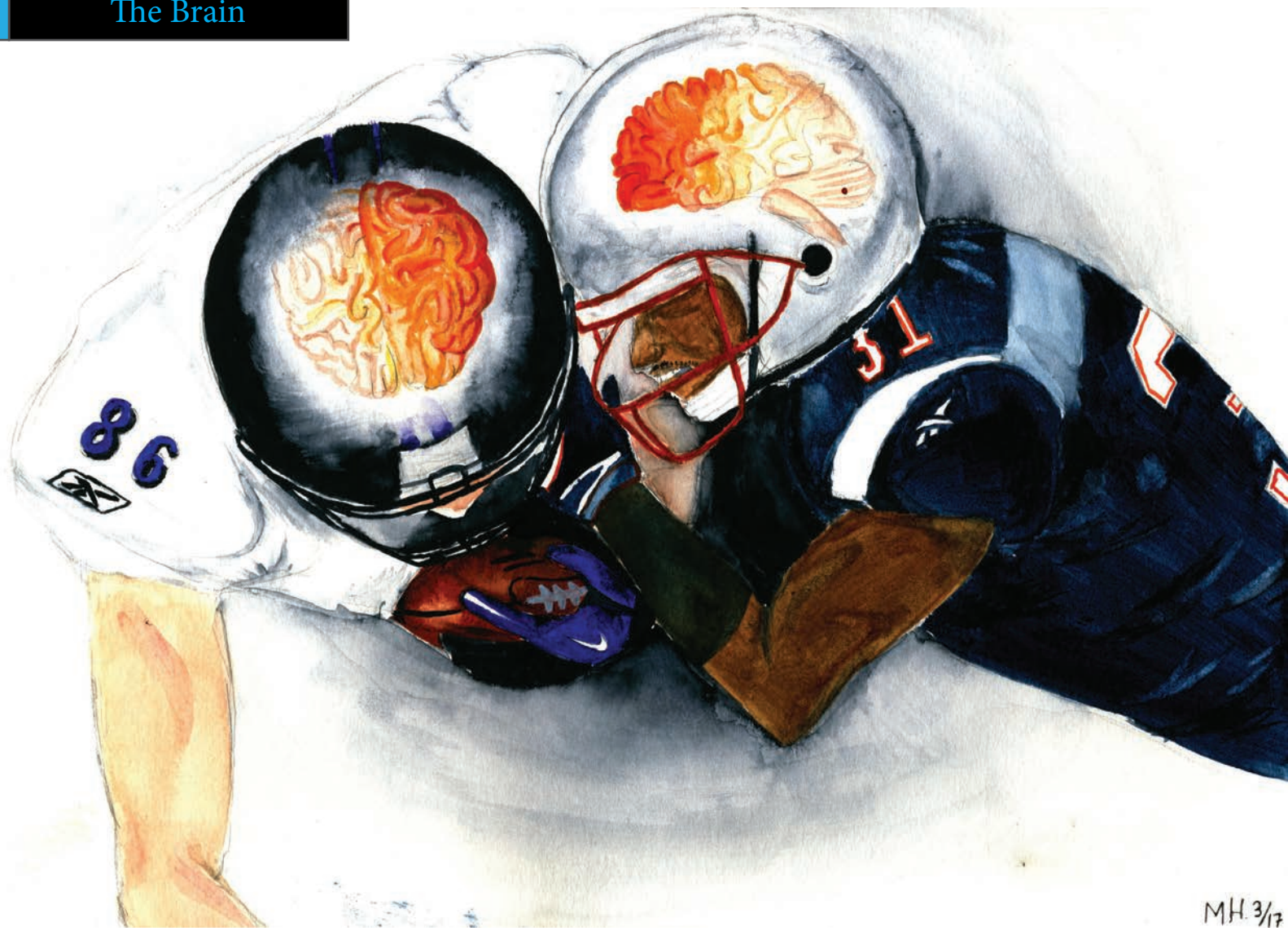

Addressing One of Football's Greatest Issues: CTE

A Discussion on the Neurology Behind the Life-Changing Disease

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It is the fourth quarter; the score is tied with little time left. As the players explode off the line of scrimmage, a war erupts. A rushing linebacker sees his shot to give his offense the ball. He slides past the blockers and closes in on the quarterback. BAM! The linebacker, and accordingly, the defense, won this battle. However, the quarterback and linebacker stumble as they attempt to regain their footing. The quarterback loses consciousness and falls back to the turf. He is taken off the field. The linebacker does not last on the pitch much longer. The game continues as if nothing happened in the previous play. However, on the sidelines, each player's body is undergoing physiological changes. The trainers note that both players are in a daze. They seem to be in some type of purgatory of consciousness.

The players are developing a condition known as Chronic Traumatic Encephalopathy (CTE), which is caused by Traumatic Brain Injuries (TBIs) such as the concussion from which the quarterback and linebacker are both suffering. After taking on a severe TBI, a person's brain starts to undergo physiological changes. Even one TBI can lead to CTE, but it is usually the culmination of multiple brain injuries. CTE wreaks havoc in a player's life. The disease changes the brain at the cellular level, which ultimately affects behaviors at the social level. A beloved player can be changed forever because of the disease. In this article, I will discuss the effects of CTE at multiple levels as well as explore possible prevention tactics for this disease.

In order to understand CTE, one must first understand the most common TBI: a concussion, or a bruise within the brain as a result of an impact with the skull. The brain is not tightly packed in the skull. Instead, it is suspended in cerebrospinal fluid (CSF) inside the skull. When a player is tackled, their head launches in the corresponding direction of the hit; eventually, the head meets a force, like the ground, which stops all momentum. However, the inertia of the hit leaves the brain moving toward the stopped skull. The brain then hits the bone. The brain contuses, causing the unfortunate player to suffer from a TBI. This is why many concussions often result from the head hitting the ground rather than the initial hit while running the ball.

Once the player has sustained a TBI, changes at the cellular level occur. CTE is a neurodegenerative disease characterized by the hyper-phosphorylation of tau proteins. Tau proteins normally help the microtubules in the neuron maintain its shape. When a phosphate group is added to the proteins, they undergo a change in shape, which is natural and not deleterious when the phosphorylated protein is at low concentrations. But in diseases like CTE, the tau protein is over-phosphorylated, which causes inappropriate protein folding and entanglements known as neurofibrillary tangles (NFTs). A plaque forms and there is a block between neurons.

One way to visualize the effects of CTE is to imagine the neural pathways as electrical information highways in the brain. The normal tau proteins help stabilize the roads. When there is an overrepresentation of hyper-phosphorylated tau proteins, the resulting plaque is like a car crash on the highway, leading to major blockage.

Blocked neural circuits can significantly change a person depending upon which area of the brain is affected. Unfortunately, CTE affects the cerebral cortex, the most important and largest part of the brain. The cerebral cortex controls personality, higher thoughts, feelings, and holds some memories. The disease can also spread from one area of the brain to another. CTE might initially affect higher thought processes by plaguing the prefrontal cortex, but then affect memory later on by spreading to the hippocampus. Additionally, the NFTs often cause neuronal death, which is why many autopsies of patients suffering from CTE show patients with significantly shrunken brains.

Chronic Traumatic Encephalopathy is not the only disease characterized by misfoldings of tau proteins; Alzheimer's disease and Tangle-Only dementia also resemble the sports-related disease. All three diseases can change a person's behavior, decision-making, and memory. Alzheimer's disease and Tangle-Only dementia usually only affect people in the later years of their lives, typically afflicting individuals age 65 and older. However, CTE can affect a person's brain decades before the other diseases. Autopsy cases have shown the presence of CTE in people in their late 30s and early 40s who were in excellent physical condition. This is perhaps the most haunting aspect of Chronic Traumatic Encephalopathy: it can affect people at very young ages.

Unfortunately, the physiological changes can be tied to severe behavioral changes. One of the best football players of all time, Junior Seau, suffered from CTE. His wife reported that she noticed behavioral changes in her husband two decades before his eventual suicide. She said that he suffered from headaches, dizziness, and insomnia for quite a long time in his football career. After games, he would quietly return to his room at home and draw the blinds to sit in the darkness for hours. These are only some of the physical effects of CTE; the extremely troubling effects were ones that changed Seau as a person. Years before his passing, he reportedly developed new habits. He made rash financial decisions. He developed addictive habits, like drinking and gambling. Lastly, he suffered from severe fluctuations in emotions and correspondingly, behavior. These symptoms are linked to the physiological effects of CTE. The development of plaque in regions of the cerebral cortex can influence all of these behaviors. Junior Seau was a good man who passed away from a disease currently viewed as incurable.

So how can we decrease the number of people suffering from CTE in the future? The simplest answer is to avoid TBIs. This is a rather tall order, though, because people love the fast-paced, intense action of physical sports like football. It is human nature to enjoy these sports — playing them as well as watching them. However, the human body was not made to crash into other humans at top speed. Maybe we can learn from other animals in nature that are able to withstand such brutal impacts.

A woodpecker is estimated to bang its head against trees around 85 million times over the course of its lifetime. Woodpeckers are able to avoid brain injury because they have a special bone to protect their brain. This bone, the hyoid bone, starts at the top of the woodpecker's beak and then it wraps around the back of the head to become the tongue in the bottom of the beak. The hyoid bone acts as a seat belt for the woodpecker's brain as it flings its head into the bark of the tree and prevents the brain from hitting the back of the skull, the main cause of concussions.

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The bighorn sheep are another type of animal who live their lives by ramming heads. Male bighorn sheep are famous for ramming their heads with other males to establish dominance for mates and territory. The bighorn sheep can withstand the massive impacts from ramming heads because of the shape and structure of their horns. The curved horns displace some of the energy to the tips instead of the skull. Additionally, the trabecular internal structure — characterized by complex, porous spatial construction to maximize bone strength — of the horns allows the energy to dissipate. The segmented design of their horns allows the energy to dissipate further as it passes each partition.

Both animals adapted to compensate for their repeated head banging while preventing brain injuries; the human body has not developed these adaptations. Although sports are exciting and fun, one must keep health and safety in mind. Companies are currently searching ways to prevent concussions through the development of new helmets. A company called Vicis has created a flexible helmet named the Zero1. The flexible design in the helmet provides a cushion to help absorb the impact of a hit. Other companies are finding inspiration in porcupines, which fall out of trees quite often. To protect themselves, the porcupines tuck into a ball and allow their quills to brace the impact. Research is currently being undertaken to pursue the potential for quill-like structures in the shock-absorbent portion of a football helmet. There are plenty of companies seeking to innovate the helmet industry, but many are having trouble securing funding; they need a larger corporation to supply funds for their research.

The National Football League (NFL) is attempting to do exactly that. The organization is now recognizing the dangers of football, and designating a lot of money towards research to prevent concussions. The NFL announced a plan to pay $100 million for an initiative to seek safety for the players. $40 million dollars will be put toward medical research and the other $60 million will be applied to developing new technologies, such as helmets.

Preventing concussions seems like an impossible task in many sports that rely on brute force. Some could argue that changing the rules is the first step. The NFL has done that already — in fact, it has made over 40 rule changes in the past couple years. Some people argue the changes are needed, while others say they are ineffective and only ruining the sport. Either way, everyone can agree something needs to be done to prevent the players from developing Chronic Traumatic Encephalopathy.