NFL Head to Ground Impact Testing Device

Long Term Health Risks of Concussions in NFL Football

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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Introduction

The National Football League (NFL) is an essential piece of American culture. The game of football is as American as apple pie or Budweiser beer (Cole, 2010). Having operated for over 100 years, the NFL has become a billion-dollar industry that affects the lives of millions across the United States. It was estimated in 2023 that the NFL made about $12 billion in the previous season (Eckstein, 2024). In polls sent out by the Washington Post, it was determined 60% of people say they are professional football fans and 37% of people say football is their favorite sport to watch (Kilgore & Clement, 2017). Although this game has great popularity among viewers, the health and safety of the players is becoming a major problem. In those same polls, 90% of people said head injuries causing long-term health problems for players is an issue in football (Ibid).

Head injuries, especially concussions, are a common injury that NFL players experience. As humans, our brains control the nervous system and when damaged can change a person's personality, movement, vision, sleep, and other bodily functions (Martin, 2023). Although concussions have a history of being seen as insignificant, links to chronic traumatic encephalopathy (CTE) are bringing about major concern of athletes brain health. In recent years there has been a decrease in the number of high school football players due to increased attention to risk of head injury (Macy et al., 2021). This attention comes from clear concussion risk in the NFL. In the 2015-16 and 2016-17 NFL seasons there were 458 concussions sustained by 401 unique players (Lessley et al., 2018). The quantity of concussions obtained by NFL players is alarming because it puts their long term brain health at risk.

Repeated concussions and sub-concussive blows to the head increases an athletes risk of developing CTE (Vanltallie, 2019). CTE negatively affects a human brain by causing symptons

like chronic depression, insomnia, paranoia, and impaired memory (Omalu et al., 2010). In a recent study of 111 NFL brains, 110 of them were determined to have CTE (Ward and Manchester, 2017). The problem is clear, NFL players brain health is at risk.

In order to solve this problem, it is important to look at how concussions in the NFL are occurring. In 2015-16 and 2016-17 seasons, 50% of head injuries sustained were caused by tackling situaions. In these situations, 18% of concussions came from head impact with the ground (Lessley et al., 2018). Historically, the main two ways that the NFL has attempted to improve player safety is by improving equipment technology and making rule changes. In 2013 and 2016 the NFL made major rule changes to help injury prevention. Although the 2013 rule change specifically taqrgeted concussions afety, the number of players who suffered head injuries did not decrease significantly (Sheth et al., 2018). To make a real change, more information needs to be available regarding helmet impact and forces on the head. The technology my capstone project seeks to develop is a test device that will allow football helmets to be studied on head to ground impacts. In this prospectus, I will explore how this technology aims to enhance concussion prevention and examine the social implications of player safety, particularly the long-term health issues concussions can cause for athletes.

Technical Topic

Throughout the years of NFL play, many new helmet designs and improvements have been made in order to increase player head safety. In a study by Viano et al., it was found that modern NFL helmets reduce impact severity on the head. To back this claim, a helmeted head-neck assembly was created and dropped in a lab using a drop test device. The study determined that newer helmets reduce the risk of concussions by 10-20%, but in some cases the concussion risk was higher with newer helmets (Viano et al., 2006). The drop tests completed in this study

were to replicate 50 NFL impact cases of varying impact types, thus lacking uniformity. In a study by Kent et al., an on-field test device was created to specifically look at head to ground impacts. This device incorporated a test dummy and a horizontal launching sled. In the study, it was determined that peak head accelerations of 190g's can be experience by players in a head to ground impact (Kent et al., 2020b). This type of acceleration is the cause of significant head injury potential (ibid). Although this device establishes a basis for injury potential in head to ground impacts, it is extremely expensive and lacks repeatability. The device my capstone group is developing will improve on these previous solutions by specifically replicating head to ground impacts with increased repeatability and affordability.

The device we aim to create will consist of a curved track, allowing an angled torso-to-head assembly to slide downard and impact the ground as seen in figure 1**.** The curved track will allow us to replicate the kinematic motion seen in figure 2. Upon sliding down the track, the

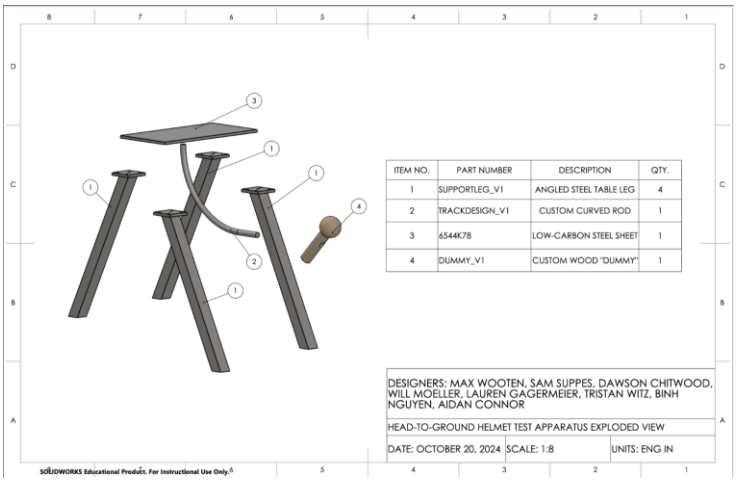

Figure 1: Device Assembly Mock Up

assembly's potential energy create horizontal velocity. When the assembly slides off the track the remaining height off of the ground will establish vertical velocity. Upon hitting the ground, the friction force on the impact point of the angled assembly create an angular velocity, causing the head to experience a whipping motion into the ground. From video analysis of on-field

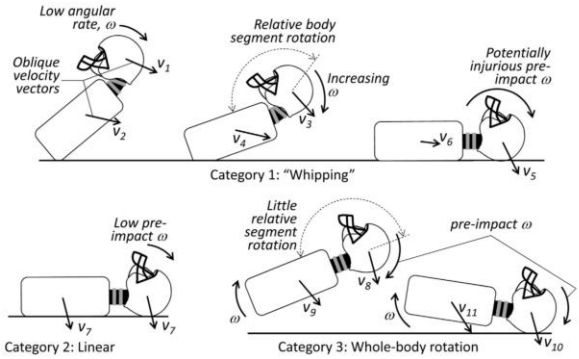

Figure 2 (Kent et al., 2020b)

concussion impacts, the resultant head velocity of NFL players ranged from 5.5 to 11.6 m/s, the angle of the upper body to the ground ranged from 12.6 to 63.6 degrees, and the resultant angular velocity of the head ranged from 4.5 to 54.1 radians/second (Ibid). The specifications of our device will allow us to test impacts in these ranges.

Our device is specifically designed to build upon the current solutions, but also establish improvements that make the device more accessible and repeatable. Since we are relying on gravity to create motion it will establish a high level of repeatability that current solutions do not have. In other test setups that rely on gravity, a head and neck assembly is used and the final conditions are controlled established limitations (Kent et al., 2020a). Our device will be inexpensive and require less set up than the on-field tests mentioned above, which will allow it to be used by many helmet manufacturers and football league. This device directly relates to the STS problem of long term player health being jeopardized because improving concussion safety can directly reduce CTE contraction among football players.

STS Topic

As humans our health and safety is a priority that stands above all else. While football provides significant entertainment, it is crucial to recognize that human safety and long-term well-being are far more important than fan and player enjoyment. As a society in the United

States, football plays a major role in our culture. At NFL kickoff live in 2003 president Bush argued that football displays values that keep America strong (Oates, 2004). The game itself promotes a masculine nature by displaying rough physical contact. The topic of concussions in sports has gained significant prominence over the last 20 years, resulting in dramatic growth in research funding, widespread media coverage, and increased public awareness (Guay et al., 2016). The existing technological solution to solve this rising force of concussion awareness has been improvements in football helmets. However, this solution has made no apparent progress as it is visible that the concussion risk in the NFL is alarming. From 2002 to 2007 there was an average rate of 0.38 concussions per NFL game played (Casson et al., 2010). The aspects of human, society, and technology are greatly integrated into the problem of concussions in the NFL. In order to improve the lives of the human players, our society has to accept changes to the game of football and its equipment which can be justified by technological advancements.

In order to understand the issue of concussions in the NFL, I will be looking at helmets and my capstone device as pieces of infrastructure. To do this I will be using the STS framework developed by Star in "The Ethnography of Infrastructure." Pieces of infrastructure are taken for granted by people and only appear to be visible when broken (Star, 1999). Football helmemts are taken for granted by people and only in recent years have people started to take note of their failure. This visibility has stemmed from increased awareness of brain health and validation of concussions and CTE as a problem. The lack of reliability in helmet protection has caused changes to laws, game rules, policies, and recovery management protocols (Guay et al., 2016). My capstone device will be used to help solve the problems with NFL helmets which visibly require improvement.

Star also argues that pieces of infrastructure are fixed in modular increments. In weeks 13 of the 2015-16 NFL season and week 1 of the 2016-17 season there were 12 different helmet types worn on the playing field (Colello et al., 2018). All of these helmet styles are created based off of different resources and information, making it integral that a device for testing head impact is accessible to all equipment companies. This will allow them to make necessary improvements given proper information.

Lastly, Star argues that infrastructure has reach beyond one single event or practice. The game of football reaches far beyond the NFL. The NFL sets the standard for helmet use that all levels of football follow. There is a correlation between participation in tackle football prior to age 12 and later life cognitive impairment (Stamm et al., 2015). Across the Canadien Football League, college football, and high school football of 202 brains that were studied, 87% of them were found to have CTE (Ward & Manchester, 2017). Football hemlmets have reach far beyond the NFL, and the test device my group aims to develop will be able to improve the concussion risk for this entire scope. By looking at our test device and NFL helmets as pieces of infrastructure, it is clear that our device will impact the visibility of failure in NFL helmets, the modular fixation of helmet safety, and the reach of all football players beyond the NFL.

Research Question and Methods

The research question I am seeking to answer is how are concussions in the NFL causing long term health risks for players. This question is important because of the implications it carries for player safety. The impact concussions can have is still unknown. In the case that they are causing long term health risks the landscape of the NFL and football as a whole could potentially change. To analyze this question I will be utilizing three methods: counts of events, prior literature, and historical analysis.

The first method I will use is counts of events. In order to understand how long term health risks are being developed it is imperative to determine how many players have experienced reoccurring concussions, which is linked to CTE. To attain this information I will review the NFL injury logs and to determine how many players have been at risk for CTE. This has been done previously by Seth et al. for the 2010-2019 seasons by using weekly injury reports from NFL teams to track major injuries (Sheth et al., 2020). Next I will use prior literature to prove the existence of CTE in NFL players. CTE does not affect players until after their career so it's not possible to execute a count of events. However, I plan to find existing literature that supports the fact that reoccurring concussions does put humans at risk for CTE. In addition, I plan to find literature that discusses cases of players who have been determined to have CTE. The last method I will use is historical analysis. Concussions and CTE have not been diagnosed in the NFL from its beginning. I will use historical analysis to determine the timeline of concussion and CTE diagnosis in the NFL to help further interpret my count of events.

Conclusion

The issue of head safety among NFL athletes is critical, as concussions have become common in games and are strongly linked to long-term health risks. Despite available solutions and ongoing research, meaningful change has yet to occur. My capstone group plans to develop a testing device that will provide essential data on head-to-ground impacts, contributing to efforts to reduce concussion rates in the NFL. This device could have a major societal impact by highlighting current shortcomings in player safety.

With accurate data on concussion causes in the NFL, gameplay strategies and helmet technology could evolve in ways that transform football. My research paper will examine how repeated concussions in the NFL are linked CTE, a condition that endangers players' long-term

health. The severe symptoms of CTE underscore the urgent need for action. As the ties between CTE and NFL play become clearer, it will be insightful to observe the responses of players and team owners to these findings.

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