Football Helmet: Head to Ground Test Device

Youth Football Participation

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By
Lauren Gagermeier

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Technical Team Members:
Dawson Chitwood
Aiden Connor
William Moeller
Binh Nguyen
Sam Suppes
Tristen Witz
Max Wooten

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.

ADVISORS

Prof. Pedro Augusto P. Francisco, Department of Engineering and Society

Prof. Richard W. Kent, Department of Mechanical & Aerospace Engineering

Introduction

Tackle football causes a large number of injuries to its players, especially head related injuries (Resnick, 2020). In my technical project I will be finding a way to test football helmets that simulate head to ground collisions in football games. A very common and under tested type of head injury in football is concussions caused by a player's head hitting the ground, which not only has a tangential velocity, but also, a rotational velocity (Kent et al, 2019). This additional velocity makes these impacts extremely dangerous, and it is imperative that helmets are tested to include this type of collision inorder to improve the safety of these helmets. My mission is to design a machine that can simulate this type of impact and be repetitive.

The sociotechnical problem that I will be researching is the safety of youth tackle football, and how to improve it. In recent years, the participation rates of youth tackle football have been decreasing across the US because of its dangers and tendency to lead to life long injuries. Repeated impacts to the head like those seen in football can lead to concussions or, over time, chronic traumatic encephalopathy (CTE) (Resnick, 2020). The risk of lifelong brain injuries has become well known to the public, and therefore we have seen a decrease in youth tackle football participation. I will research how serious the risk of lifelong injury from playing youth football really is and identify safety measures that can prevent these injuries while still keeping youth football alive.

The two topics of testing NFL football helmets for common concussion causing impacts and the decline of youth football participation are deeply connected. Both are rooted in their concern for player safety. If football helmets are better tested, then companies can use the data to improve the padding and design of their helmets. This improved design will then be used not just by NFL players, but also by children throughout the country, thus improving the safety of youth

tackle football. This will help preserve the future of the sport while prioritizing the safety and well-being of the athletes who play it.

Football Helmet: Head to Ground Test Device

In recent years, there has been an increase in football helmet testing for the National Football League (NFL). Traditional football helmet testing is performed using a linear impactor striking a stationary helmeted head of a crash test dummy (think of this like an automatic arm punching a stationary helmet). This is designed to simulate helmet-to-helmet (H2H) impacts. There has been a large amount of research and experimentation done on H2H impacts, which cause a majority of in game football concussions. However, 19% of concussions in the NFL are caused by helmet to ground (H2G) impacts, which have had limited testing completed to evaluate these types of impacts (Kent et al., 2020). Our mission is to design a device that can be used to test the impact performance of football helmets in helmet to ground impacts.

The current testing measures used for H2H impacts would not adequately simulate a H2G impact because the helmet is stationary when the collision occurs. Prior to the collision in H2G cases, the head has both horizontal and vertical motion. There do exist different types of H2H linear impactor testing devices that can represent this type of motion before impact, however H2G impacts have an additional key component that makes them so much more dangerous than H2H impacts, that previously existing devices can't convey (Kent et al., 2019). Due to the way the human body hits the ground at different times (hips, then shoulders, then head) there is a rotational velocity introduced. This causes a whipping-like motion of a player's head into the ground which causes the head to hit the ground with a large amount of force compared to H2H impacts. Another reason current H2H impact devices can't represent H2G impacts well is

because the force caused by the ground is much larger than the force caused by another helmet due to the shear mass of the ground.

So the challenge that we faced was to design a device that could meet the following specifications:

1. Allows for mounting of a helmeted dummy head/neck.
2. Simulates pre-impact velocity of the head along a range of vector directions representing those preceding concussive H2G impacts (around 8m/s into the ground)
3. Simulates pre-impact rotational motion of the head over a range representing concussive H2G impacts (around 55 rad/s into the ground)
4. Deploys a boundary condition that reasonably reflects the hardness and frictional characteristics of a helmet striking an NFL football field.

Not only did it have to meet these specifications, but it also had to be repeatable, cost efficient, and easy to reproduce so that helmet companies could use it to test their helmets.

The solution we came up with is a curved track that the crash test dummy could slide down and then be released a distance above the ground to simulate the head to ground impact. You can think of the track as a 4m tall, 4m long downhill roller coaster that the crash dummy rides. There are two tracks, one on each side of the dummy, that have “runners” that slide up and down the tracks. These runners will be bolted to the “hips” of the dummy, securing it to both tracks. Once the dummy reaches the end of the track, it slides off and enters freefall for around 1.5 meters until it impacts the turf on the ground. The curved track allows the dummy to reach the necessary horizontal velocity needed to simulate NFL tackles, and the 1.5 m drop allows the dummy to reach the necessary vertical velocity. The dummy can be launched at multiple different angles relative to the ground in order to achieve a range of different rotational velocities

after impact with the ground. This design is a simple solution that will allow us to meet all the specifications in a costly manner, and can improve the testing of helmets across the NFL.

Youth Football Participation

Football is a staple of American culture and has been played by people of all ages for well over a century ("Who Invented Football?," 2023). Despite America's love for football, there has been a concern about the high number of injuries caused by the sport, especially amongst child participants. Infact, within the past decade, we have actually seen a decrease in high school tackle football participation, like we have not seen before (Gilligan, 2023). Since 2011, there has been a steady decrease in high school football participation. The 2021-2022 school year was the first season since the year 2000 to have under 1 million participants[1]. The number was about 1.03 million in the 2023-2024 school year, which is down 7.3% from its peak in the 2008-09 season. Additionally, in 2023, the average number of children ages 6-12 who participated in tackle football was 2.7%, which is significantly less than what it was in 2013 (3.5%) ("State of Play 2024," 2024). While there has been a decrease in youth tackle football participation over the past decade, there has been a steep increase in youth flag football participation (3.8% in 2023 vs 2.8% in 2013). This steady decrease in tackle football participation is likely due to rising concerns about the high injury rate in tackle football. This begs the question, is it safe for children to play tackle football, and if not, what safety measures should be taken to keep the youth sport alive?

To answer this question, I will evaluate how many injuries are sustained by children playing tackle football, including where children get injured the most. I will also evaluate whether there is a connection between playing youth football and experiencing long term brain

[1] It is likely that this number was partially affected by the COVID-19 Pandemic, which caused a decrease in participation in every sport during this school year

injuries or hindered brain development based on research done by experts. I will also discuss the benefits of playing tackle football as a child, including exercise, social interaction, teamwork skills, and stress release. Using this information, I will be able to firmly state whether children should continue to play tackle football regardless of risk of injuries. Additionally, I will study how these injuries occur in order to determine what measures could be put in place to prevent them. These measures could include improving safety equipment like helmets, pads, and helmet covers; increased regulation on practices including increasing the number of contactless practices or implementing new styles of play that reduce tackling while still emphasizing proper tackling techniques; increased concussion education for players; or even rule changes mimicking those made in the NFL. I will also explore if these options are realistic or wanted by parents and people related to the game of football like coaches and fans. I will determine this using parent polls that have been recently conducted, and reviewing statements made by coaches and fans about recent changes to football. After suggesting the possible changes to the traditional game/practice styles, I will end with a call to action to coaches, parents, and players to encourage participation in tackle football to continue the legacy of the sport, but I will also emphasize the importance of changing the culture around football, to promote safety.

Conclusion

Athlete safety is of extreme importance in every sport. In football, it has gained increased attention at every level, from little league to professional play. This emphasis on safety has sparked nationwide research on the severity of hits and tackles on players' heads. The current research conducted testing helmet to helmet collisions has led to improved designs of helmets and new regulations in the NFL. It is imperative to continue this type of research, while also

expanding our bounds to helmet to ground collisions to continue to improve helmet safety and minimize long term brain injuries for players. My capstone project hopes to create a device that can be repeatedly used to measure the dangers of helmet to ground impacts. The research of my technical paper hopes to discover what measures can be put in place to improve youth tackle football, to make it safer and reduce injuries at all ages.

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