Reducing Player Injury in the NFL

Final Report

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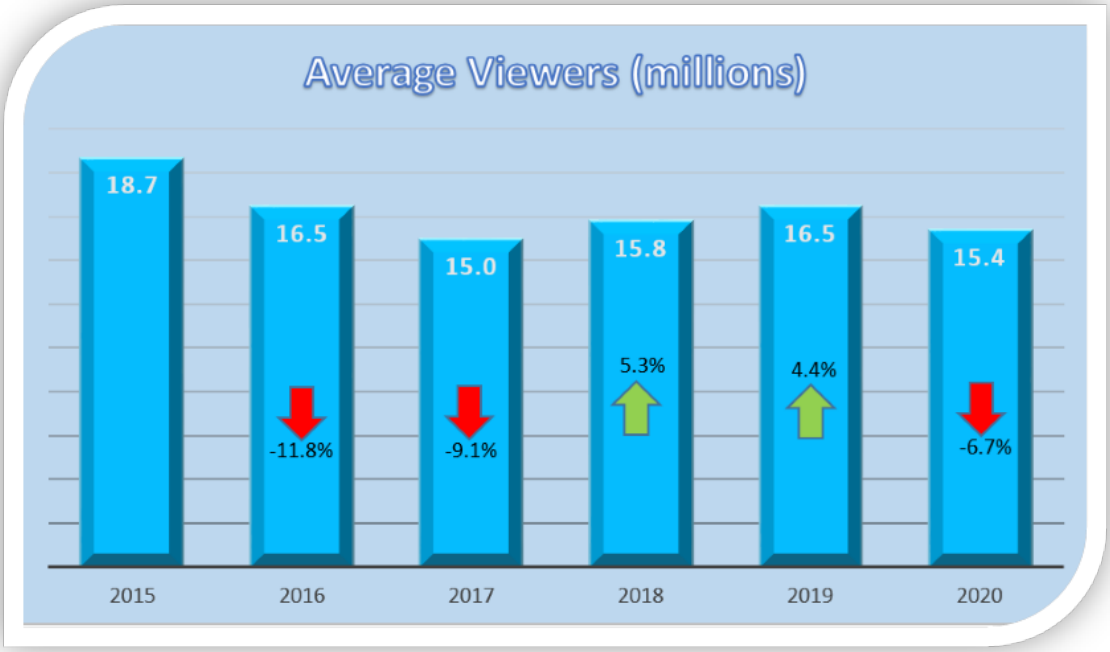
Executive Overview

This document presents a final report on Pick 6's analysis and proposals to reduce NFL athlete injury. Included is a review of the proposal objectives, summary of methods, analysis and modeling, and future priorities for the NFL. The team is pleased to report that all project deliverables have been meet and are consistent with our proposal to improve player safety and health.

Problem Statement

The NFL is a leader in the global sports industry. However, **television viewership is on the decline (3 of past 5 years)** due to a number of factors, one of which is debilitating injuries to star players. Also, the **future popularity of the game is at risk** due to concussion-related concerns among fans and young players of the long-term effects of CTE and brain injury.

The league is therefore at a **pivotal point** in its continuing success whereby eliminating these avoidable risks should be thoroughly analyzed and evaluated. As sports consulting experts, we are prepared to provide in-depth analysis to help the NFL address and mitigate these key business and health risks in order to increase viewership and revenue while keeping players safe.



Review of Proposed Objectives

Our main objective is to **keep the players safe** and injury-free and deliver the best viewership experience possible. The 2020 season alone presented a litany of unique challenges due to COVID-19, a major one being player injuries. As an example, the average number of Achilles tendon ruptures in the NFL typically impacts about 12 players per year, but just halfway through the 2020 NFL season, there were 15 players who suffered from the same injury, according to a Yahoo Sports. This is indicative of the high injury rate that has plagued the NFL this season.

In addition to the number of injuries that have occurred in the 2020 season, ***injuries from the 2019 season have been attributed to over $500 Million dollars in expenses incurred by NFL teams*** according to Forbes. The quantity of injuries combined with the revenue ramifications present a unique opportunity to more heavily scrutinize the data surrounding player injuries and implement substantial changes in order to keep players healthy and in the game. Our project's focus will be just that; analysis of injury data from past years through various regression analyses and Computer Vision to gain concrete recommendations and actionable insights that will lead to the reduction of player injuries and, in turn, minimize the injury-related expenses incurred by teams.

There are **3 key areas of focus** that we narrowed this report down to. Given that football is a contact sport and we can't change the very nature of the sport, our criteria was to mitigate injury where we deemed it was most avoidable.

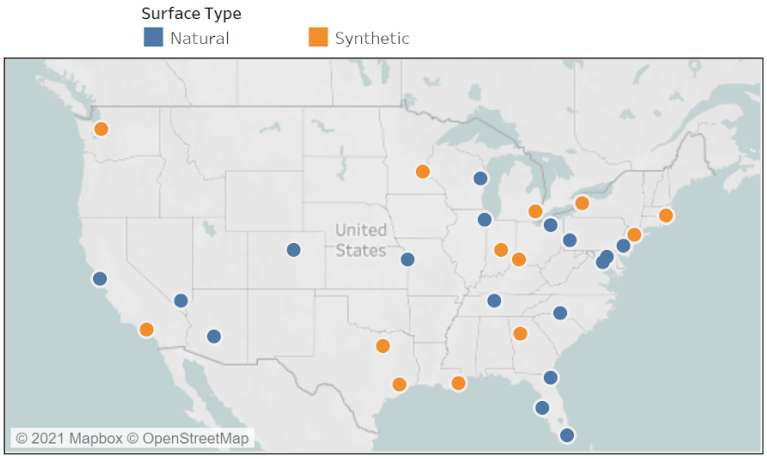
1. **Non-contact lower limb injuries that are sustained due to differences in playing surfaces – natural grass vs synthetic grass**
2. **Players suffering concussions on punt return plays – both teams are running at each other full speed.**
3. **Multiple helmet impacts that are generally sustained near the line of scrimmage – where the linebackers stand right as the play commences.**

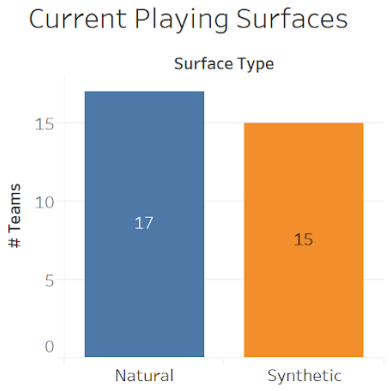
For each of these sections, we will not only provide detailed analysis but also include solutions and recommendations. In addition, we will address rule changes, provide a dashboard as well as an app, and future investment or partnership opportunities to curb these injuries in the long term.

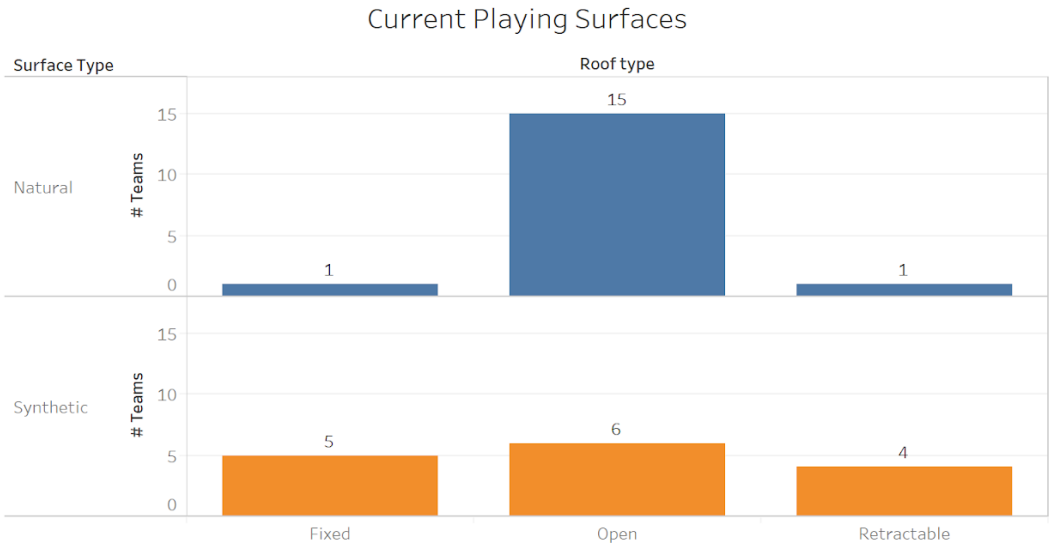
Data Overview

Surface Analysis

In the NFL, there are currently 32 teams (30 stadiums) that host games, of which **15 use synthetic turf and 17 employ some form of natural or hybrid grass**. Of the last 6 stadiums built in the last 10 year, 4 have employed a roof, either a closed or a retractable one. So, we are seeing a growing sense of equity in the types of fields NFL athletes play on, with studies suggesting there are biomechanical differences in football cleat-surface interactions between the two surfaces.







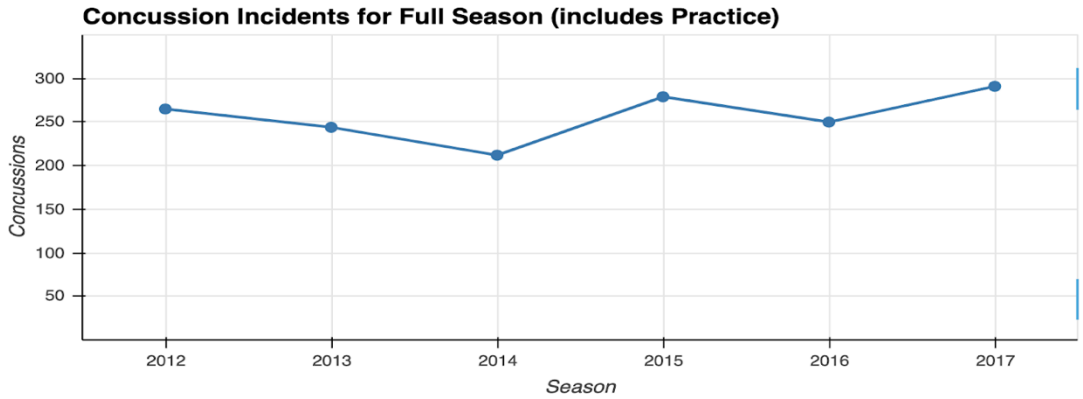
The surface analysis dataset that we used was over a 2 year period and includes variables of external factors such as weather, type of stadium and type of field. In addition to that, play-by-play data for each of these games such as the position the athlete plays on the team (Running back, Wide receiver, Tight End)

Field	Format	Description
PlayerKey	XXXX	Uniquely identifies a player with a five-digit key
GameID	PlayerKey-X	Uniquely identifies a player with a player-game
PlayKey	PlayerKey-GameID-X	Uniquely identifies a player's plays within a game
RosterPosition	character string	Provide;s a player's roster postion
PlayerDay	integer	An integer sequence that reflects the timeline of a player's participation in games.
PlayerGame	integer	Uniquely identifies a player's games, matches last integer of GameID
Stadium_Type	character string	A free text description of stadium
FieldType	character string	A catagorical description of the field type (natural or sythentic)
Temperature	float	On field temperature at start of the game
Weather	character string	A catagorical description of th eweather
PlayType	character string	A catagorical description of the playtype
PlayerGamePlay	character string	An ordered index denoting the running count of plays the player has participated in
Position	character string	A catagorical description of the player's position
PositionGroup	character string	A catagorical description of the player's position group
BodyPart	character string	Identifies the injured body part
Injury Miss >1 Day	1 or 0	1 if injury results in missing 1 or more days
Injury Miss >7 Days	1 or 0	1 if injury results in missing 7 or more days
Injury Miss >28 Days	1 or 0	1 if injury results in missing 28 or more days
Injury Miss >42 Days	1 or 0	1 if injury results in missing 42 or more days
Count	1	1 for counting purposes

Punt Play Analysis

The NFL brand includes domestic and international branding and broadcasting, revenue sharing, and strong team brands and franchises.

Player safety has always been a concern for football. Over the past few seasons, concussions occurring during play have become one of the most visible and controversial issues affecting players and fans as well. The figure below shows the incidence of concussions since 2012.

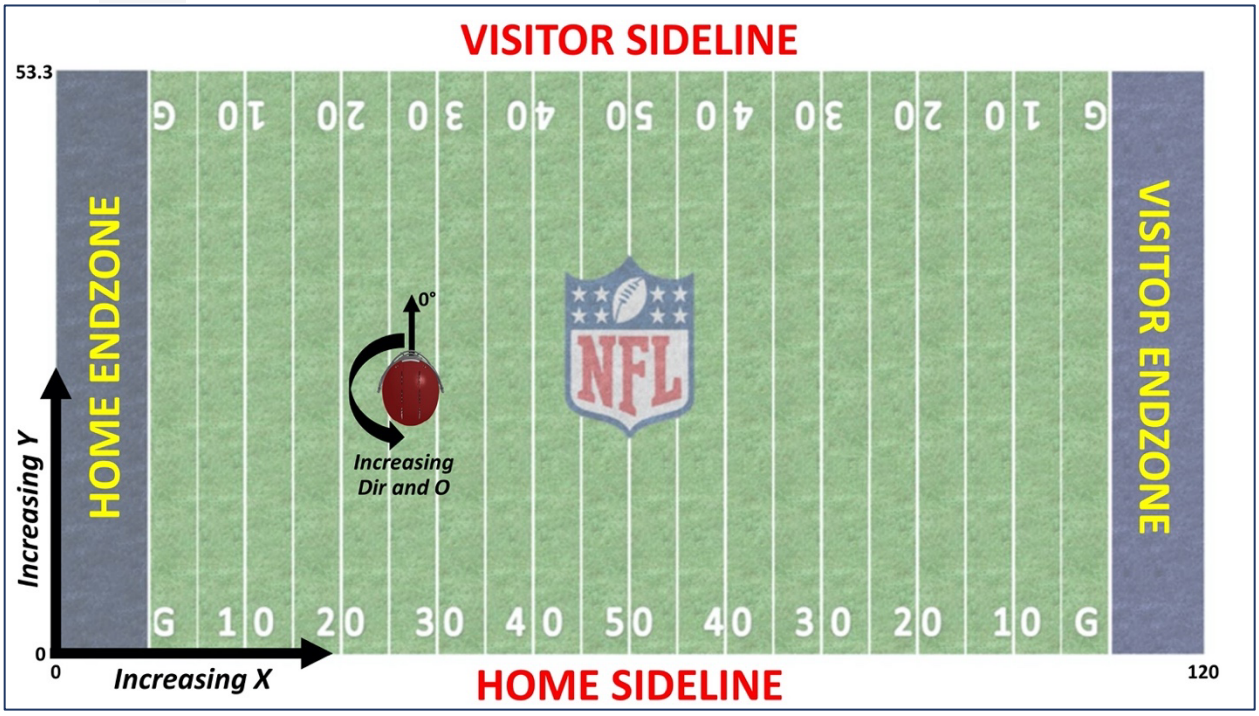


Source: IQVIA

The punt play data that was analyzed represents a 2-year period and includes Next Gen Stats (NGS) data as well as Kaggle Competition data. The data includes the specific position of each player during the play at intervals of 0.1 seconds, as well as the player's direction of travel and orientation. The data also include the events that occurred on the field at each time interval. Below is an example of NGS punt plays where the “Event” represents a concussion or None.

	GameKey	PlayID	GSISID	Time	x	y	dis	o	Event
3333	418	2690	4091	2017-09-17 19:08:14.400	56.56	53.47	0.080	76.699997	None
3334	418	2690	4091	2017-09-17 19:08:14.500	56.56	53.55	0.080	74.339996	None
3335	418	2690	4091	2017-09-17 19:08:14.600	56.56	53.63	0.080	72.400002	None
3336	418	2690	4091	2017-09-17 19:08:14.700	56.55	53.71	0.080	70.769997	None

- gameKey: the ID code for the game.
- playID: the ID code for the play.
- GSISID: Unique player identification, unique across seasons
- time: timestamp at 10 Hz.
- x: player position along the long axis of the field. See figure below.
- y: player position along the short axis of the field. See figure below.
- dis: distance traveled from prior time point, in yards.
- o: orientation of player (degree).
- event: game events like a snap, whistle, etc.



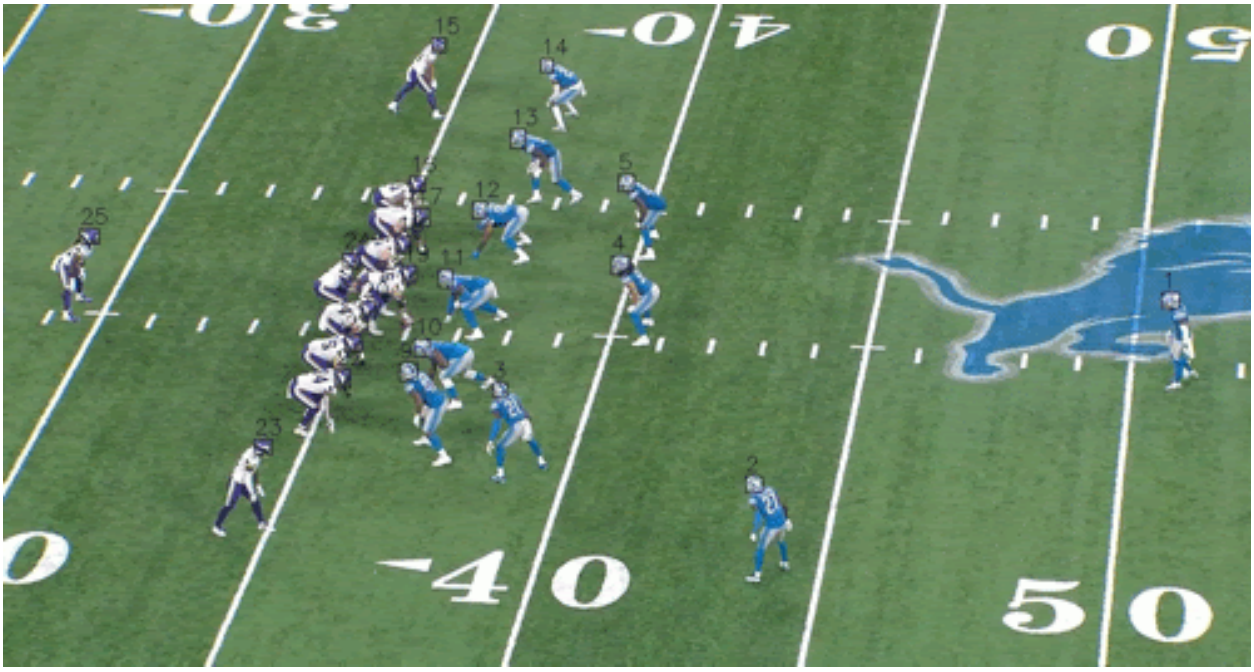
Helmet Impact Analysis

The plays we investigate here are not punts but regular snaps that are taken by the offense and study the helmet impacts that typically occur to the linemen and running backs at the line of scrimmage. All the data is in the form of MP4 videos and frame-by-frame images

The goal is to create a computer vision model that detects on-field helmet impacts

For the purposes of evaluation, definitive helmet impacts are defined as meeting three criteria in our data of 120 plays:

- **Impact = 1** [1 = Helmet Impact and 0 = No Impact]
- **Confidence > 1** [1 = Possible, 2 = Definitive, 3 = Definitive and Obvious]
- **Visibility > 0** [0 = Not Visible from View, 1 = Minimum, 2 = Visible, 3 = Clearly Visible]

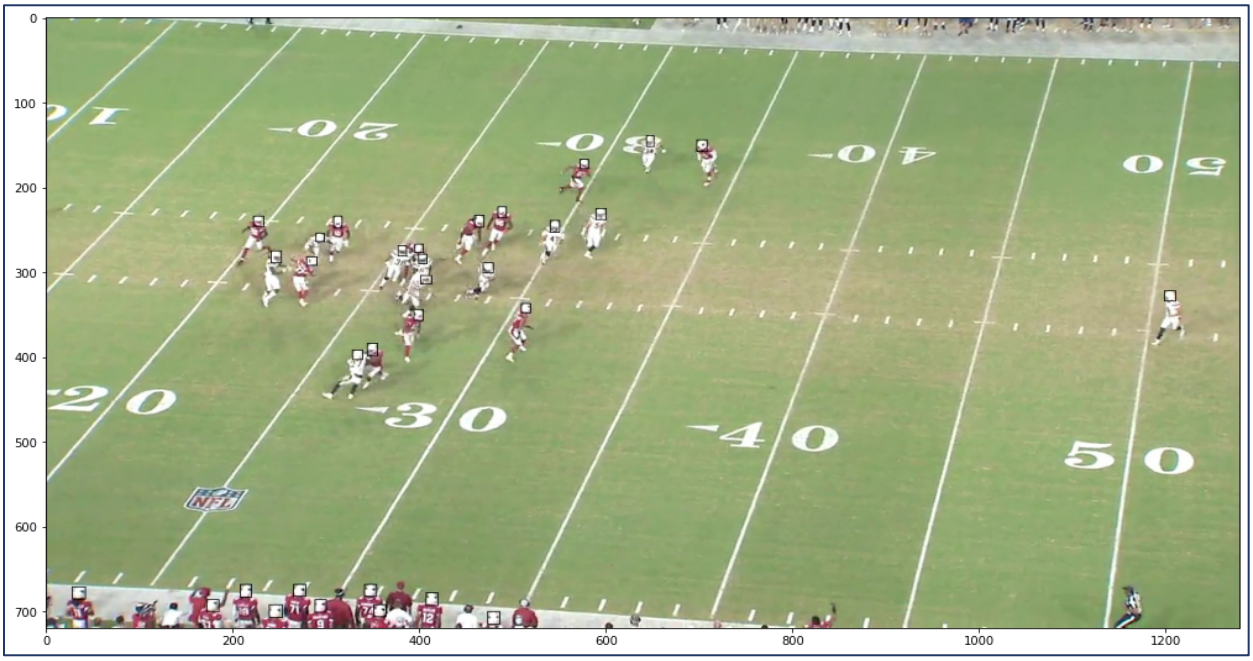


Camera View

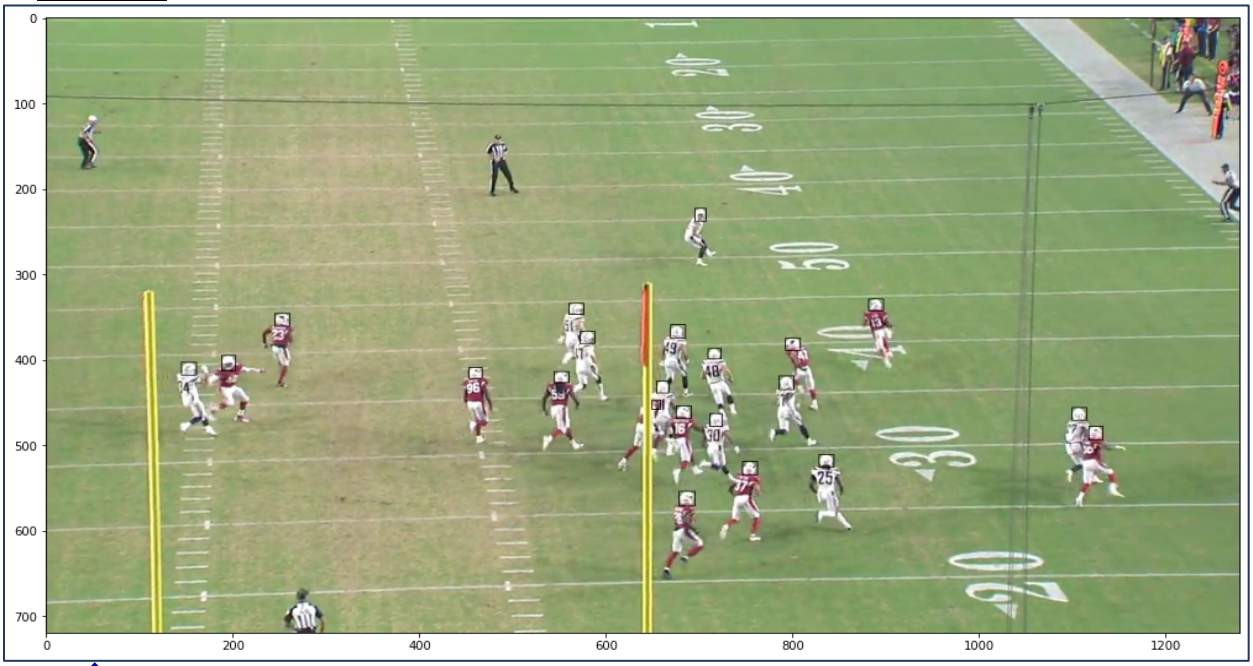
Each play analyzed is accompanied with 2 camera angles: **The Sideline View and the Endzone View**

We use bounding boxes to identify each players' helmet

Sideline



Endzone



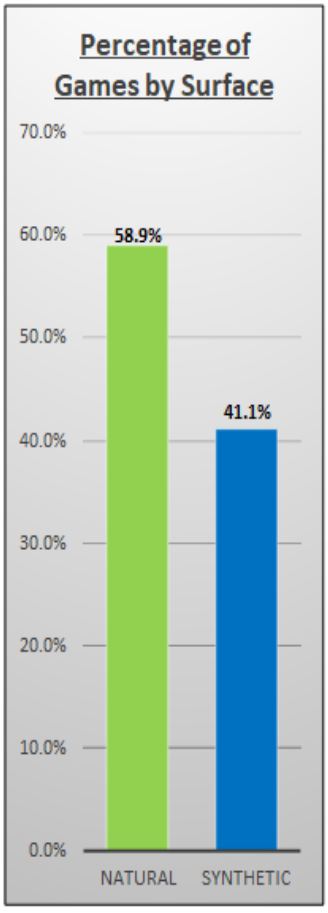
Data Modeling & Analysis

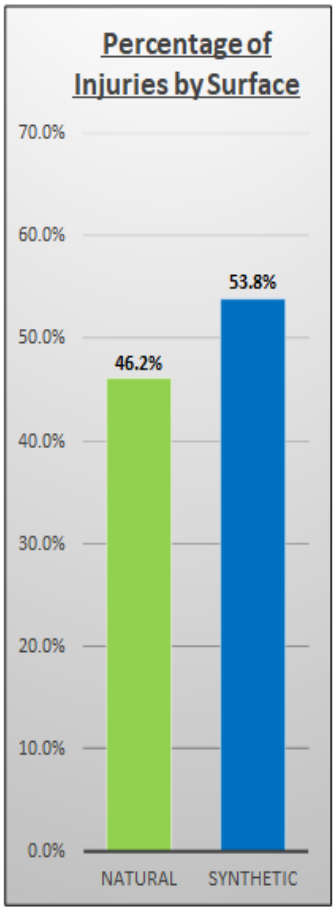
Surface Analysis

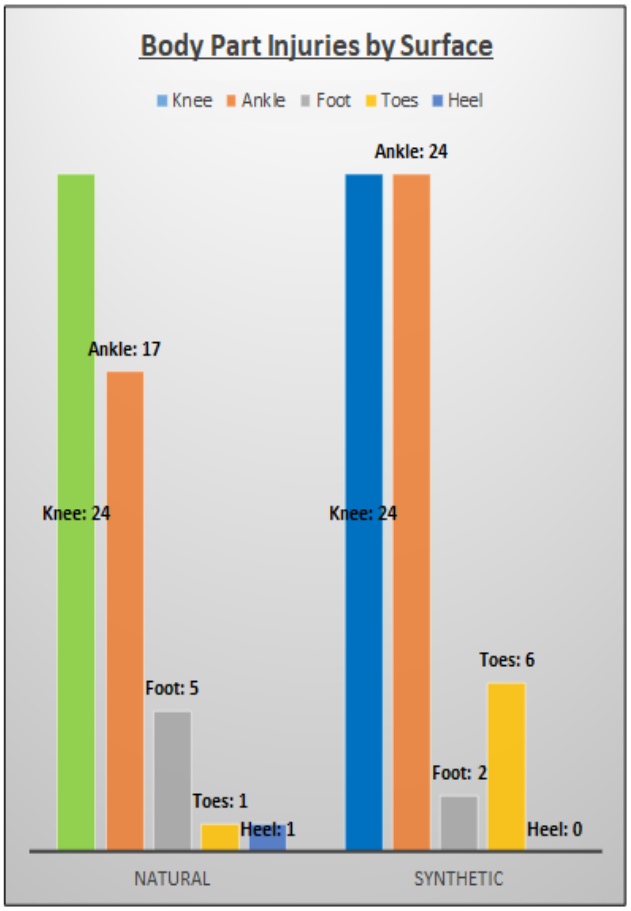
Body Parts

Over the 2-year period of the data analyzed, almost 59% of the games were played on natural grass, but almost 54% of the non-contact lower limb injuries occurred on synthetic turf. There were a total of 104 of these types of injuries with 48 being to the knee and 41 being to the ankle. The injuries were fairly close in numbers on the two surfaces for the knees, but the ankle and toes were greater on the synthetic turf.

Typically knee injuries are considered the worst because of the length of recovery, long term risk, as well as cost of surgery rehabilitation.

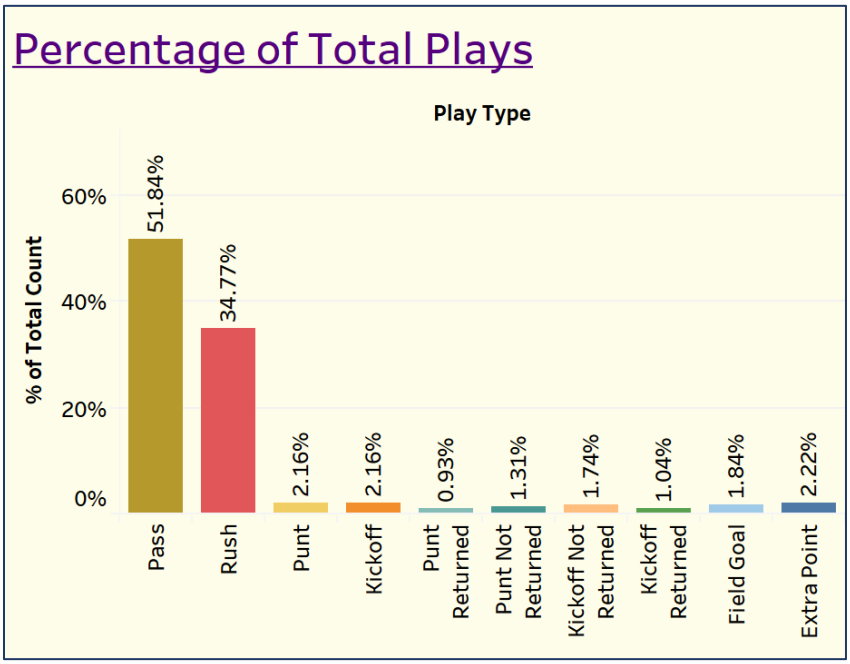


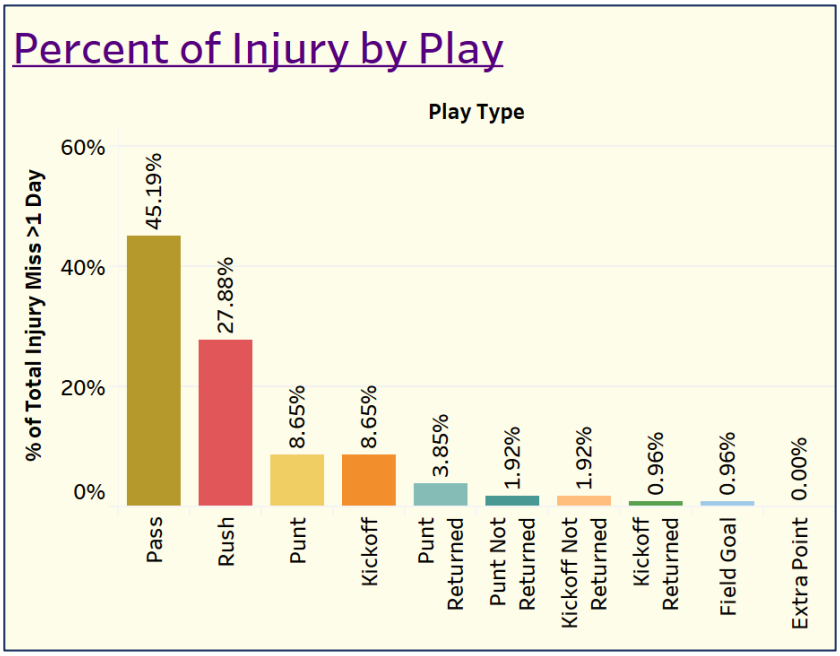




Play Types

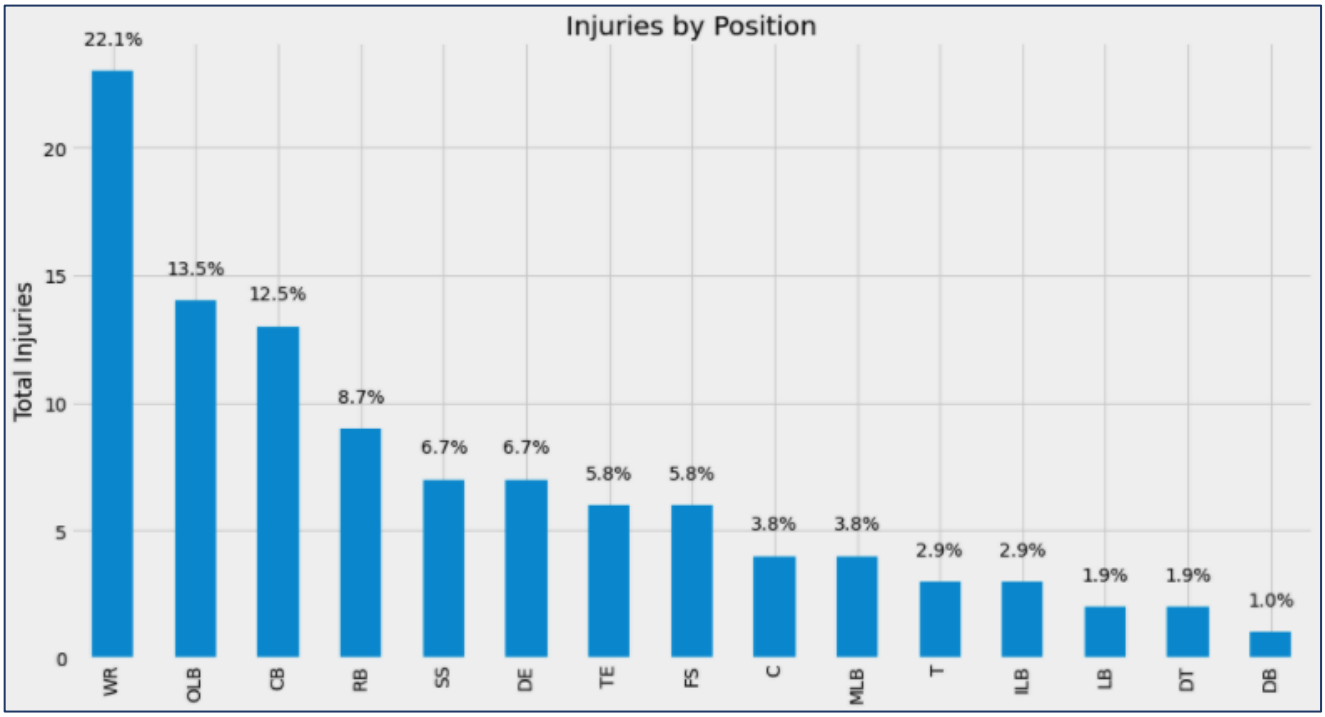
The percentage of play type on for all plays and plays with injuries is fairly close with the exception of punts and kickoffs. **Those two play types accounted for almost four times (~8% to ~2% for both) the number of injury plays by percentage than all plays.**





Positional Injuries

Taking a closer look at the distribution of plays by position versus injuries by position, the likelihood of an injury is correlated to the number of plays accumulated by position. **For example, Wide Receivers accumulate the most plays, and account for the most injuries, 22.1%**. Positions that stand out are Guards, who accumulate a large number of plays but account for very few total injuries, and conversely, Running Backs, who do not account for a large percentage of plays but disproportionately account for over 8% of all injuries.

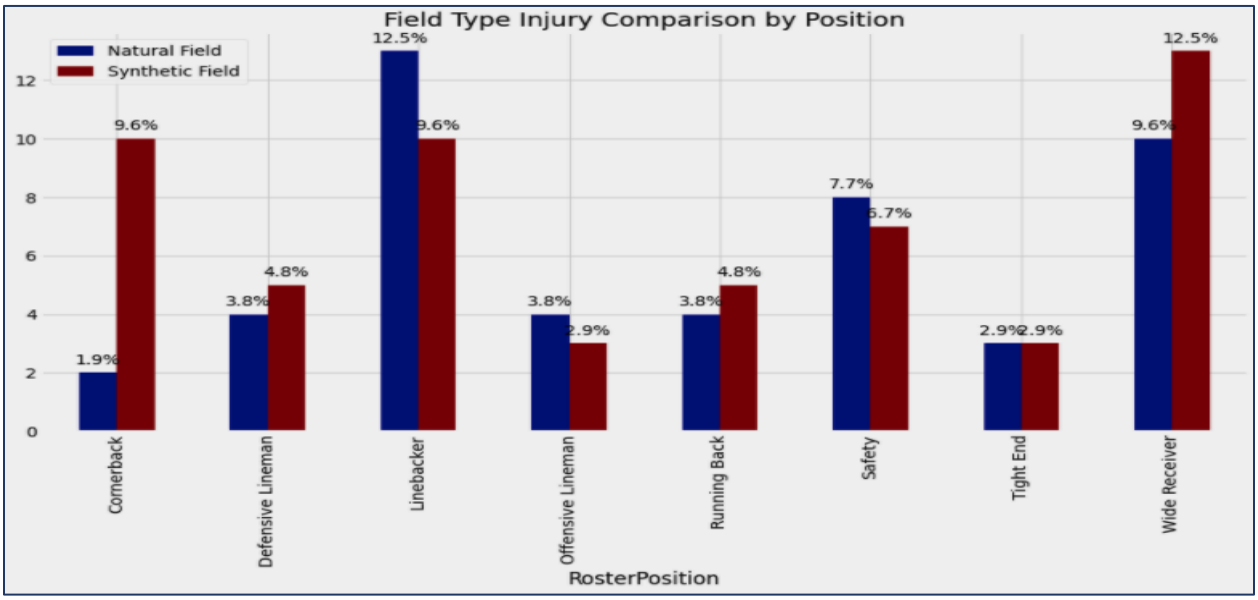


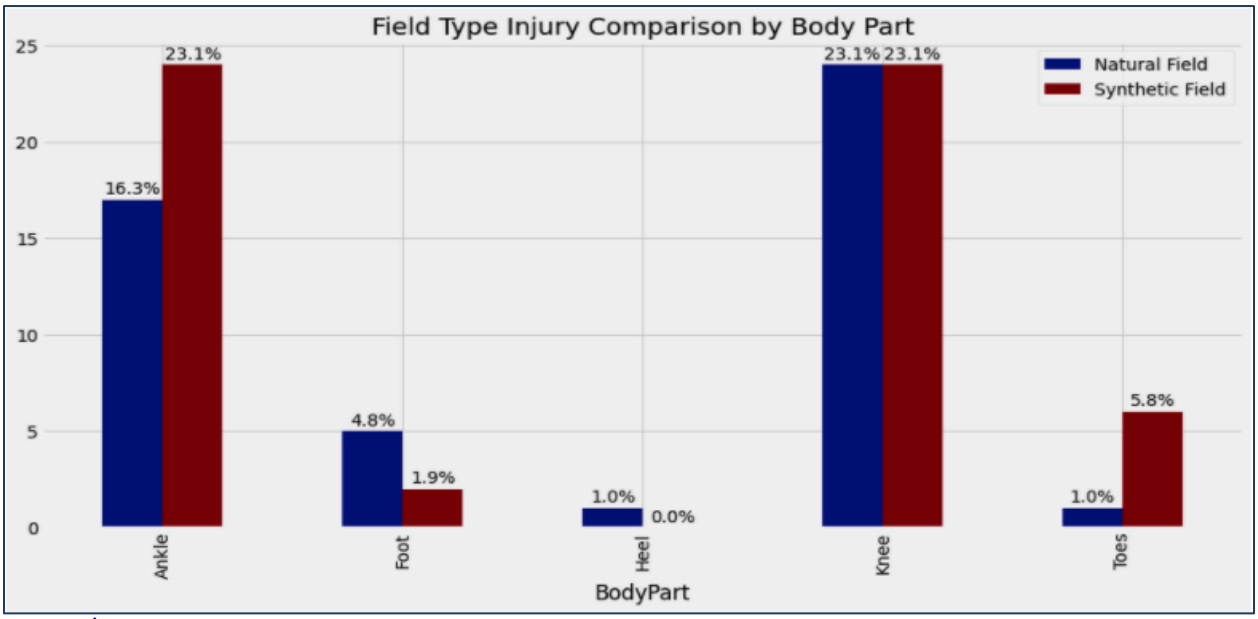
Analytics

Positional Injuries (Continued)

Looking more closely into injuries by players and positions, we can see that Receivers and especially Cornerbacks are much more likely to be injured when playing on Synthetic fields. **Cornerbacks and Receivers combined account for over one-third of all injuries, so right away we can see a troubling trend**.

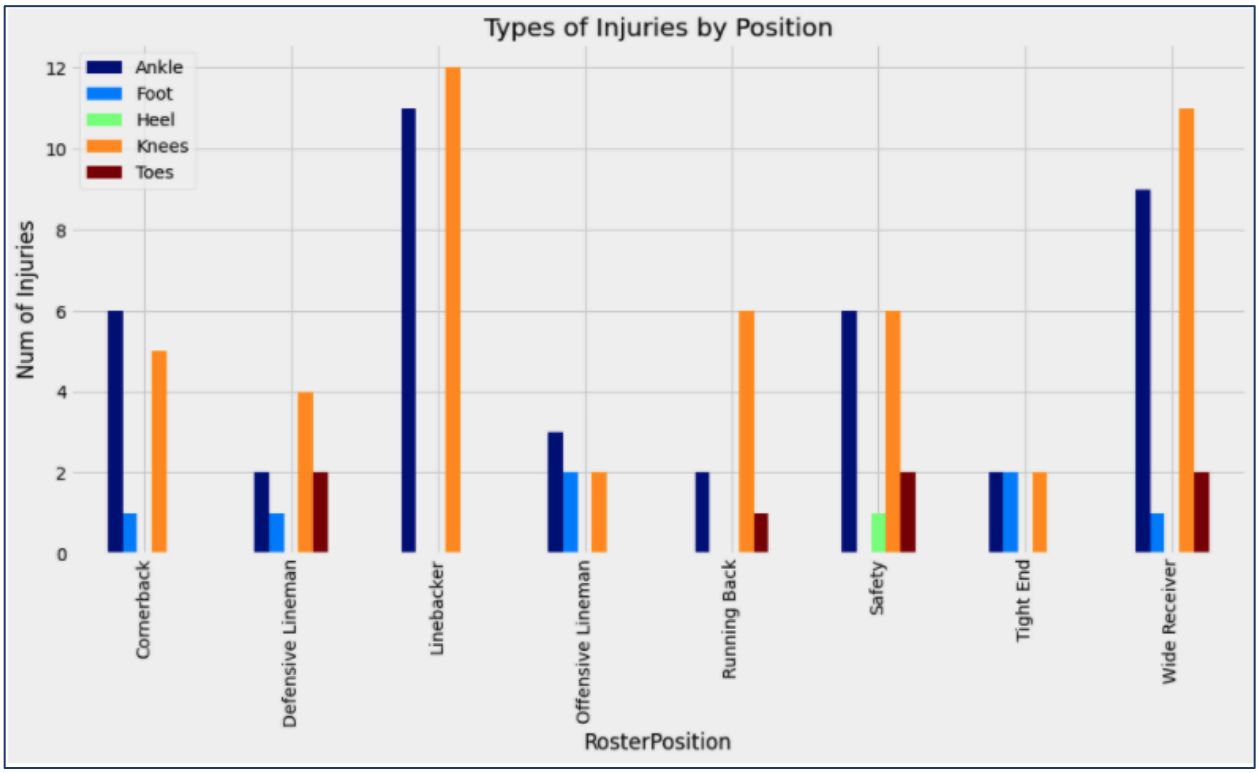
When considering the percentage of types of injuries when comparing natural and synthetic fields, **we can see ankle and toe injuries are significantly higher on artificial fields**. Conversely, foot injuries are much more common on Natural Fields. And it's important to highlight, knee injuries are identical when comparing the two field surfaces.





Positional Injuries (Continued)

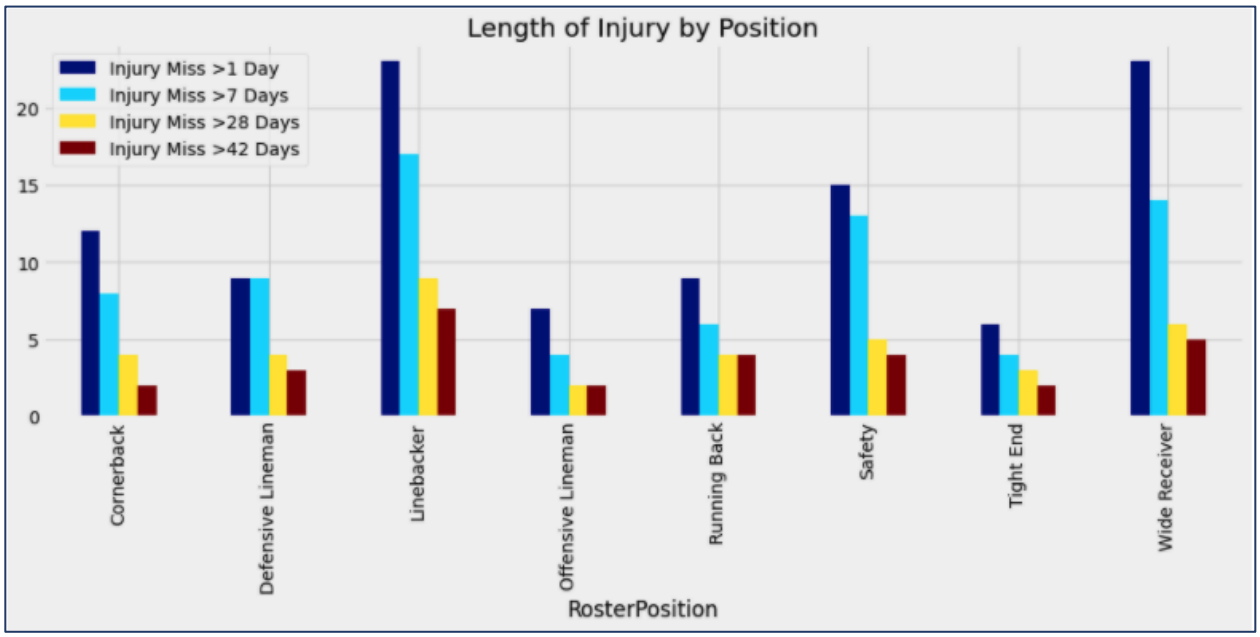
The type of injuries by position is important to consider. We already know that Ankle and Knee injuries account for most injuries and are starting to see that synthetic fields are especially correlated to Ankle injuries. This graph below identifies 4 positional groups that had at least 6 ankle injuries.

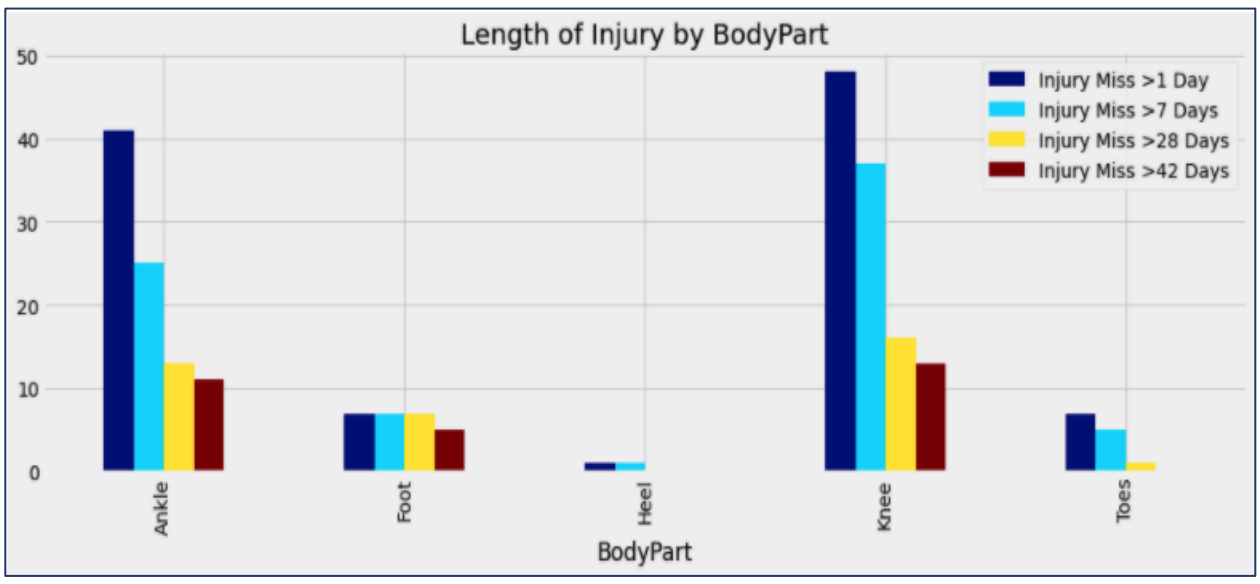


Injury Severity

When looking at the injury data, it's important that we not only minimize injuries in general, but when possible, minimize the most severe injuries. It's positive to see that the majority of injuries are shorter-term injuries, and missing more than 42 games, the most severe injury, is the least likely scenario across all positions.

It also comes as little surprise to see Knee and Ankle injuries account for the most severe injuries; both injury types are the only two that have over 10 cases where players missed more than 42 games.



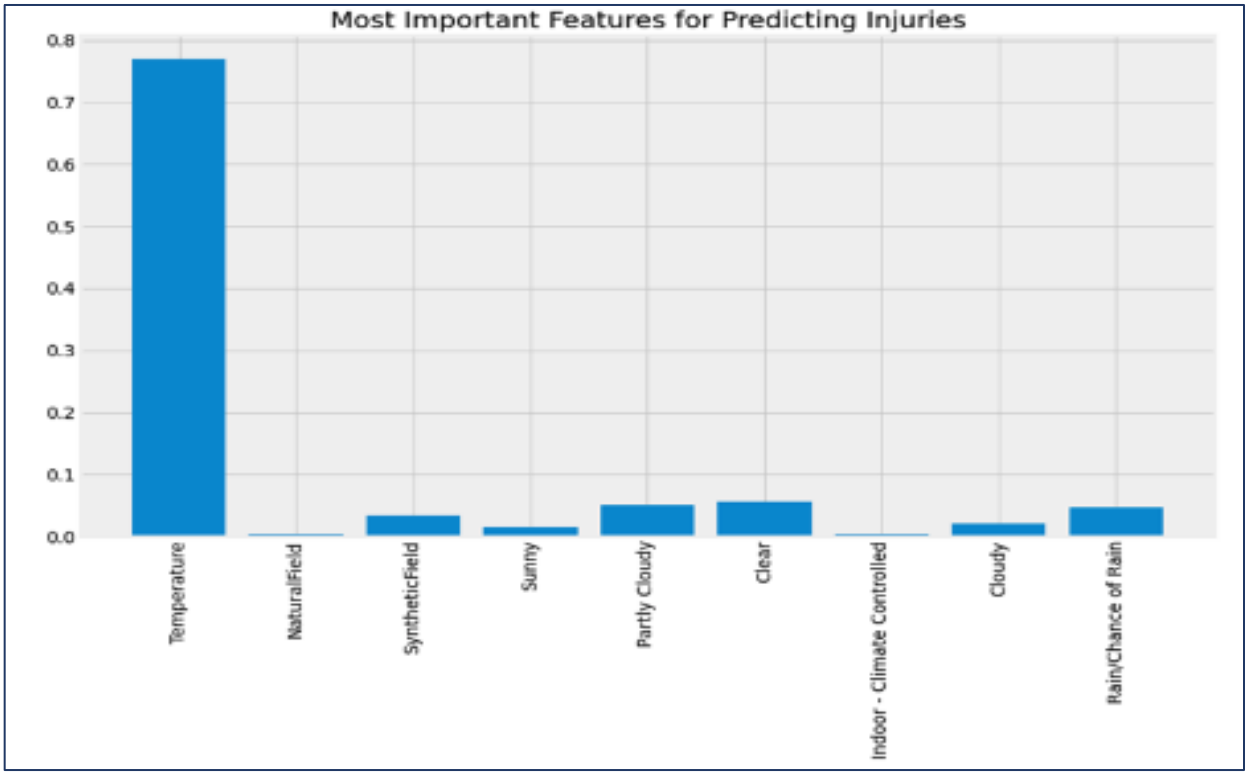


Playing Surface Management Recommendations

Knowing that the type of injury, player movement and speed, and biomechanical releases off the ground are different with natural and synthetic turf, **we highly recommend the NFL continue to partner with shoe companies such as Nike and Adidas and invest in research and development into cleats that are best suited for each surface type** – one for natural and one for synthetic.

Players are about 15% more likely to be injured on synthetic surfaces compared to grass, even with a disproportionate number of games being played on grass, almost 60%.

We project we can reduce total injuries by 1% per NFL stadium that switches from a synthetic to a grass field, of which there are 14 NFL stadiums eligible. Also, to push for use of natural grass whenever stadiums are built or refurbished. This is a longer term suggestion as team's make updates to their stadiums or move to new stadiums. As seen with the new Las Vegas Raiders stadium, natural grass can now even be installed in closed roof stadiums.



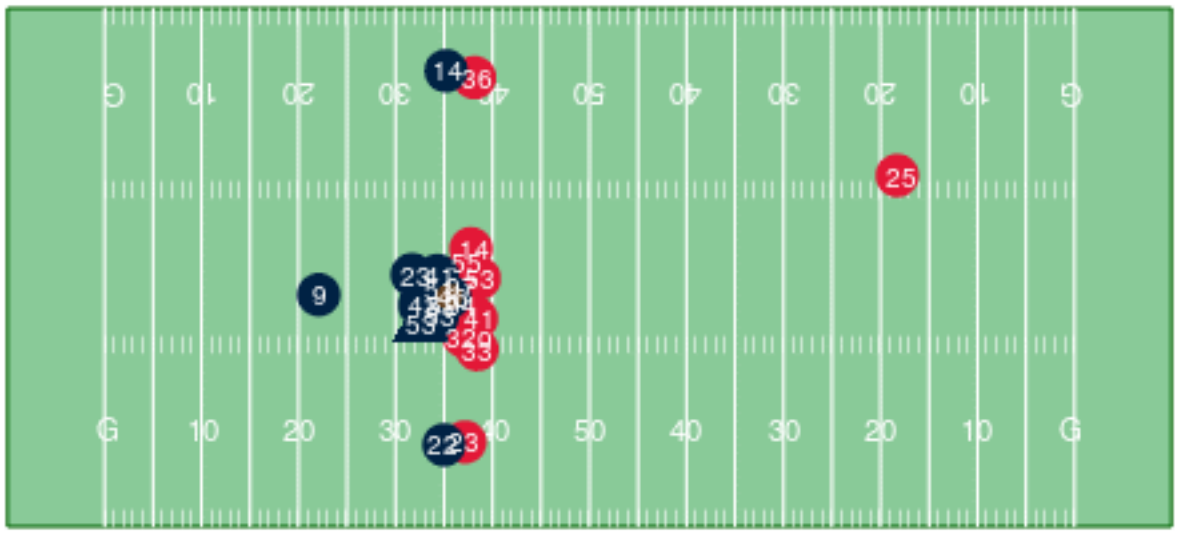
We are also providing a dashboard, shown in the Application Development section, that will give you and the Board and Directors a comprehensive view of various surface and weather conditions that can impact potential injury risk for the players. A per game analysis was analyzed and a Logistic Regression model was implemented to forecast per game injuries. Multiple regression techniques were considered, but the Logistic Regression was implemented as it returned the best results. The graph above highlights the most important features from our model in forecasting player injury. We observed that when outdoors Surface Type, Weather and Temperature play a significant role in player injury (See Correlation Matrix in Appendix). **Therefore, we suggest using this dashboard as a source of knowledge to make executive decisions. Suppose the dashboard shows that the current combinations of physical conditions for a game suggests that players' risk is high, you can delay or postpone the game.**

By leveraging the insights provided by the dashboard and being able to make decisions in real-time regarding playing or postponing a game due to weather and the field surface, **we expect to decrease total injuries by 5%**, the majority of the decrease coming from non-contact related injuries.

Punt Play Analysis

Play Example

NGS (Next Gen Stats) data can be used to see how NFL punting plays unfold over time. Below is an animation of an example punt play in which a lineman from the punting team receives a blindside block from a fast-moving opponent as he closes in on the punt returner. The player who becomes concussed and the partner player involved appear below as triangles.



Punt Play Analysis - Breakdown

Data Resources included the following items:

- Sports articles on punt plays and players
- NFL Official Rules
- Articles and research papers on sports-related concussions

Also included is data provided from the punt play Kaggle Competition along with data gathered from nfl.com and concussion data compiled by IQVIA. The table here shows the percentage of concussions for passing and running plays vs. the percentage from punt plays, where Risk Multiple represents the pct of Punts/pct of Passes_Runs, broken down by year.

Concussion Percentages by Play Type

	Passes_Runs	Punts	Risk_Multiple
2016	0.42%	0.61%	1.4
2017	0.47%	0.56%	1.2

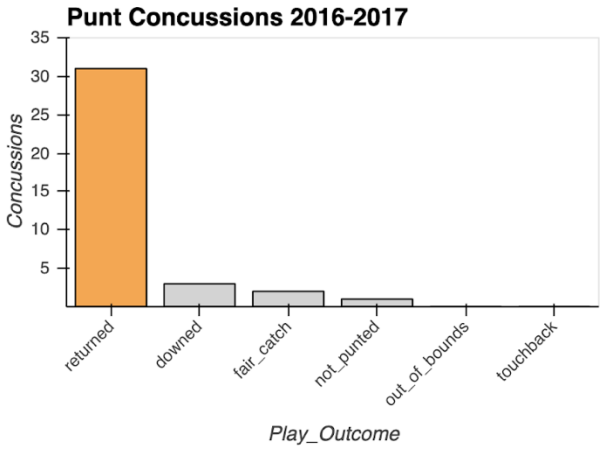
Concussions

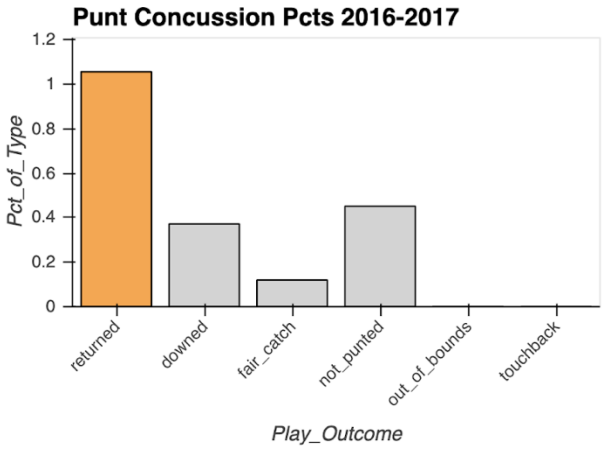
The following classifications were used for punt outcomes based on punt play description:

- Returned
- Fair Catch
- Touchback
- Downed
- Out of Bounds
- Not Punted

Example:
(12:30) J.Hekker punts 52 yards to DAL 1, Center-J.McQuaide, downed by LA-E.Sims. Dallas challenged the kick downed ruling, and the play was REVERSED. J.Hekker punts 53 yards to end zone, Center-J.McQuaide, Touchback.
The figures and table show that returned punts are by far the most common outcome for both the number of concussions and the percent of concussions.

Fair catches, on the other hand are relatively low on both percentage and number of events of concussions.





Comparison of Play Outcomes

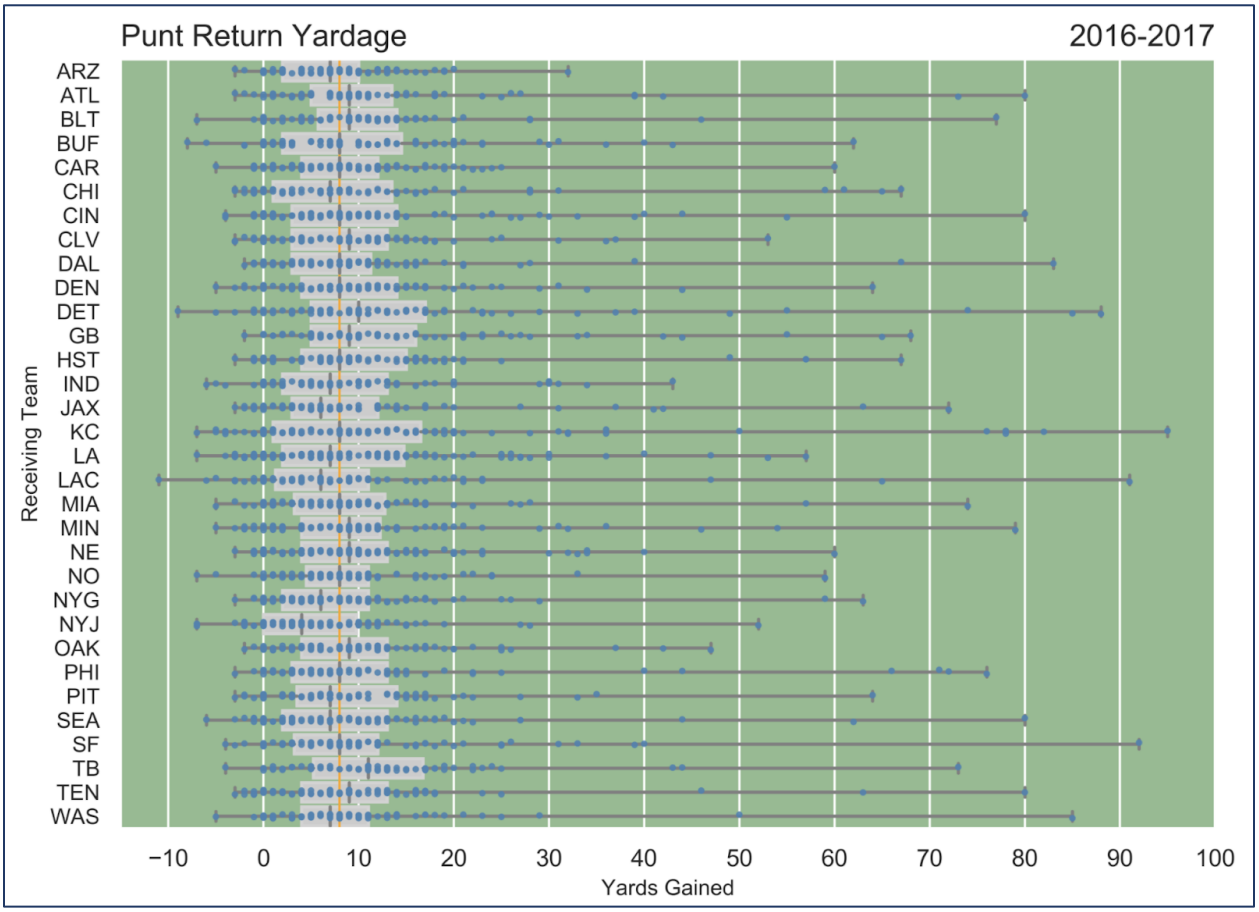
Play_Outcome	Zero_Concussions	Concussions	Pct_of_Type
Returned	2903	31	1.06%
Downed	802	3	0.37%
Fair_Catch	1658	2	0.12%
Not_Punted	220	1	0.45%
Out_Of_Bounds	654	0	0.00%
Touchback	407	0	0.00%

Punt Returns

As shown, the NFL would most likely see fewer concussions if some returned punts are shifted to other outcomes by changing the rules as they have the highest likelihood of a concussion event.

However, another important consideration is to analyze yards gained from returned punts. The figure below shows yards gained on each punt when a returner gains control of the ball (through a valid catch) with the intent to return the football. The vertical orange line in the plot indicates the median of all returns analyzed for 2016-2017.

The figure shows that most every team had returns falling largely in the 5-15 yard range. The median return for all returns was 8 yards.



Punt Play Analysis - Yards Gained

The table here shows the percentiles in five-yard intervals. **The key takeaway here is that 63% of all punt returns gained 10 yards or less. Also, returns over 20 yards (which tend to be the most explosive and result in significant changes to a game's outcome by virtue of points scored) occurred only 10% of the time.**

Punt Return Percentages by Yards Gained

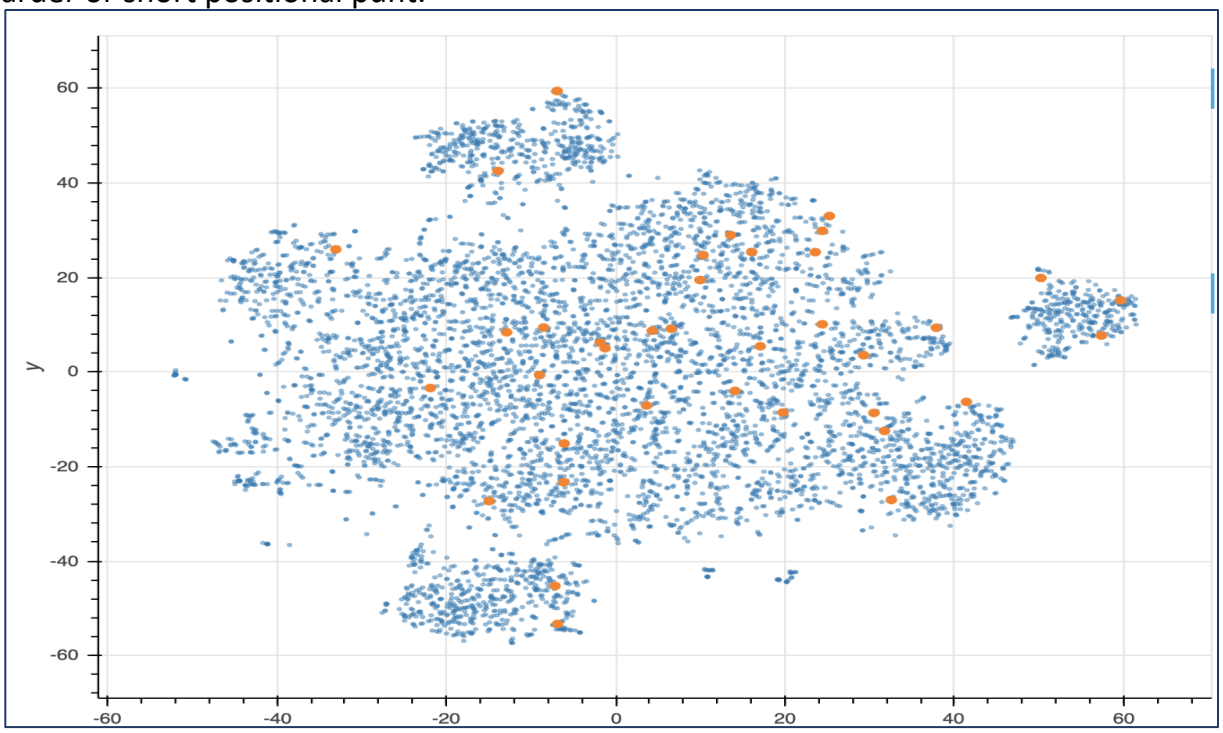
Yards_Gained	Total_Pct_of_Returns
0 Yards or Less	10%
5 Yards or Less	34%
10 Yards or Less	63%
15 Yards or Less	81%
20 Yards or Less	90%

Punt Play Analysis - Clusters

Next Gen Stats data fueled this part of the analysis which was aggregated first for each player, and then for each play. This data was then analyzed using a technique called t-SNE applied to the aggregated data (a form of unsupervised machine learning).The t-SNE analysis compares given factors like those listed below and groups similar points together in a graphic plot. Here are the following factors which were used to group the various punt plays:

- Distance from scrimmage line to goal
- Score difference
- Formation of each team at line-up
- Location of players on the field during the play
- Player speeds
- Punt distance

The figure shown below represents a spatial map of factors representing punt plays with different characteristics. There are three groups separated from the main core, which show up as "independent" groups of points above, right, and below the main core of points. **Plays in which a concussion occurred are shown in orange**. In this case, orange dots are found across the plot in all areas, including within the separated independent clusters indicating that concussions can occur in many different types of punt plays and are not necessarily concentrated in one particular group or style i.e. a booming 70 yarder or short positional punt.



Analytics

Punt Play Management Recommendations

Rule Change Impact and Analysis

We propose to automatically add 10 yards for the returning team from where the player catches the ball and signals for a fair catch.

PROPOSED RULE CHANGE:
Under RULE 10 OPPORTUNITY TO CATCH A KICK, FAIR, the following Article will be proposed for the Owners and Players Association to vote on:

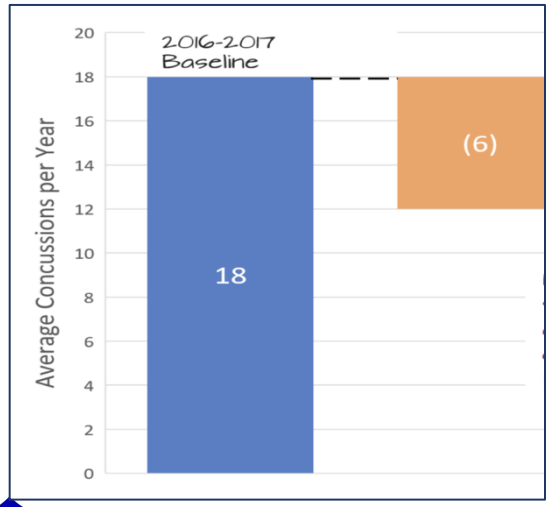
Article: FAIR CATCH ON PUNTS. When a player signals for a fair catch on a punt return, 10 yards will be added for the returning team from the spot of the catch.

This change is to incentivize teams without a dynamic punt returner to fair catch the ball instead of risk a concussion via a return play which only averages an 8 yard net gain.

We also recommend the referees to emphasize penalties on blindside blocks with forcible contact to any part of a defenseless player's body next season onwards to help our cause as well.

Fair catches had a concussion rate 1/8th that of live returns. Therefore, increasing the incentive for a fair catch could reduce risk to both punt returners and offensive linemen downfield. Punt returners may not be as pressured to take a hit in situations where the most likely outcome is at best a 5-10 yard return.

Changing this rule for punt plays could result in up to 6 fewer concussions per year, or a 33% reduction in total concussions from punts per year (18), with calculations shown in the chart below.



FAIR CATCH 10-YARD SPOT	
Fair Catches	1660
Returned	2933
% of plays < 10 yards gained	63%
Plays < 10 yards gained	1848
Risk discount	70%
Plays switched to Fair Catch	1293
New Fair Catches & other low-risk	2953
New Returned	1640
Fair Catch Concussion Rate	0.12%
Return Concussion Rate	1.06%
New Concussions	21
Actual	33
Reduction	12

Analytics

Helmet Impact Analysis

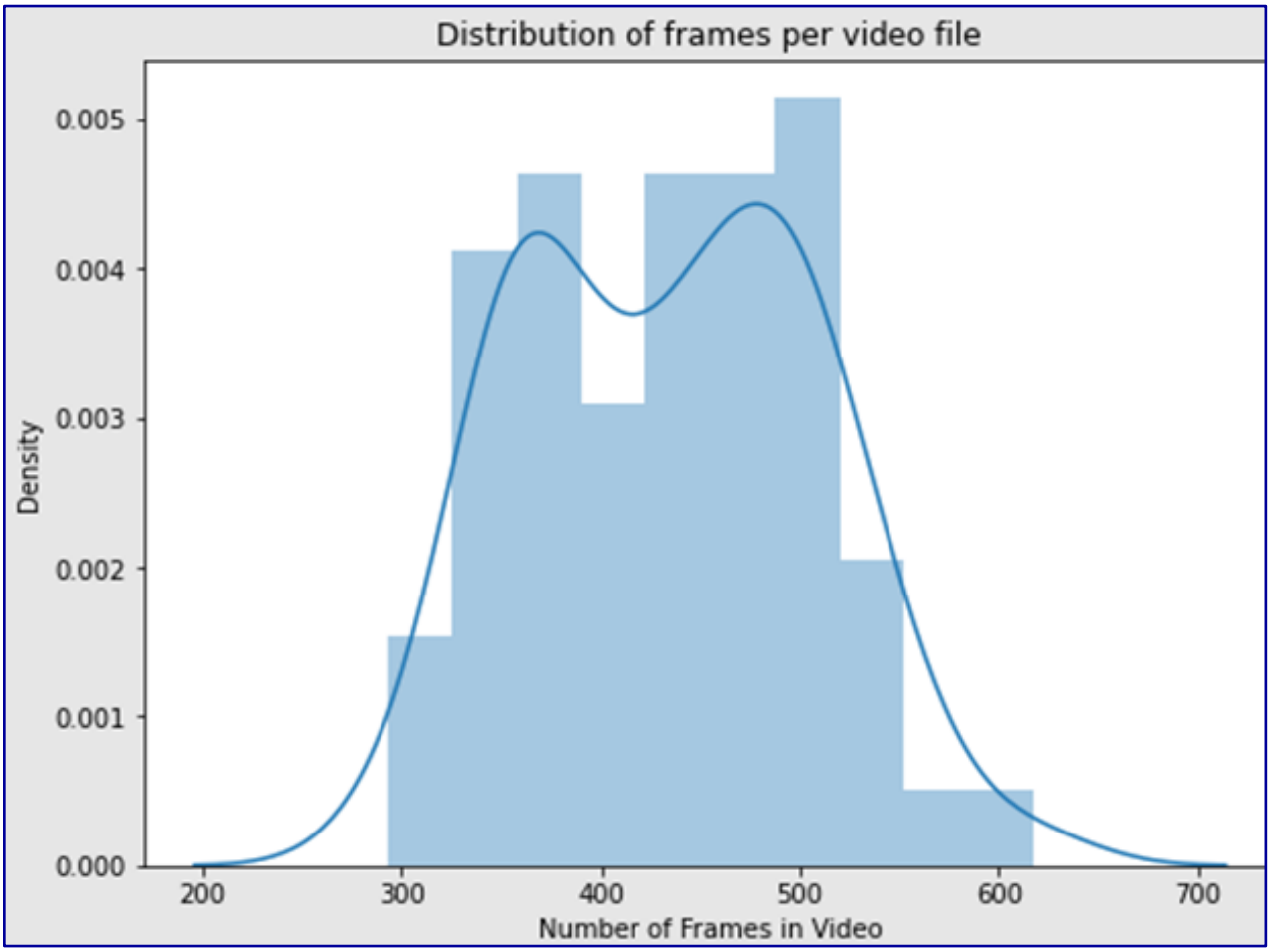
Before diving into the Computer Vision Model, here are some key takeaways that will shape our recommendations to you and the Ownership Group.

Frames

There are roughly **60 frames recorded per second**.

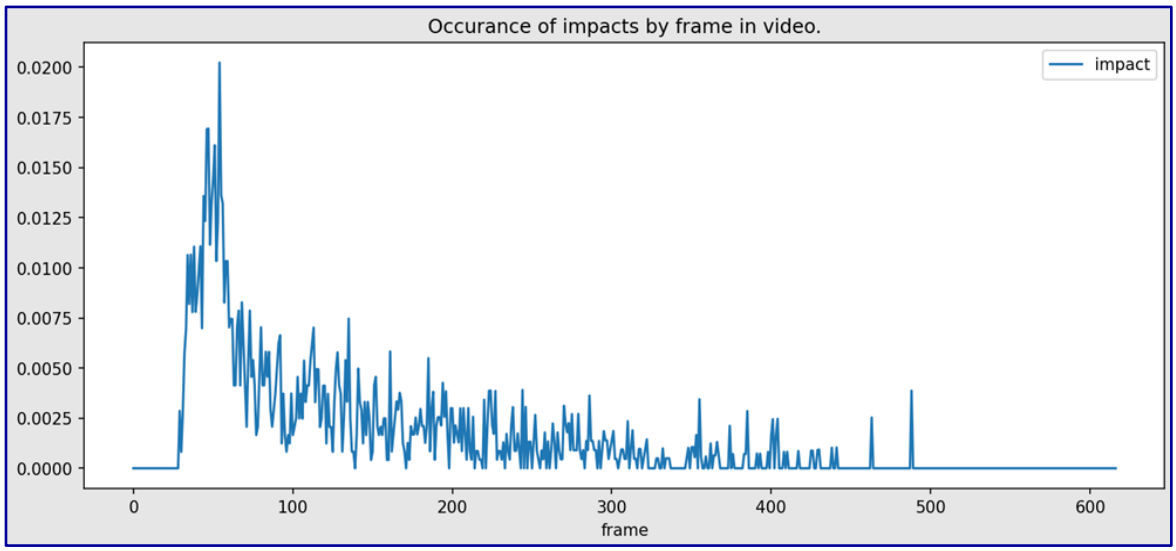
Therefore, majority of these videos range from **5 to 10 seconds**.

This means we analyzing the helmet impacts that occur during the early moments of the snap, a period when most linemen are tackling each other. This makes it harder for coaches and referees to be able to determine when helmet impacts occur, especially since they are preoccupied with monitoring other penalties such as holding and tripping.

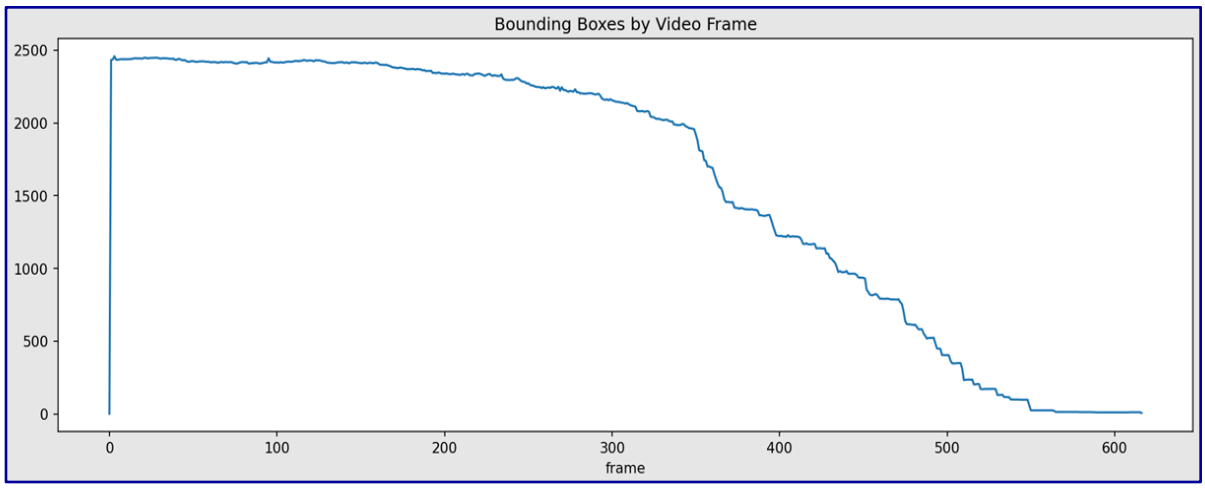


Impact Occurrence

From these distribution plots, it appears most of the helmet impacts occur within the first second of the play and start to taper off as the play develops further.



This is further reiterated in the second figure below, where the number of bounding boxes, or helmets visible in the frame significantly take a dive after 4 second mark. Our understanding is that once the ball is snapped, the players disperse from their formation which explains the number of helmets in the frame reducing.



More importantly this shows how a significant amount of helmet impacts occur in the split seconds right after the ball is snapped since the players are in close contact.

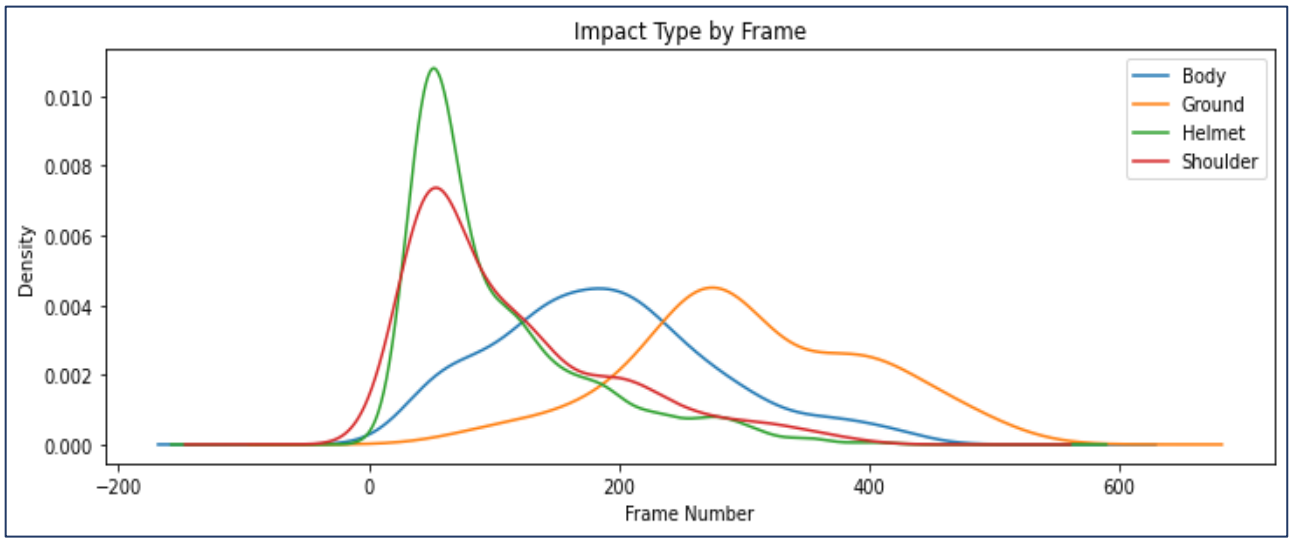
Being able to monitor this as a referee or a coach is not always possible, and our model can assist the league in identifying these early impacts.

Impact Type

Majority of the helmet impacts are with other players' helmets. This not only increases the chances of concussions compared to the other impacts, but helmet to helmet impacts affect both players, doubling the risk.

It is also apparent that most of the helmet-to-helmet and helmet-to-shoulder impacts occur within the first second of the play while the rest occur in later frames. Once again, this brings up the issue that the more significant helmet impacts occur way too early in the play to be naturally perceptible, which further strengthens our case that a computer vision application to detect these would benefit the players.

It is important to note that Helmet-to-Helmet impacts are the worst because of concussion risks for both players. With nearly 2/3rds of all helmet impacts being of that nature, that is a glaring issue the NFL needs to address.

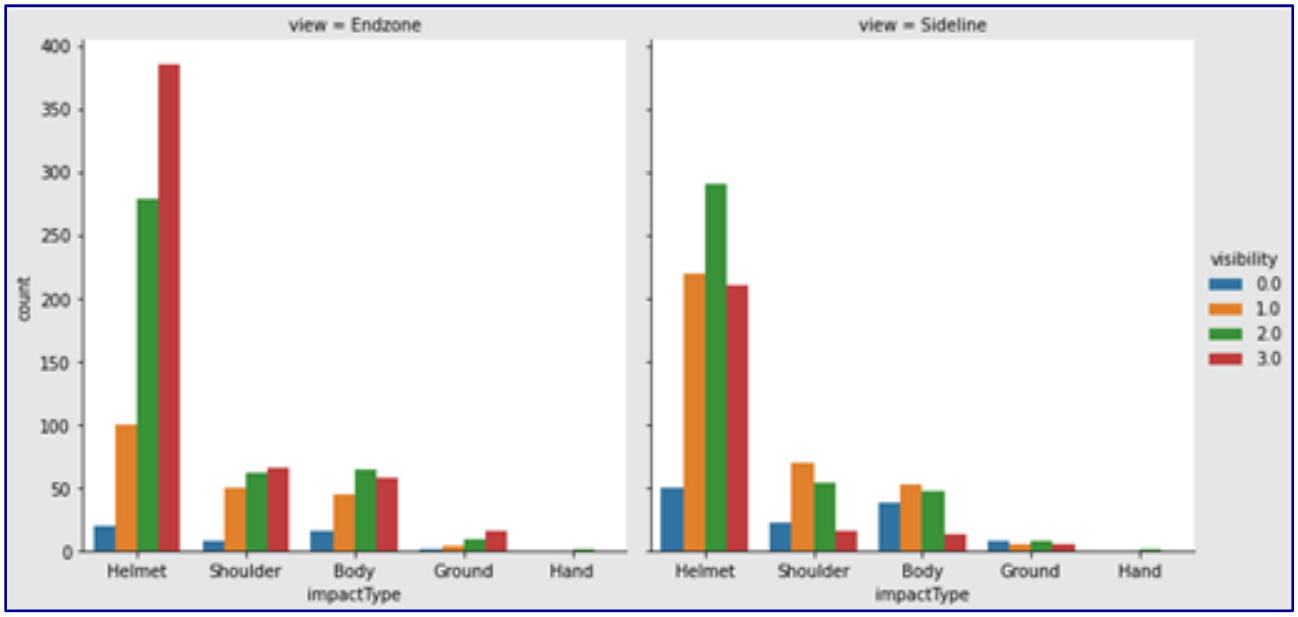


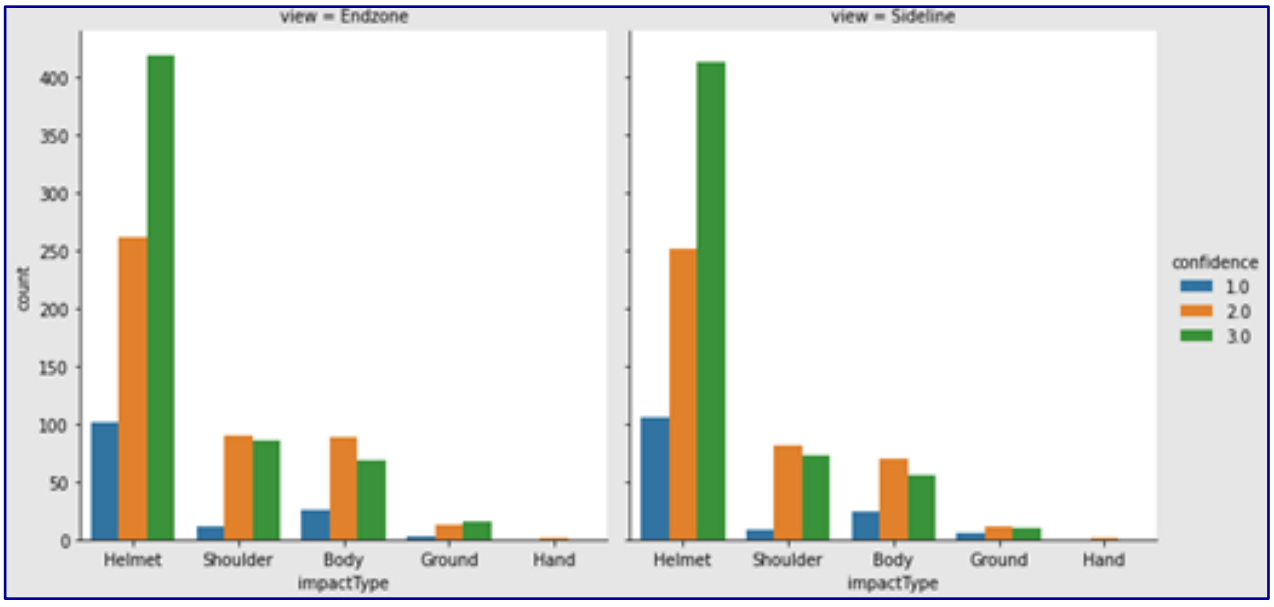
Impact Type	Frequency
Helmet	1553 (67.79%)
Shoulder	348 (15.19%)
Body	332 (14.49%)
Ground	56 (2.44%)
Hand	2 (0.09%)

Camera Angle

The Endzone Camera View offers significantly better visibility, notably for helmet-to-helmet impact which should be our top priority.

It is interesting that while the while the visibility of the helmet impacts is better from an endzone view, the human confidence in their being an impact is pretty much the same regardless of camera angle.

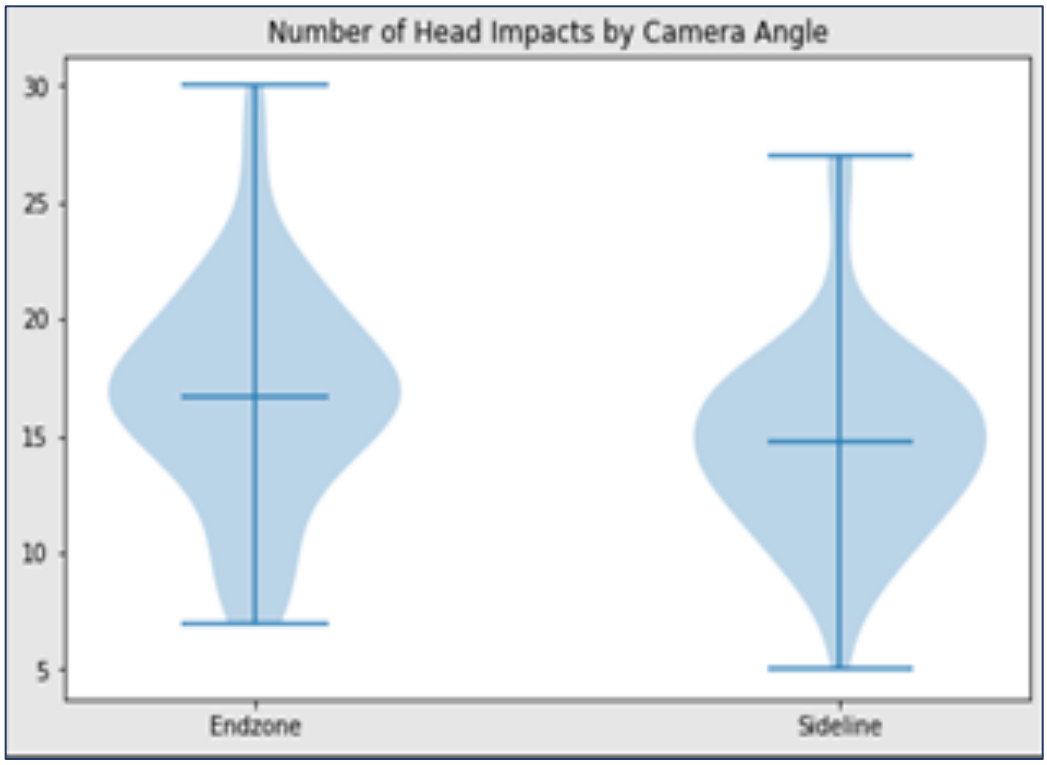




Camera Angle (Continued)

Finally, from the figure below it's clear that more helmets impacts are registered from the endzone than from the sideline angle

Average Helmet Impacts per play: **16.72 vs 14.75**



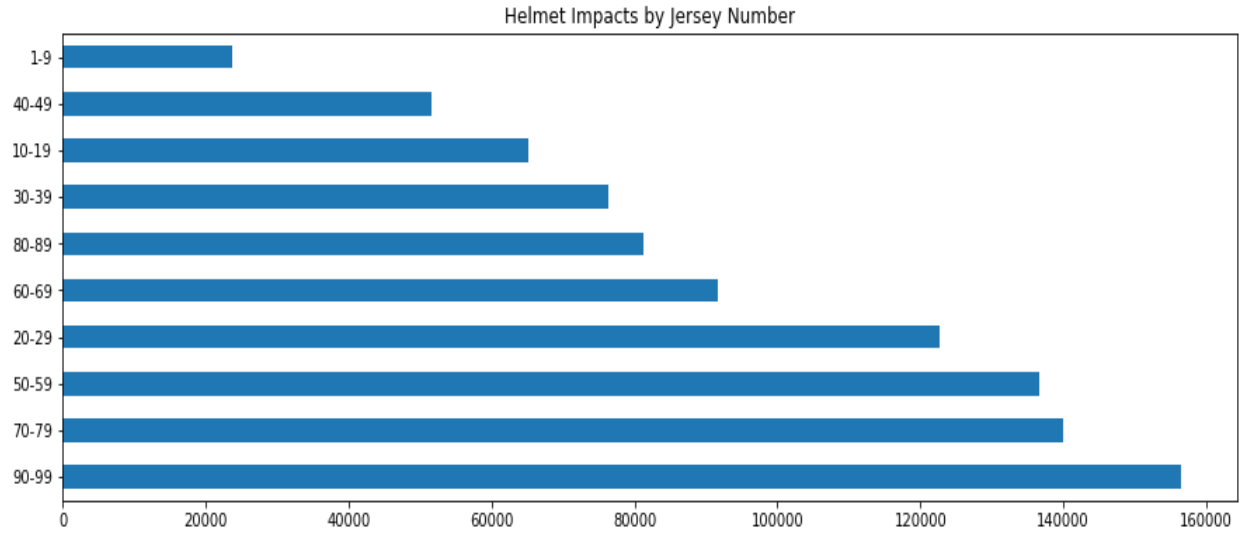
Therefore for our model, we have decided to prioritize Endzone video footage in order to detect helmet impacts.

Analytics

Impacts by Jersey Number

The NFL has a numbering system for their jerseys such that certain player positions play can only choose from a range of number for their jersey. For example, quarterbacks can only wear number 0-19 and running backs 20-49. This prevents any confusion when announcing substitutions or eligibility of receivers for opposing teams.

The current dataset we are working assigns a player ID which includes what team they are representing ('H' for Home or 'V' for Visitor) and their Jersey Number. By taking the jersey numbers for each player, we calculated what ranges of jersey number suffer more helmet impacts than the others and accordingly what positions are more susceptible.



Jersey Number	Positions
0-9	QB (Quarterback), K / P (Kicker / Punter)
10-19	QB, K/P, WR (Wide Receiver)
20-29	RB (Running Back), DB (Defensive Back)
30-39	RB, DB
40-49	RB, DB, TE (Tight End), LB (Line Backer)
50-59	LB, OL (Offensive Lineman), DL (Defensive Linemen)
60-69	OL, DL
70-79	OL, DL
80-89	WR, TE
90-99	DL, LB

Red denotes a defensive position. Highlighted rows represent top 3 impacted

- **The most impacted positions are heavily defensive positions, notably those that tackle near or at the line of scrimmage** – linemen and linebackers.
- Among the offensive players, only the offensive linemen - who are tackling the defensive linemen - are impacted on the helmet the most.
- Other offensive skill positions, such as quarterback, wide receiver and tight end, generally rank in the bottom 3 of helmet impacts

Therefore, the rule recommendation we will make should cater to the defensive players and offensive linemen, while not mandating offensive skill players to them.

Computer Vision Model / Solution Overview

Our solution consists of a two-step pipeline - detection and classification - We use 2D detection to find possible impact boxes, and then we use 3D classification to determine which boxes are impacts.

We used the DetectoRS(ResNeXt-101-32x4d) model for detecting impacts. Our detection model outputs the red box as a possible helmet impact.

The walkthrough of the model (including a video demonstration) will be included in the Application Development Section of the report.

Helmet Impact Management Recommendations

On average, there are 120-140 offensive snaps played. Given that there are approximately 15 helmet impacts are detected from our data per play, that does not bode well for players' health and safety long-term.

We propose our app be installed into all the tablets that the coaching staff and video coordinators use to review film. They can review which players have sustained helmet impacts and can subsequently make necessary substitutions to reduce the frequency of helmet impacts for any given player. Other long term benefits include improving coaching tactics and tackling form.

PROPOSED RULE CHANGE:
Under RULE 5 PLAYERS, SUBSTITUTES, EQUIPMENT, GENERAL RULES, SECTION 2 SUBSTITUTES AND WITHDRAWN PLAYERS, the following Article will be proposed for the Owners and Players Association to vote on:

Article: MANDATED SUBSTITUTIONS. Upon assessment from the Pick 6 Helmet Impact Detection App that a player has sustained helmet impacts on consecutive plays, the player must be substituted out of the game immediately and cannot participate for at least one play. This rule excludes offensive skill players such as Quarterbacks, Running Backs, Wide Receivers and Tight Ends, unless they are displaying concussion symptoms.

The primary reason we are not subjecting offensive skill players to this rule is because we don't see the need to potentially reduce the quality of offensive play when there's less than a 15% chance collectively that any offensive player suffers helmet impacts on any given play.

This will also require the play clock to be extended by 10 seconds to give teams and referees time to review each play. This would mean the play clock is now 50 seconds for each snap, which will be amended in all applicable rules. **This will reduce the number of offensive snaps or plays run by 20%. That approximately reduces the number of potential helmet impacts from ~1900 to ~1500.**

With these mandatory substitutions, we theoretically estimate to reduce the number of helmet impacts for each player by 33%. Last season, there were 224 reported concussions in the preseason and regular season, of which roughly 65% occurred to offensive and defensive linemen, defensive tackles, tight ends and running backs – ~145 concussions. These are positions prominently featured in our videos as well.

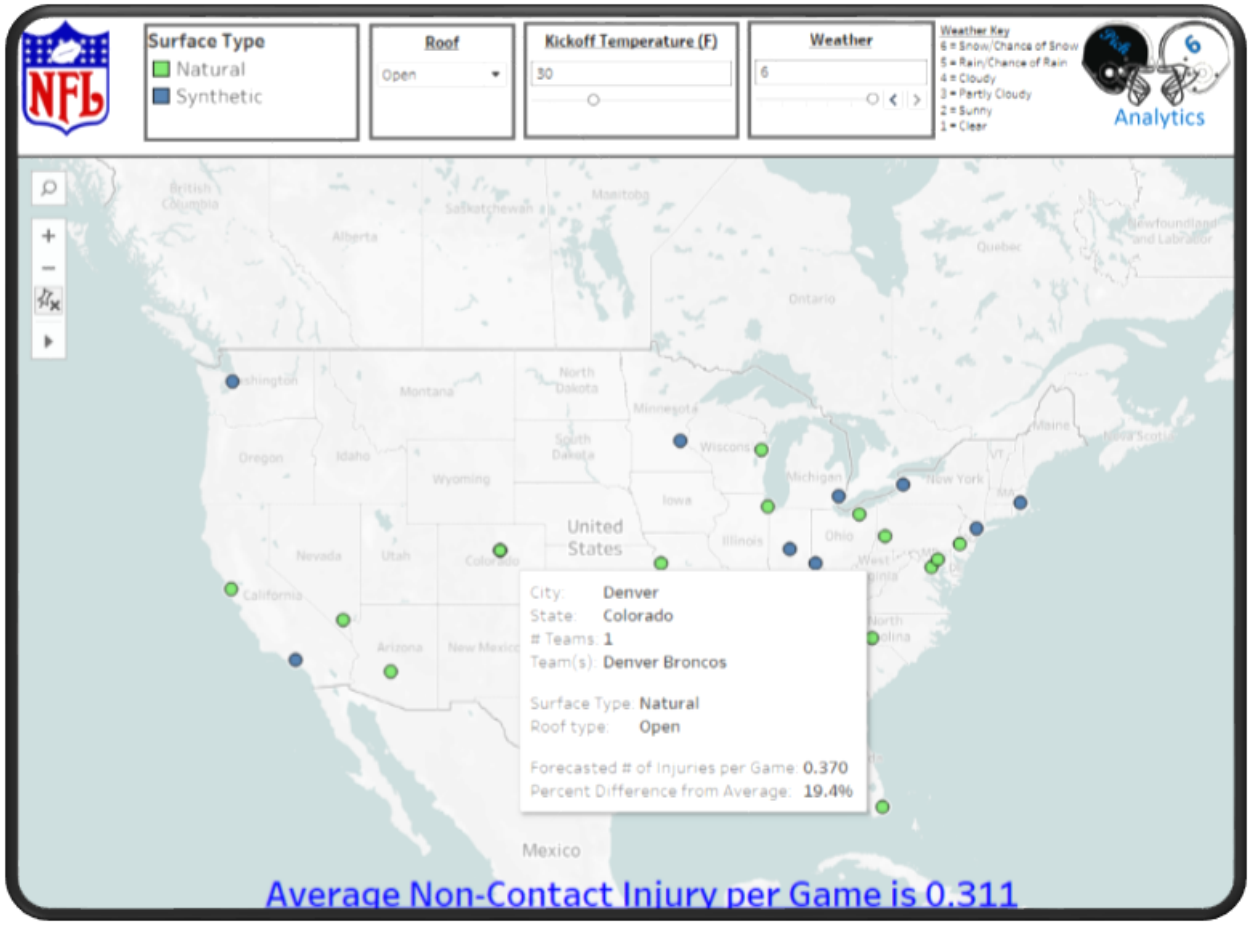
A reduction in multiple helmet collisions can potentially bring this down to approximately 175 concussions, a 20% reduction overall.

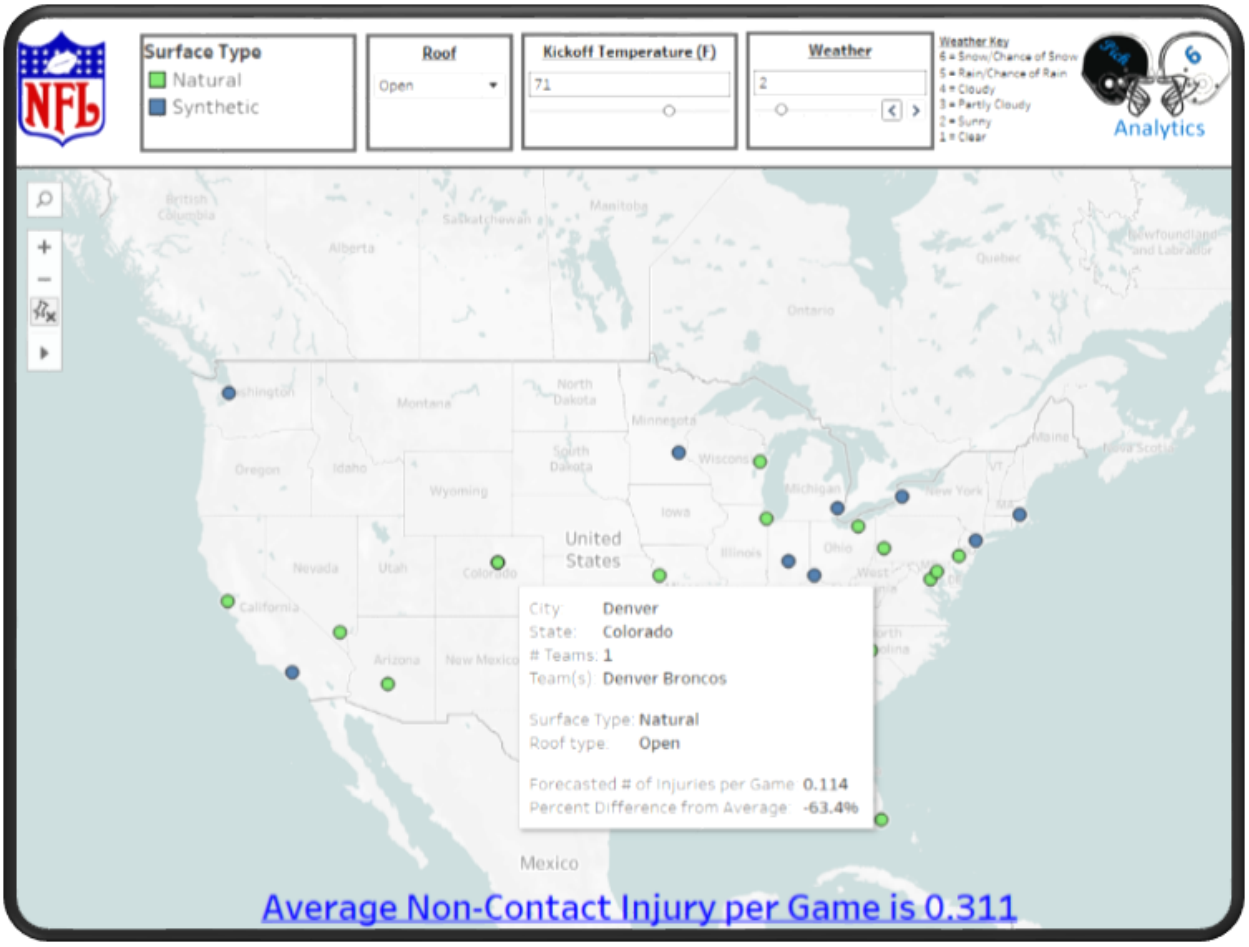
We also highly recommend the NFL to continue its cooperation with the NFL Players Association and Helmet companies such as Riddell, Schutt, VICIS and Xenith to continuously test, research and develop safer helmets for NFL athletes that reduce concussion rates.

Application Development

Tableau Dashboard

As mentioned in the Surface Analysis Management recommendations, an interactive dashboard was developed using Tableau software. It allows the user to filter through three different data elements to produce a "Forecasted Number of Injuries per Game" and then compares this number to the Average Non-Contact Injuries per Game of 0.311 to return the percent difference. Below is an example of two different scenarios involving the Denver Broncos with different Weather and Temperature Settings





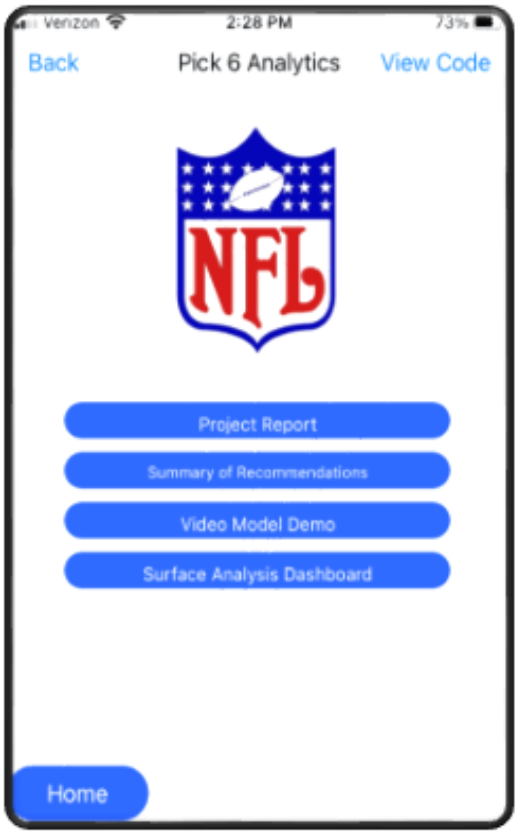
Cell Phone Application

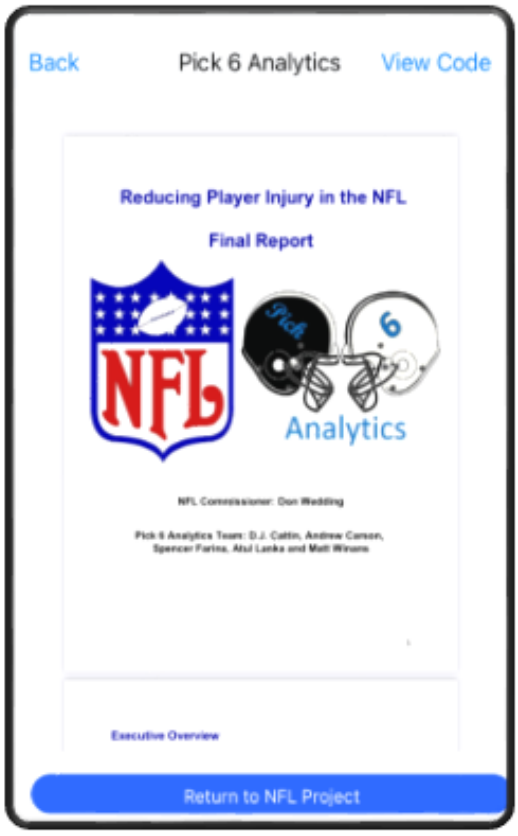
A cell phone application is also being developed and examples of current development are below.
The App includes the following pages:

- Home
- Team
- NFL project
- Project Report that includes this full report
- Summary of Recommendations (to be updated w/ final recommendations)
- Demo of Helmet Video
- Surface Analysis Example Dashboard with Link to Tableau Mobile
- Tableau Mobile (once Server is set-up)


Back
Pick 6 Analytics
View Code
Welcome to
Analytics
The Team
NFL Project


Back
Pick 6 Analytics
View Code
Pick 6 Analytics Team
D.J. Cattin
Andrew Carson
Spencer Farina
Atul Lanka
Matthew Winans
Home


Back
Pick 6 Analytics
View Code
Project Report
Summary of Recommendations
Video Model Demo
Surface Analysis Dashboard
Home


Back
Pick 6 Analytics
View Code
Reducing Player Injury in the NFL
Final Report
Analytics
Executive Overview
Return to NFL Project


Back
Pick 6 Analytics
View Code
Video Model Demo
Coming Soon - Link to Video Web Based Application
Return to NFL Project

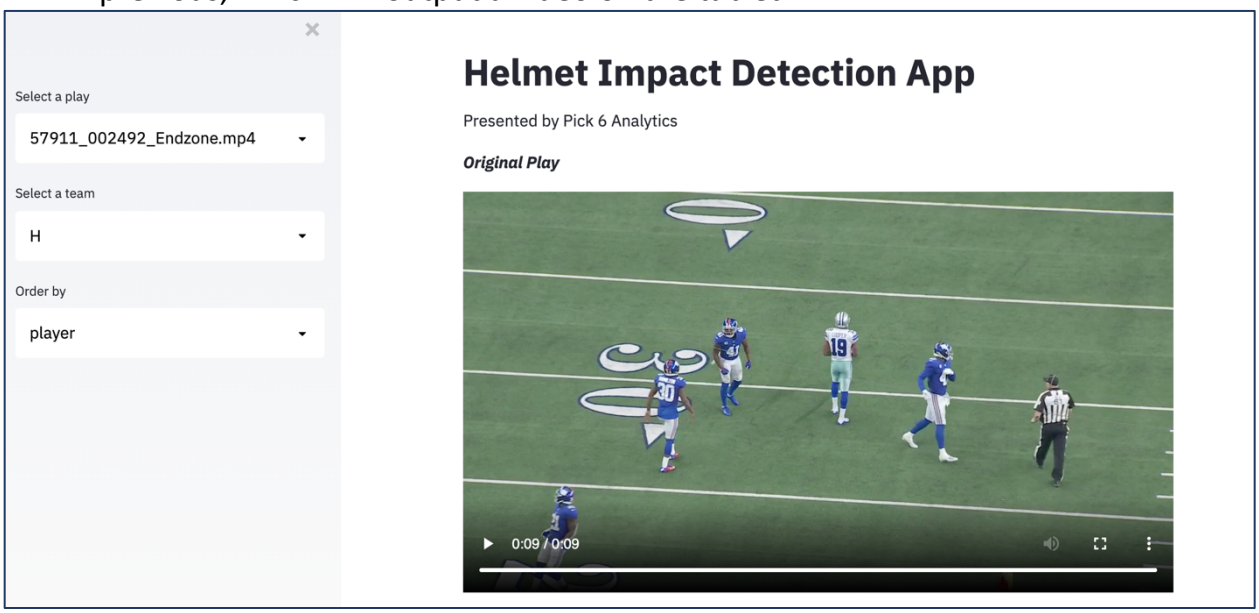

Verizon
3:39 PM
55%
Back
Pick 6 Analytics
View Code
Summary of Recommendations
Surface Analysis
- NFL continue to partner with shoe companies such as Nike and Adidas and invest in research and development into cleats that are best suited for each surface type.
- Use dashboard as a source of knowledge to make executive decisions.
- Push for use of natural grass whenever stadiums are built or refurbished.
Punt
- Rule Change: Propose to automatically add 10 yards for the returning from where they catch the ba
Helmet Analysis
- Rule Change: A player cannot be on the field after sustaining consecutive helmet impacts.
- Continued cooperation with the NFL Players Union and Helmet companies such as Riddell, Schutt, VCIS and Zenith to continuously test, research and develop safer helmets for NFL athletes.
Return to NFL Project


Back
Pick 6 Analytics
View Code
Surface Analysis Dashboard
Link to Tableau Dashboard Web App
Return to NFL Project

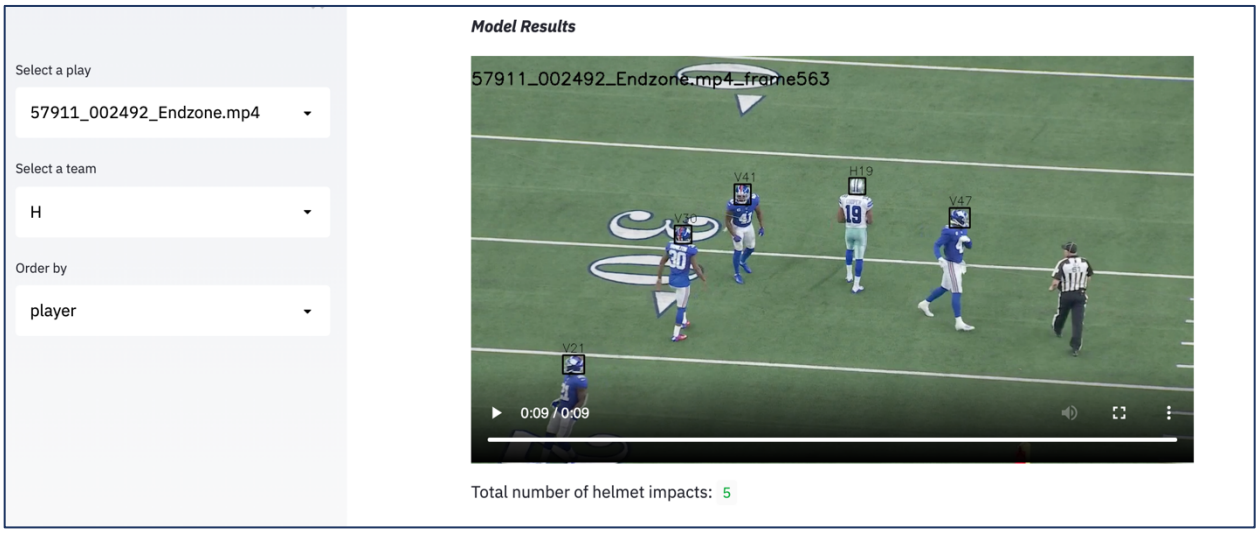

Back
Pick 6 Analytics
View Code
Coming Soon with Server Set-up
Welcome to Tableau Mobile
Access data no matter where you are.
Sign In
Learn more
Return to Surface Analysis

Computer Vision Application for Helmet Impact Detection Walkthrough

1. The user will select the play, either the sideline or the endzone view of the previous, which will output a video on the tablet



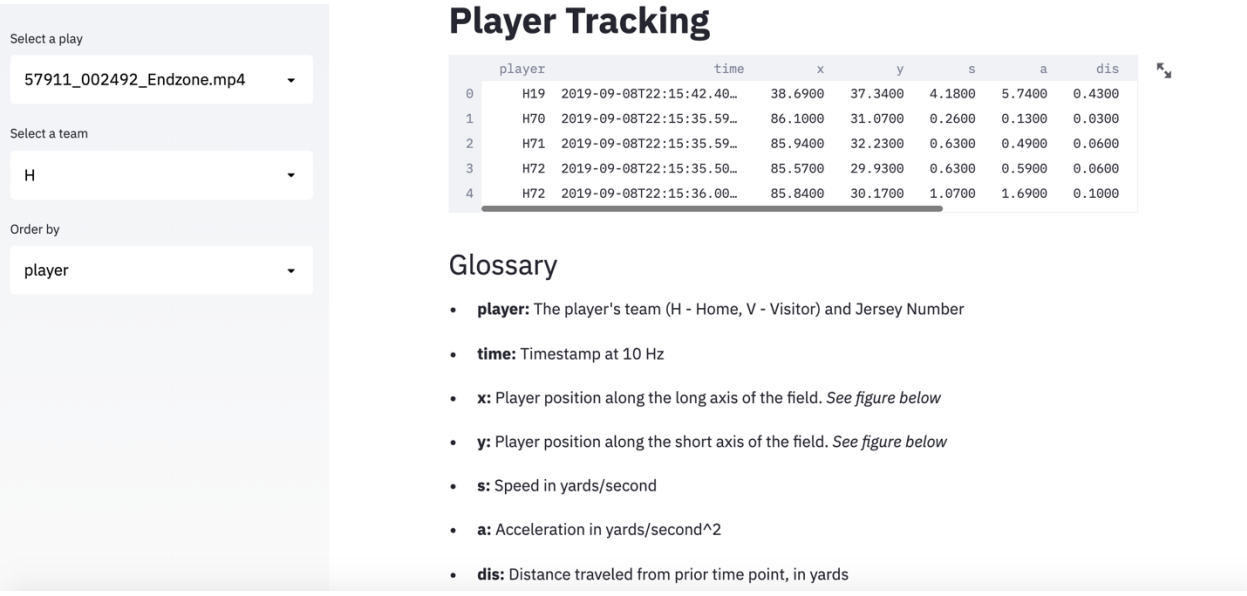
2. After processing this video, the computer vision model we deployed onto this application will output a video that should apply a box over every player's helmet. **These boxes will flash red once the model determines that there has been a helmet impact.**



3. Once the model has generated the output video, a player tracking table is also created. This summarizes the players that have sustained a helmet impact and also provide some tracking data for the approximate moment the player is struck on the helmet.

   This table can be customized using two features also included on the left. The user can choose whether they are the Home or the Visiting team and whether to order the Player Tracking table by Jersey Number (player) or by Time. This way the user can view the impacts by frequency or chronologically.

   In the image above you can see the statement - Total number of helmet impacts: _'. This will also change based on what team the user selects.



Video Walkthrough

You can also open this link to view and understand the workings of this app - https://youtu.be/xyujT_VlF2c

Summary of Management Recommendations

Dashboard / Apps:

- Tableau Dashboard / Mobile Application to assess player injury risk when playing in certain physical conditions – to be used by Commissioner
- Computer Vision Application to detect which players suffered helmet impacts after each play – to be used by Coaching Staff

Rule Changes:

- **FAIR CATCH ON PUNTS.** When a player signals for a fair catch on a punt return, 10 yards will be added for the returning team from the spot of the catch.
- **MANDATED SUBSTITUTIONS.** Upon assessment from the Pick 6 Helmet Impact Detection App that a player has sustained helmet impacts on consecutive plays, the player must be substituted out of the game immediately and cannot participate for at least one play. This rule excludes offensive skill players such as Quarterbacks, Running Backs, Wide Receivers and Tight Ends, unless they are displaying concussion symptoms.

To be voted on by Owners and Players Association (NFLPA)

Partnership Opportunities:

- Shoe companies such as **Nike and Adidas** to invest in research and development of cleats that are best suited for each surface type – one for natural grass and one for synthetic turf – while recommending newly built or renovated stadiums move towards natural grass
- Helmet companies such as **Riddell, Schutt, VICIS and Xenith** to continuously test, research and develop safer helmets that reduce chances of concussions for NFL athletes.

Business Impact

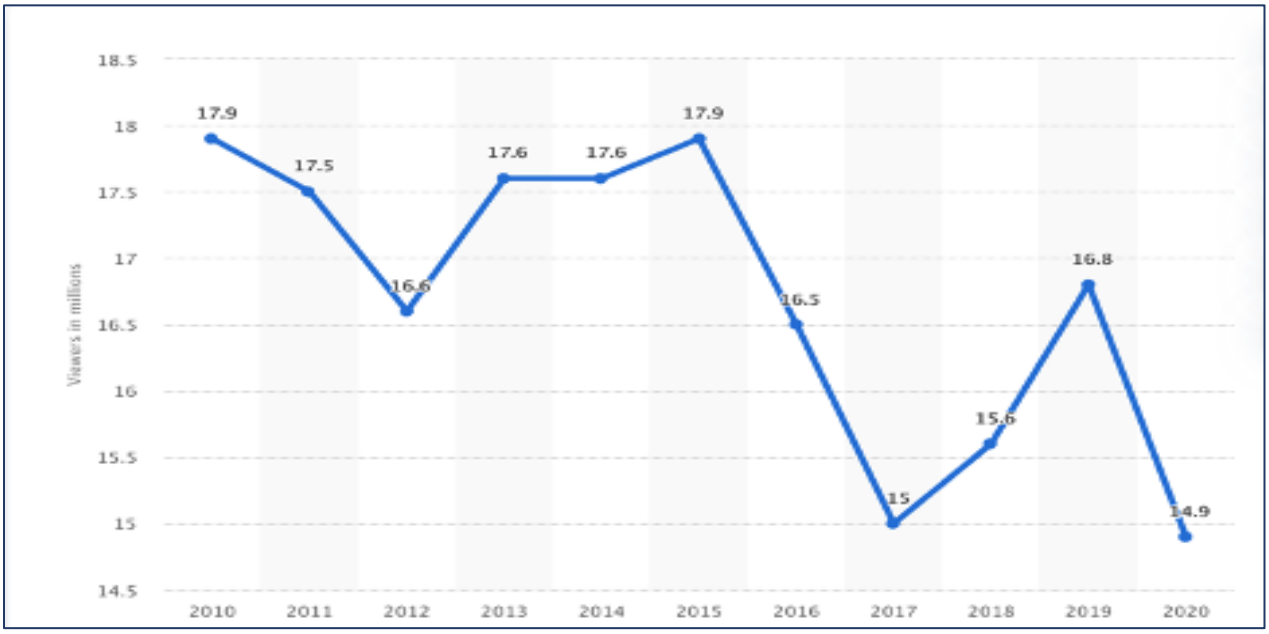
We project that our recommendations will significantly reduce the medical expenses incurred by the league and increase viewership, corporate sponsorships and negotiation power for future media contracts and revenue.

By our estimates, concussions will go down by roughly 30% overall and total injuries by at least 5% immediately, with a long-term estimate of 20% with the continued partnership to provide safer playing conditions and equipment.

As far as costs, as stated earlier, injuries have been attributed to about $521 million dollars in expenses from teams last season, so:

- Conservative, immediate savings: 5% or **$26 million saved per season**
- Probable savings: %10 or **$52 million saved per season**
- Aggressive, long-term savings: %15-%20 or **$78 million - $104 million saved per season**

Keeping the best players on the field will also positively impact viewership. A Gallup poll from 2017 determined that football is American's favorite sport to watch, however, viewership has been declining over the past 5 years. The graphic below, from Statista, portrays this trend, showing average viewership of NFL games over the past decade.



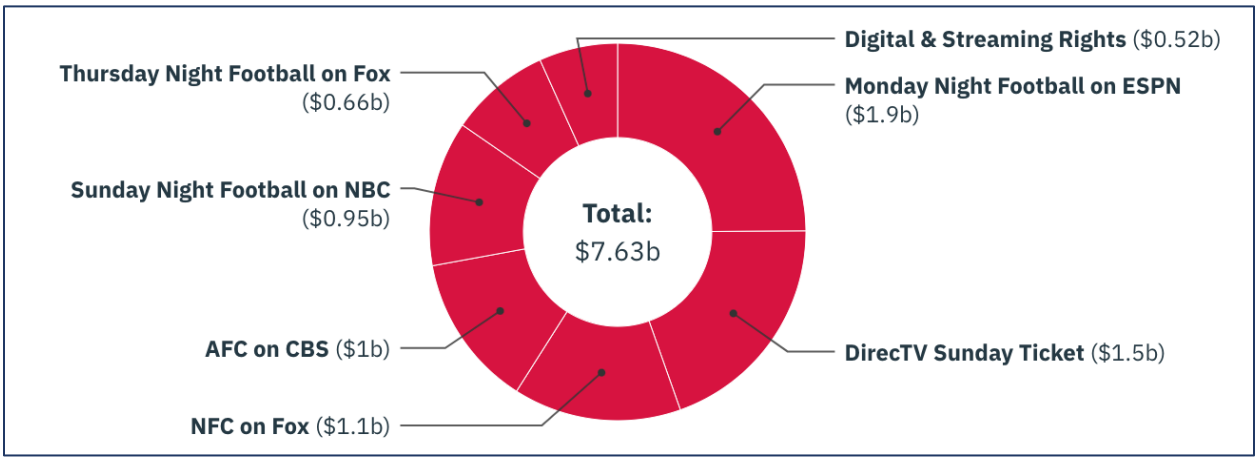
Although a multitude of factors contribute to the decrease in viewership, such as political reasons and Coronavirus, injuries are still a contributing factor. For example, in

2017 when the NFL suffered its worst viewership ratings, stars such as Aaron Rogers, J.J. Watt, and Andrew Luck were all out due to injuries.
Using Linear Regression to project TV ratings from the total number of injuries since 2012, our proposed decrease in injury rates among NFL athletes would result in TV ratings rising up to the **17.0 - 17.2** range.

This gives the NFL a lot of negotiating power when discussing its upcoming media contracts in the following year.

The NFL makes over 50% of revenue from these enormous television deals. Many of these deals are multi-year deals where networks own the right to play specific games, for example ESPN owns the rights to air Monday Night Football.

<u>This is the current breakdown of the media (Television and Streaming) rights:</u>



Boasting higher TV ratings and an increased availability of healthy star player can force these TV networks to negotiate more lucrative deals. We project that this **$7.63 billion figure can increase to $10 billion by next year** with renegotiated contracts – football still widely remains to be most popular sport in the country. This will get you closer to your goal of **$25 billion revenue by 2027.**

Television ratings won't make an immediate impact on revenue, but in order for the NFL to continue to sign large network deals for rights to air games, viewership needs to stabilize and ideally increase, and injury prevention can achieve that.

<u>Partnerships</u>

In our recommendations, we advise the NFL to bolster partnerships with shoe and helmet companies to improve player equipment. Companies like Nike and Riddell

already have sponsorship agreements in place. We recommend that the NFL amend their current deals or upcoming deals with every company to include a clause where the NFL will invest in these companies' Football R&D Departments to accelerate the development of safer equipment:

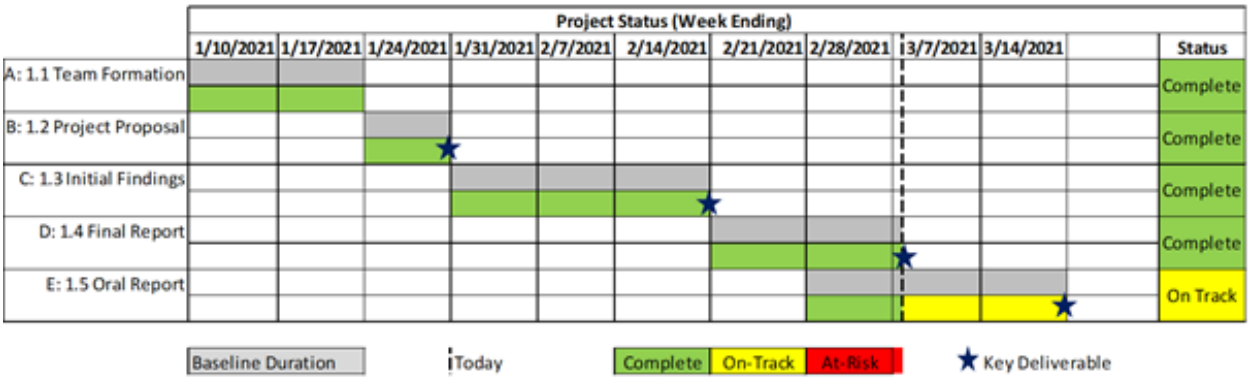
Projected Expenditures:

- Shoe companies (Nike and Adidas): $50 Million in research a year + a maximum $10 million for buying sponsored pairs of cleats for every active player = **$60 Million per season**
- Helmet companies (Riddell, Schutt, VICIS and Xenith): $5 Million in research a year + a maximum $5 Million to purchase helmets for every active player = **$10 Million per season**

Projected Total R&D Expenditures for injury prevention per season < $70 Million

While this investment in these partnerships will lead directly to decreased injury-related expenditures and subsequently, increased renegotiated media revenue, the NFL will continue to bolster its financial stability via corporate sponsorships – which only rise with every season (see Appendix) - and the advent of legal gambling in several states.

Project Status: On Track



In accordance with the project schedule, the following deliverables remain:

<u>Presentation of Findings and Oral Report</u>

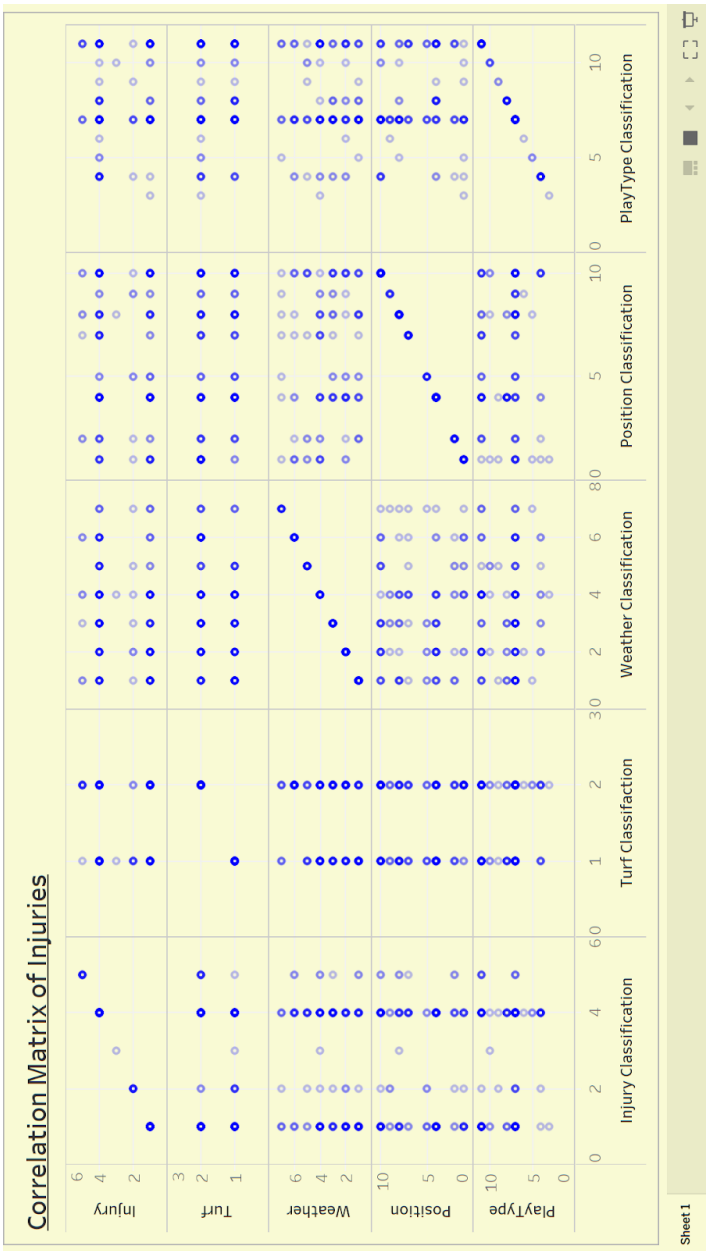
To conclude the project engagement, our team will deliver an oral report to the CEO/Commissioner and the Ownership Group focusing on the problem we addressed, the data we used, how our analyses were performed, and our conclusions and recommendations. We will also demonstrate the dashboard's and/or mobile application's functionality, and field any questions from the CEO and Ownership Group.

Future Considerations

- Further development of the Mobile and Tablet Apps to enhance real-time capabilities that would include access to the Tableau Mobile application, pop-up notifications and faster generation of video and tabular outputs of helmet impacts and player tracking data for the Helmet Impact Detection Application

Appendix

Surface Analysis



Injury Classification	
Toes	5
Knee	4
Heel	3
Foot	2
Ankle	1
No Injury	0

Turf Classification	
Synthetic	2
Natural	1

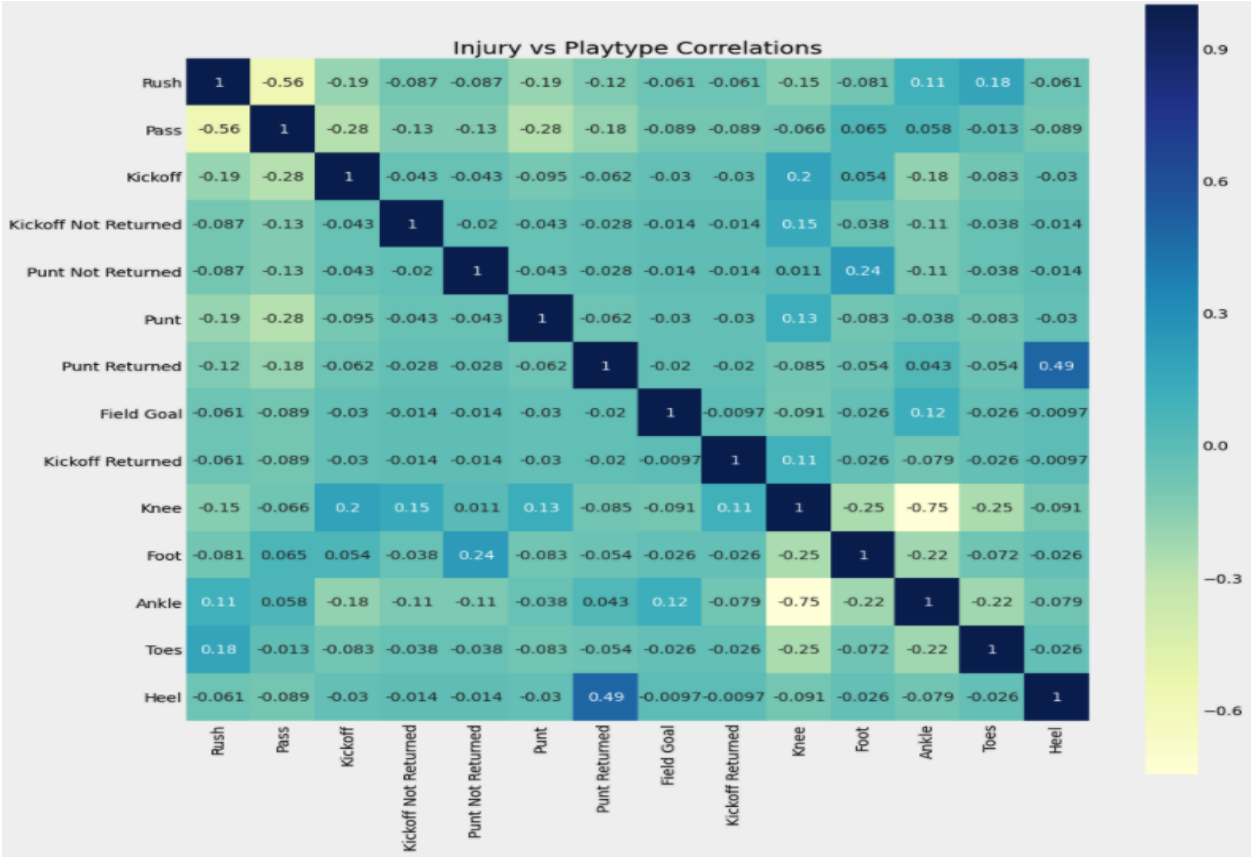
Weather Classification	
Snow/Chance of Snow	8
Missing Data	7
Indoor - Climate Controlled	6
Rain/Chance of Rain	5
Sunny	4
Partly Cloudy	3
Cloudy	2
Clear	1

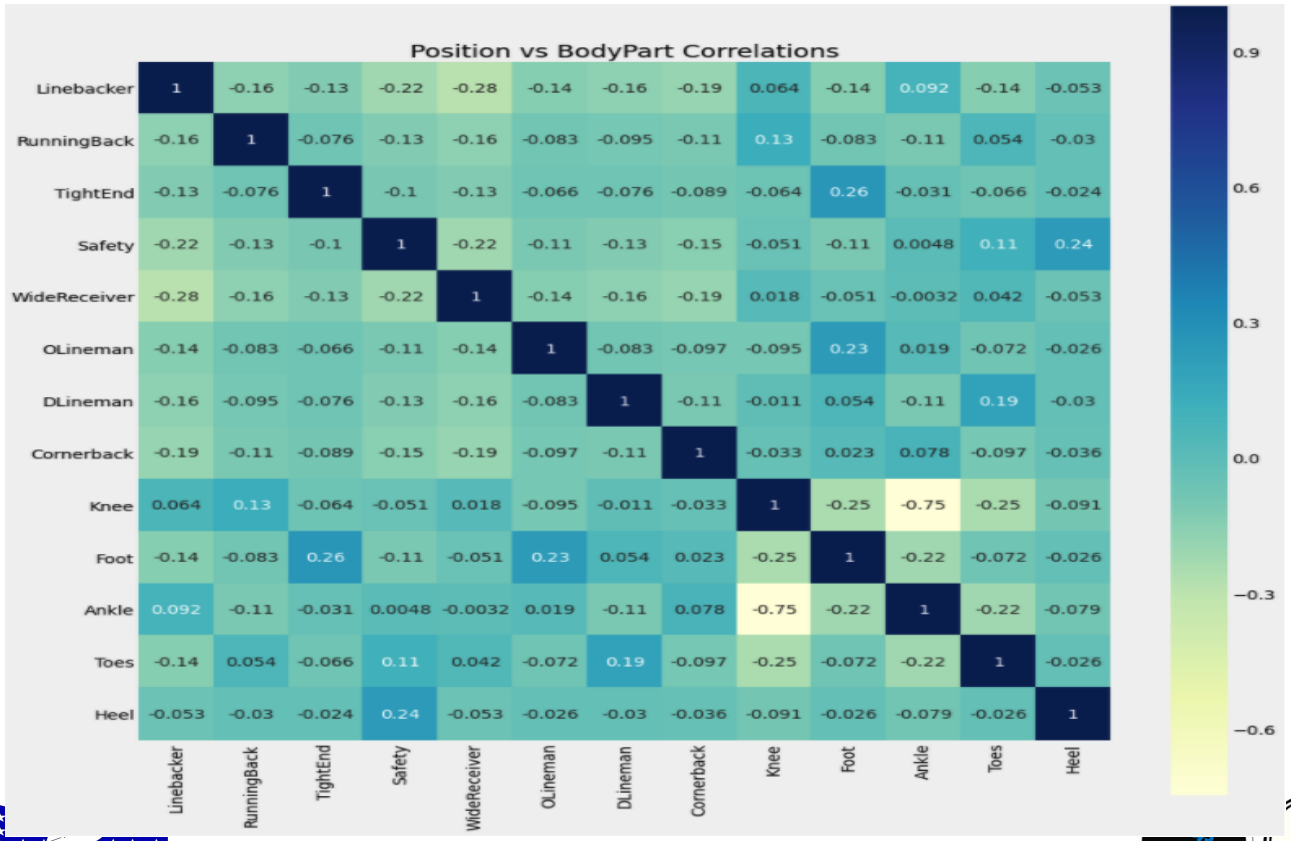
Position Classification	
Wide Receiver	10
Tight End	9
Safety	8
Running Back	7
Quarterback	6
Offensive Lineman	5
Linebacker	4
Kicker	3
Defensive Lineman	2
Cornerback	1

Play Type Classification	
Rush	11
Punt Returned	10
Punt Not Returned	9
Punt	8
Pass	7
Kickoff Returned	6
Kickoff Not Returned	5
Kickoff	4
Field Goal	3
Extra Point	2
Missing Data	1

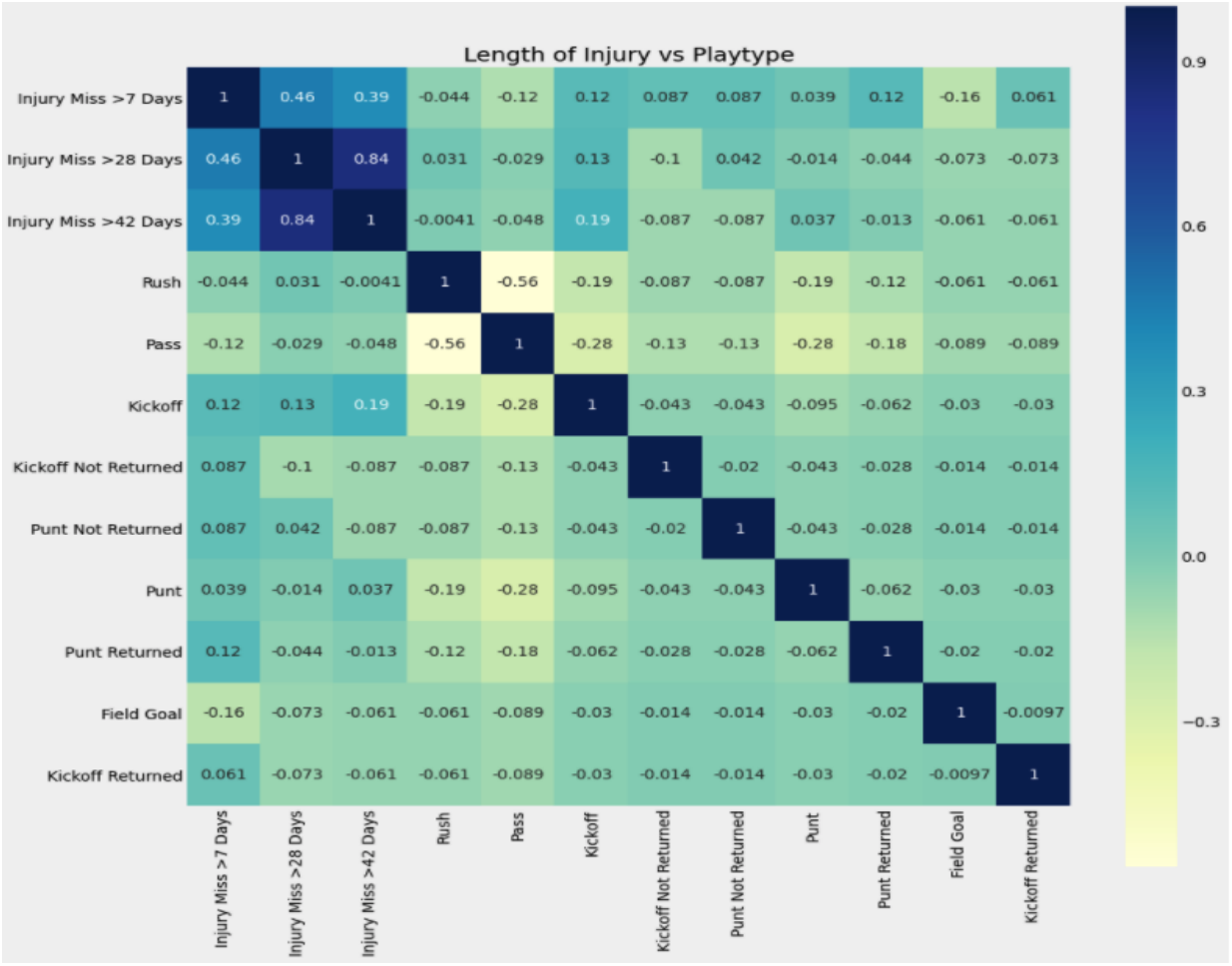
Analytics

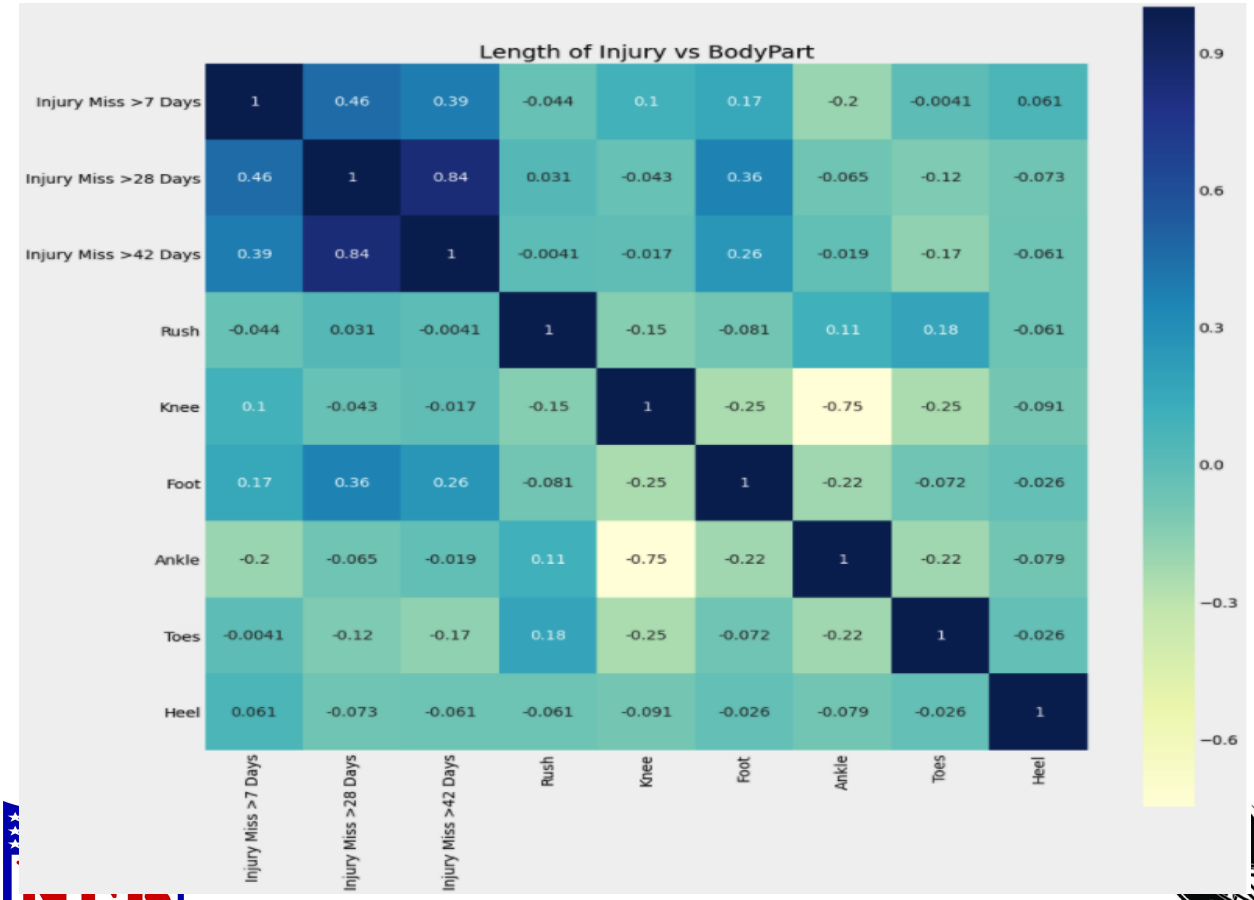
Correlation Heatmaps



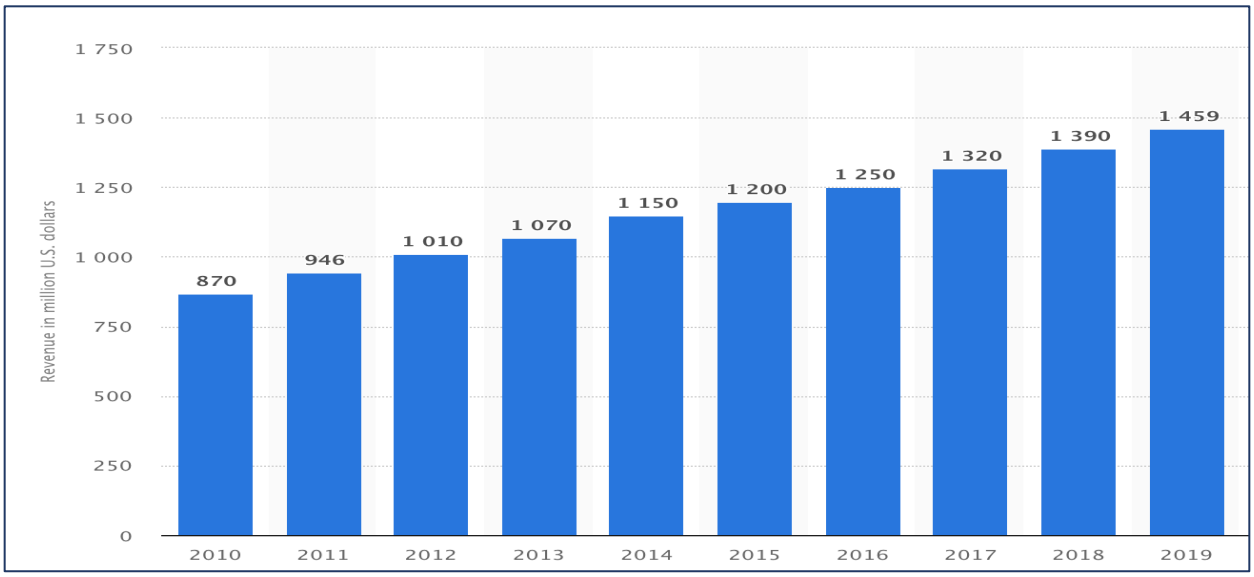


Analytics


Length of Injury vs Playtype
Injury Miss >7 Days 1 0.46 0.39 -0.044 -0.12 0.12 0.087 0.087 0.039 0.12 -0.16 0.061
Injury Miss >28 Days 0.46 1 0.84 0.031 -0.029 0.13 -0.1 0.042 -0.014 -0.044 -0.073 -0.073
Injury Miss >42 Days 0.39 0.84 1 -0.0041 -0.048 0.19 -0.087 -0.087 0.037 -0.013 -0.061 -0.061
Rush -0.044 0.031 -0.0041 1 -0.56 -0.19 -0.087 -0.087 -0.19 -0.12 -0.061 -0.061
Pass -0.12 -0.029 -0.048 -0.56 1 -0.28 -0.13 -0.13 -0.28 -0.18 -0.089 -0.089
Kickoff 0.12 0.13 0.19 -0.19 -0.28 1 -0.043 -0.043 -0.095 -0.062 -0.03 -0.03
Kickoff Not Returned 0.087 -0.1 -0.087 -0.087 -0.13 -0.043 1 -0.02 -0.043 -0.028 -0.014 -0.014
Punt Not Returned 0.087 0.042 -0.087 -0.087 -0.13 -0.043 -0.02 1 -0.043 -0.028 -0.014 -0.014
Punt 0.039 -0.014 0.037 -0.19 -0.28 -0.095 -0.043 -0.043 1 -0.062 -0.03 -0.03
Punt Returned 0.12 -0.044 -0.013 -0.12 -0.18 -0.062 -0.028 -0.028 -0.062 1 -0.02 -0.02
Field Goal -0.16 -0.073 -0.061 -0.061 -0.089 -0.03 -0.014 -0.014 -0.03 -0.02 1 -0.0097
Kickoff Returned 0.061 -0.073 -0.061 -0.061 -0.089 -0.03 -0.014 -0.014 -0.03 -0.02 -0.0097 1
Injury Miss >7 Days
Injury Miss >28 Days
Injury Miss >42 Days
Rush
Pass
Kickoff
Kickoff Not Returned
Punt Not Returned
Punt
Punt Returned
Field Goal
Kickoff Returned
0.9
0.6
0.3
0.0
−0.3


Length of Injury vs BodyPart
Injury Miss >7 Days 1 0.46 0.39 -0.044 0.1 0.17 -0.2 -0.0041 0.061
Injury Miss >28 Days 0.46 1 0.84 0.031 -0.043 0.36 -0.065 -0.12 -0.073
Injury Miss >42 Days 0.39 0.84 1 -0.0041 -0.017 0.26 -0.019 -0.17 -0.061
Rush -0.044 0.031 -0.0041 1 -0.15 -0.081 0.11 0.18 -0.061
Knee 0.1 -0.043 -0.017 -0.15 1 -0.25 -0.75 -0.25 -0.091
Foot 0.17 0.36 0.26 -0.081 -0.25 1 -0.22 -0.072 -0.026
Ankle -0.2 -0.065 -0.019 0.11 -0.75 -0.22 1 -0.22 -0.079
Toes -0.0041 -0.12 -0.17 0.18 -0.25 -0.072 -0.22 1 -0.026
Heel 0.061 -0.073 -0.061 -0.061 -0.091 -0.026 -0.079 -0.026 1
Injury Miss >7 Days
Injury Miss >28 Days
Injury Miss >42 Days
Rush
Knee
Foot
Ankle
Toes
Heel
0.9
0.6
0.3
0.0
−0.3
−0.6

NFL league and team sponsorship revenue



Source: https://www.statista.com/statistics/456355/nfl-league-team-sponsorship-revenue-worldwide/

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Pick 6 Analytics