Individual Analytical Analyses I

18F17 - Smart Helmet

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NORTHERN ARIZONA UNIVERSITY

Memorandum

Design4Practice (D4P) Program

To: Dr. Trevas

From: Titus Yazzie

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Re: Individual Analytical Analysis I

This assignment is due 11/09/18.

Introduction

A contemporary issue in athletic sports are injuries, specifically head injuries. Contact to contact sports such as American football is one of the highest head related injuries in any sports. The analytical analysis that will be researched is the amount of G-forces a person can take before taking serious injuries. The G-forces will aid in the overall Smart Helmet project by providing information on how to calibrate and interpret data when a player exhibits any impacts. The main objective of the Smart Helmet is to collect data on any impact to the head and be able to read the data to prevent further injuries.

Assumptions

The assumptions are based off NFL players and their performances during games. The numbers are converted to SI Units to make calculations simple.

The average weight of an NFL players is 250 lbs. [1] and converting pounds to kilograms is m = 113.4 kg.

The average speed is about 25 mph [2] which was converted to meter per second which equals to v = 10.3 m/s.

The average time per play in a game is about 4 seconds, t = 4 s. [3]

Another assumption made is the time a player contacts another player; the time will vary due to the lack of information provided. The time will vary from 1s – 0.01s because a player stops abruptly. This can determine the amount of G-forces a player takes in the various amounts of time to come to a complete stop.

These assumptions determine the force, acceleration, and G-force of a player can create as well as the moment of the impact. The amount G-force a player exhibit will show the potential injury and then be compared to data where the table shows the risk of injury.

Equations

The equations used are to determine the acceleration of a player and the force of the player and the impact of a hit.

The force equation as seen in (1) shows the potential force that a player can take while getting tackled. This force can be transferred to the head that will cause brain injury. The m represents the mass of the player and the a represents the acceleration.

$$F = ma \tag{1}$$

The acceleration equation can be seen in (2). The v_f represents final velocity of the player and v_i is the initial velocity, which is zero because the player is not moving, and t is the time of the play. The acceleration of the player will determine the G-force created. On an Excel spreadsheet, the various times to determine the acceleration at impact will help see the different accelerations at certain times.

$$a = \frac{v_F - v_i}{t} \tag{2}$$

The amount of G-force that is created is equal to the acceleration of gravity which is 9.81 m/s^2, the relationship between G-force and acceleration can be defined in equation (3). The various times on impact will allow the team to see the G-forces at certain times and give more information on when the impact can be fatal.

$$G = \frac{a}{9.81} \tag{3}$$

Results

The results from the equations shows how the acceleration of the player will determine the G-force the players will feel. There are other methods of calculating acceleration such as using accelerometers and other sensors that can collect the data. The purpose of this research is to determine the calculations by hand and then compare the results to a sensor that a team member is currently working on. The assumptions of the equations are based off stats from professional football players and then inputted into the equations. The force of a player can expect is about 292 N and be compared to the force on impact. The values increase dramatically when compared to one another as seen in Appendix A. From F1 to F19 shows the time from 1 second to 0.01 seconds respectively. As the time decreases, the higher the force is which is expected because of the increase in acceleration that can be seen in Appendix B. Depending on the time the player that is being hit stops will determine how the impact of G-forces will have on him. Research of injury related to G-forces [4] can be seen in table 1 below, where the data shows exactly how much G-forces a person can withstand along with the description of injury. The goal of the Smart Helmet is to prevent serious brain injuries, the team's most optimal aim is to have a player take less than 50 G-forces to prevent any type of injury. As seen in Appendix C at G18, where the time is at 0.02 seconds, the G-force is at 52 Gs, which is a bit above the 50G mark. This shows that the hit should take more than 0.02 seconds to prevent any serious injuries based off the assumptions. Also, the range of speeds will play an effect due to the player's performance and their acceleration at the time. The top speed was considered even though most of the players will not reach the speed unless given the time and opening. The calculations show that players undergo high G-forces when tackling and can cause head injuries while playing and what is considered safe to players. This data will help the team move forward by either comparing results with a sensor or being able to calibrate or modify any code that is necessary in the sensor.

Table 1: Relationship between G-forces and injury

Max linear acceleration	AIS level	Injury description
<50g	0	No injury
50-100g	1	Minor
100-150g	2	Moderate
150-200g	3	Serious
200-250g	4	Severe
250-300	5	Critical
>300g	6	Non-survivable

Appendix

Appendix A:

Table A: Force of Impact

Force of impact	
F (N)	
F1	1168.02
F2	1297.8
F3	1460.025
F4	1668.6
F5	1946.7
F6	2336.04
F7	2920.05
F8	3893.4
F9	5840.1
F10	11680.2
F11	12978
F12	14600.25
F13	16686
F14	19467
F15	23360.4
F16	29200.5
F17	38934
F18	58401
F19	116802

Appendix B:

Table B: Acceleration of Impact

Acceleration of impact	
a(m/s^2)	
a1	10.3
a2	11.44444444
a3	12.875
a4	14.71428571
a5	17.16666667
a6	20.6
a7	25.75
a8	34.33333333
a9	51.5
a10	103
a11	114.4444444
a12	128.75
a13	147.1428571
a14	171.6666667
a15	206
a16	257.5
a17	343.3333333
a18	515
a19	1030

Appendix C:

Table C: G-forces on impact

G force of impact	
G	
G1	1.049949
G2	1.16661
G3	1.312436
G4	1.499927
G5	1.749915
G6	2.099898
G7	2.624873
G8	3.49983
G9	5.249745
G10	10.49949
G11	11.6661
G12	13.12436
G13	14.99927
G14	17.49915
G15	20.99898
G16	26.24873
G17	34.9983
G18	52.49745
G19	104.9949

Reference

[1] "Male Body Image and the Average Athlete," PsychGuides.com. [Online]. Available: https://www.psychguides.com/interact/male-body-image-and-the-average-athlete/. [Accessed: 08-Nov-2018].

[2] M. Bowen, "Ranking the NFL's fastest players," ESPN, 08-Jun-2017. [Online]. Available: http://www.espn.com/nfl/story/_/id/19520414/ranking-nfl-fastest-players-2017. [Accessed: 08-Nov-2018].

[3] "The Average NFL Game Has Only 11 Minutes Of Action," Curiosity.com. [Online]. Available: https://curiosity.com/topics/the-average-nfl-game-has-only-11-minutes-of-action-curiosity/. [Accessed: 08-Nov-2018].

[4] "Examination of Brain Injury Thresholds in terms of the Severity of Head Motion and the Brain Stresses," International Brain Injury Association - IBIA. [Online]. Available: http://www.internationalbrain.org/examination-of-bi-thresholds-in-terms-of-the-severity-of-head-motion-and-the-brain-stresses/. [Accessed: 09-Nov-2018].