FAMU-FSU College of Engineering

Head Armor Pro

Team 101

Design Review #1

Team Introduction

Saiabhinav Devulapalli
Biomedical Engineer

Anghea Dolisca
Biomedical Engineer

Connor Hollis
Mechanical Engineer

Riley Stroth
Mechanical Engineer

Maddie Valachovic
Biomedical Engineer

FAMU-FSU College of Engineering

Sponsor and Advisors

DEPARTMENT OF
CHEMICAL & BIOMEDICAL
ENGINEERING

FAMU-FSU
College of Engineering

<u>Project Supervisor</u>
Dr. Stephen Arce

<u>Project Coordinator</u>
Dr. Shayne McConomy

<u>Academic Advisor</u>
Emily Thiel

FAMU-FSU
College of
Engineering

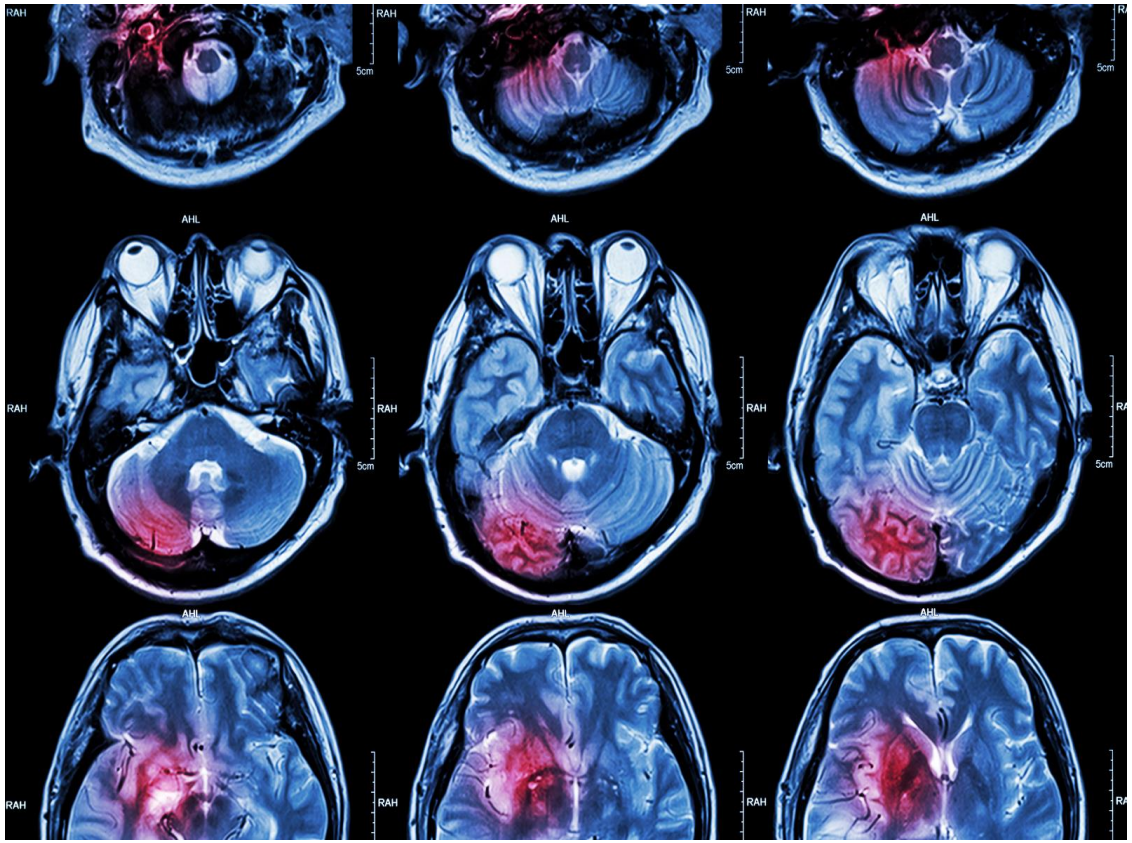
Objective

The objective of this project is to research and design a device that will reduce the risk of concussions for athletes across all sports, with a specific focus on football players.

Impact of Concussions on Brain Health

Connor Hollis

- 50% of NFL players would not allow their kids to play
- 1/3 of players have sustained a brain injury
- Short term effects
  - headaches, memory loss, nausea, mood swings
- Long term effects
  - Chronic traumatic encephalopathy (CTE), traumatic brain injury (TBI), and more



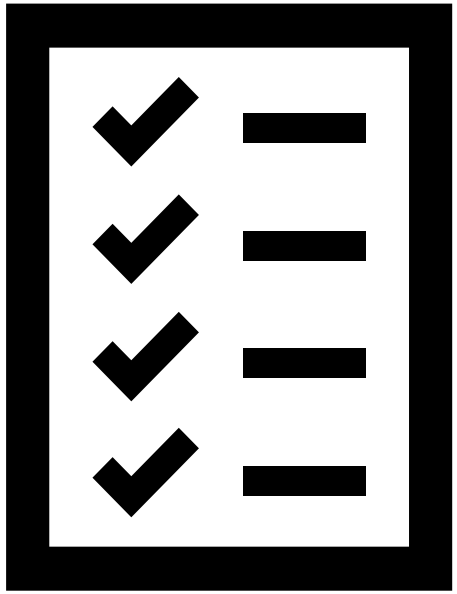
FAMU-FSU College of Engineering

Existing Solutions

- Helmets
- Q-Collar
- Guardian Caps
- SISU Smart Mouth Guard

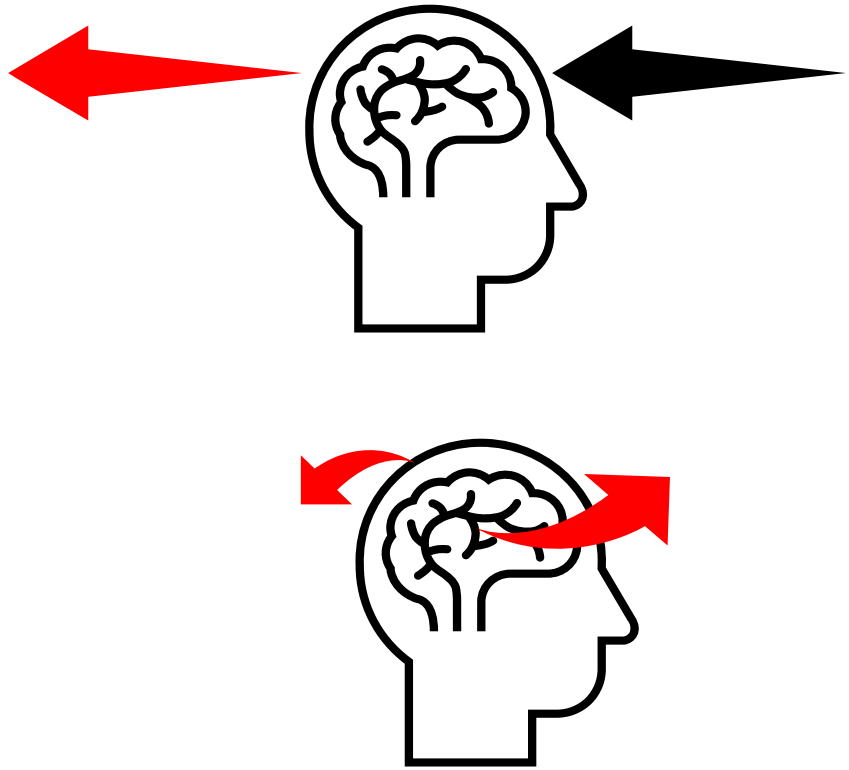
Parameters to Consider

- Player position
- Anticipated and unanticipated collisions
- Rotational and linear impact forces
- Impact location



Rotational vs. Linear Impacts

- Focal and diffused brain injuries
- Predictability of concussions and measurement
- Threshold:
  - Linear = 70g – 100g
  - Rotational = 4000 rad/s² – 5000 rad/s²
  - Head Impact Criteria of 250



Research Challenges

- Underreporting of Concussions
- Focus on Collegiate and Professional
- Time and Resources

Saiabhinav
Devulapalli

Design Objectives

1. Focus on maintaining functionality, weight, and comfortability

2. Preventing more than skull fractures

3. Reduce risk of concussions, but acknowledge complete elimination may not be possible just yet

FAMU-FSU College of Engineering

Saiabhinav
Devulapalli

Research-Driven Approaches

Impact Absorption

HIT (Head Impact Telemetry) Sensor

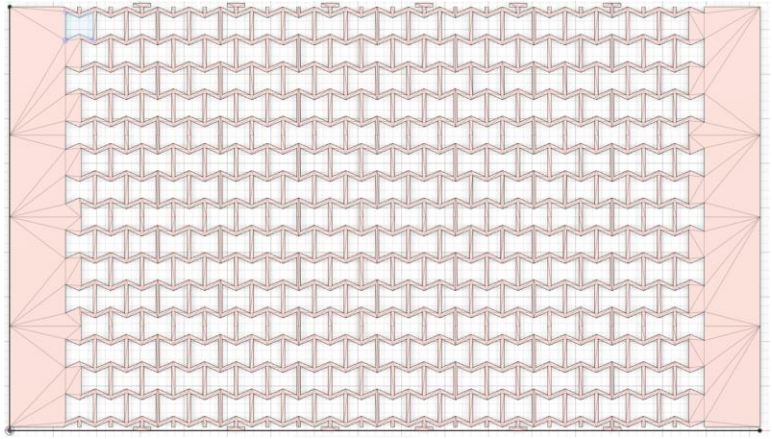
Jugular Vein Compression Collar (JVCC)

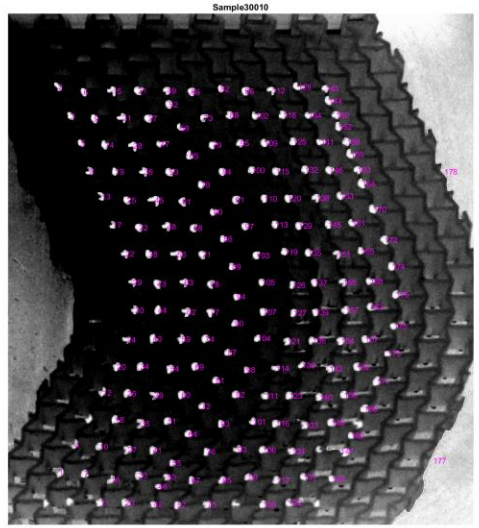
FAMU-FSU College of Engineering

Saiabhinav
Devulapalli

Impact Absorbing Material

- 3D printed Hourglass Design
  - Auxetic Structure
    - Printer: Formlabs 3B+
    - Resin: Flexible 80A Resin
  - Testing
    - Clamp and Image Analysis with MATLAB
    - Simulations performed on Autodesk FUSION
  - Experimenting with Other Structural Designs
- Placement
  - Designing patterns to incorporate foam design to protect the Head





FAMU-FSU
College of
Engineering

Saiabhinav
Devulapalli

Impact Absorbing Material

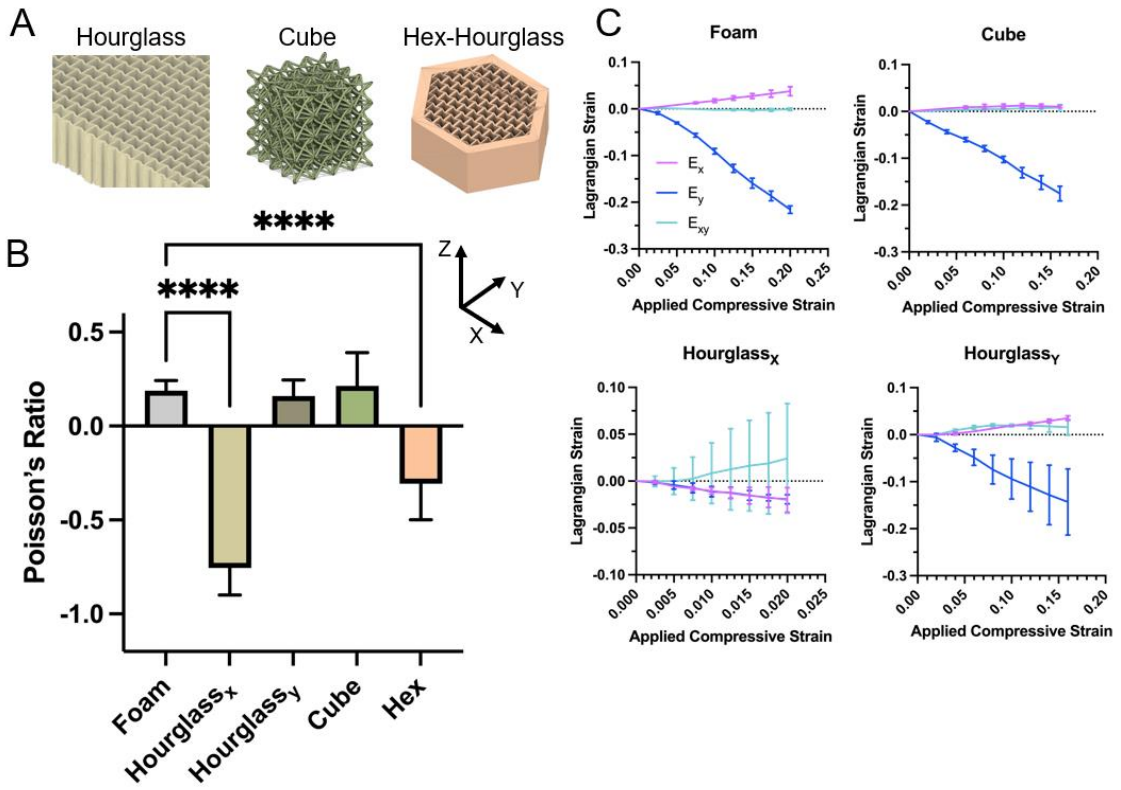


Figure 1: (A) Geometry of prints with (B) Calculated Poisson's Ratio for each (****p<0.0001, One-way ANOVA with Tukey's post hoc, n>10 measurements / group from 2 independent experiments). (C) Strain Diagram of Football Foam, compared to Flexible 80A Prints: Hourglass Vertically Oriented (compressed along X), Hourglass Horizontally Oriented (compressed along Y), "Triclinic" Cube, and Hexagonal Hourglass.

FAMU-FSU
College of
Engineering

Saiabhinav
Devulapalli

Impact Absorbing Material

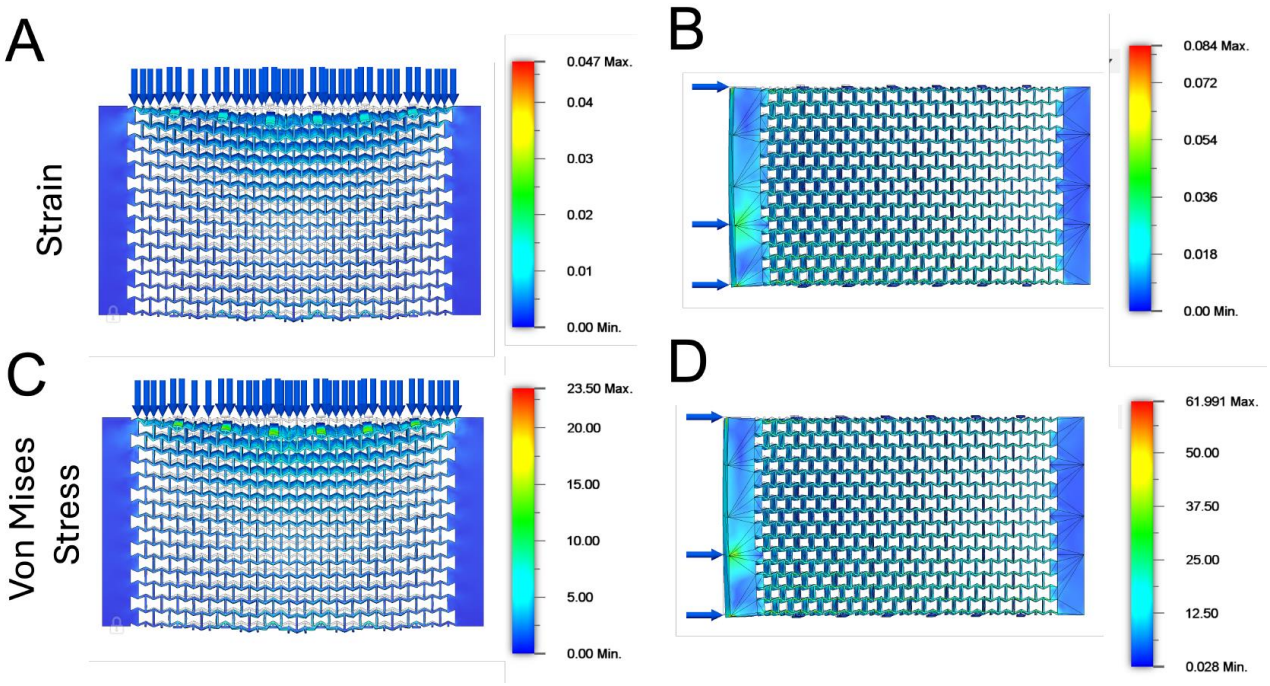
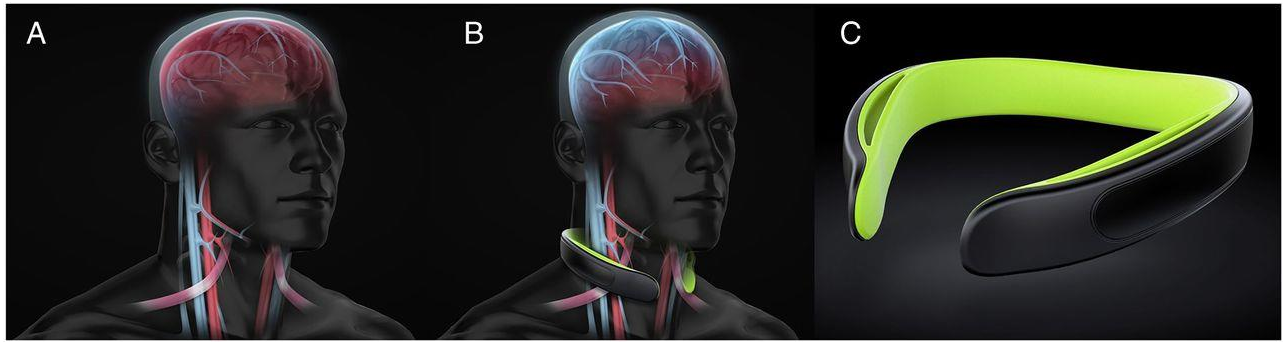


Figure 2: Fusion Simulated Force Diagram of Flexible 80A Hourglass – Y Compressed (A,C) & X Compressed (B,D) at 1200 N. Distributed Load Y Direction (A,C) with the following results: Total Deformation = 1.587 mm, Calculated Poisson's Ratio = -0.333. Distributed Load X Direction (B,D) with the Following results: Total Deformation = 28.87 mm, Calculated Poisson's Ratio = -0.806.

FAMU-FSU
College of
Engineering

JVCC

- Research on Bighorn sheep shows increased skull blood volume acts as "bubble-wrap" around brain
- This then led to discovery of the Jugular Vein Compression Collar
  - Causes pooling of blood above application of the collar, blood leaves skull slower
- Currently being used by pro-athletes as Q-collar

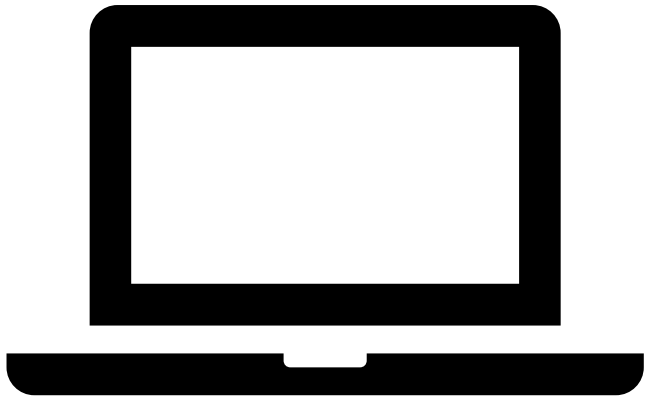


Example of NFL athlete wearing device

Sensors for Impact Monitoring

HIT (Head Impact Telemetry) Sensor

Biometric Monitoring



Future Work

- 3D print and test a neck compression device (NCD)
- Combine NCD with hexagonal foam
- Get MRI and ultrasound data done using the 3T Scanner at the College of Medicine
- Interview with Dr. Greg Myer
- Sensor's materials, placement, and circuit

Questions?

References

- "The Pathophysiology of Concussion" https://pubmed.ncbi.nlm.nih.gov/22035678/
- https://www.technologyreview.com/2007/09/10/223860/a-helmet-that-detects-hard-hits/
- "Head Impact Exposure in Youth Football" https://pubmed.ncbi.nlm.nih.gov/22350665/
- "Descriptive Characteristics of Concussions in National Football League Games, 2010-2011 to 2013-2014" https://pubmed.ncbi.nlm.nih.gov/28056179/
- "Rotational Head Kinematics in Football Impacts: An Injury Risk Function for Concussion" https://pubmed.ncbi.nlm.nih.gov/22012081/
- "Analysis of head impact exposure and brain microstructure response in a season-long application of a jugular vein compression collar: a prospective, neuroimaging investigation in American football" https://bjsm.bmj.com/content/50/20/1276
- "Descriptive characteristics of concussions in NFL games" file:///C:/Users/crh21j/Downloads/clark-et-al-2017-descriptive-characteristics-of-concussions-in-national-football-league-games-2010-2011-to-2013-2014.pdf
- file:///C:/Users/crh21j/Downloads/nihms444765.pdf
- "How Water Can Affect Keratin: Hydration-Driven Recovery of Bighorn Sheep (Ovis Canadensis) Horns" https://onlinelibrary.wiley.com/doi/abs/10.1002/adfm.201901077
- "Dynamic structural analysis of ramming in bighorn sheep" https://www.proquest.com/docview/1756281997/fulltextPDF/58009372C92243DAPQ/1?%20Theses&accountid=4840&sourcetype=Dissertations%20
- "What Is the Q-Collar, the Band NFL Players Wear Around Their Necks?' https://www.profootballnetwork.com/what-is-the-q-collar-band-nfl/