# The Difference in a Linear Impact on a Human Skull with and without a Helmet

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Background:

- Injury Biomechanics
- Reason for choosing the topic:
  - California Motorcyclist Population
- According to Centers of Disease Control and Prevention:
  - Helmets reduce the risk of death by 37% and head injury by 69%
- States that employ universal helmet laws:
  - Saves more lives on average than those without helmet law or partial

842,106
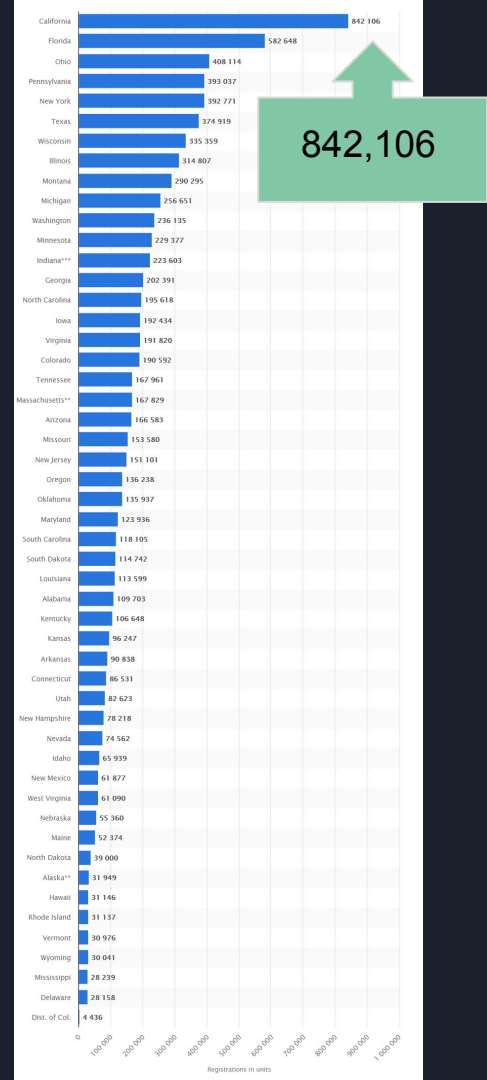
Prior Methods:

- Biomechanical Evaluation of Motorcycle Helmets: Protection against Head and Brain Injuries:
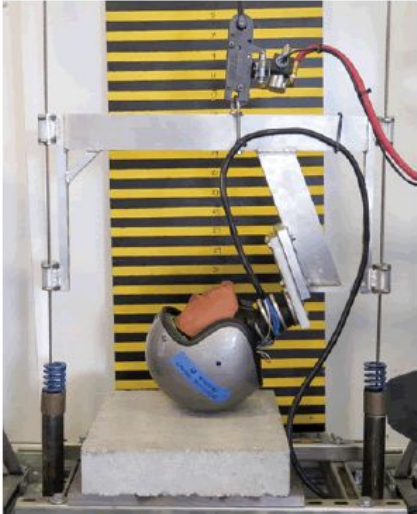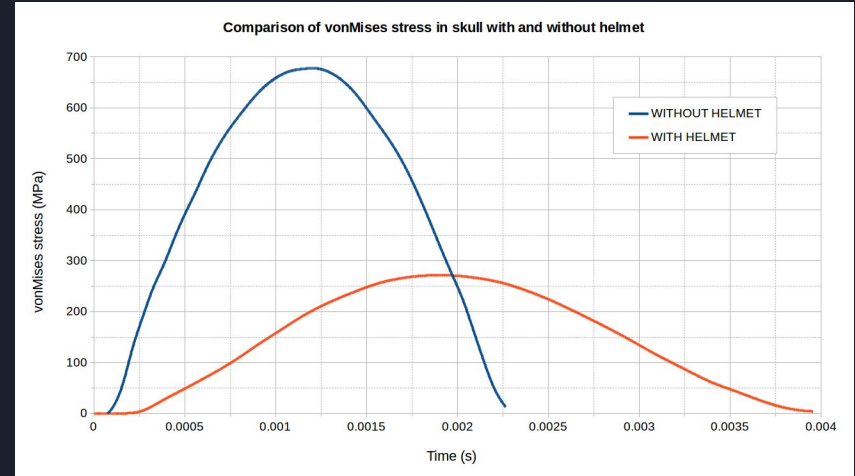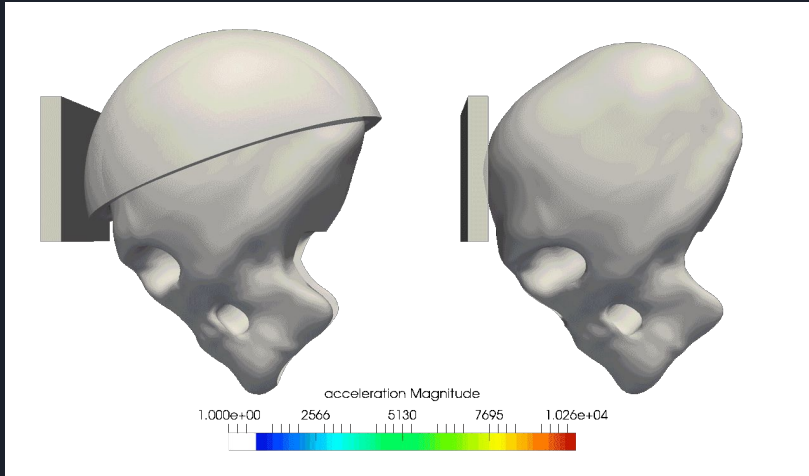

Figure 2: Modified head drop system with Hybrid III head/neck.

**Figure 4:** Motorcycle helmet models evaluated.

Prior Methods Continued

- Impact Analysis of the Skull with and without Helmet:

Summary of Project:

- Comparing the dispersion of force on skull with and without a helmet
  - Standard motorcycle helmet
- Analysis of force on frontal bone skull
  - Observing a linear force impact
- Simplifications Made:
  - Using spheres to model the skull and the helmet
  - Ignored viscoelasticity of skin as a factor and any analysis of the brain/cerebrospinal fluids
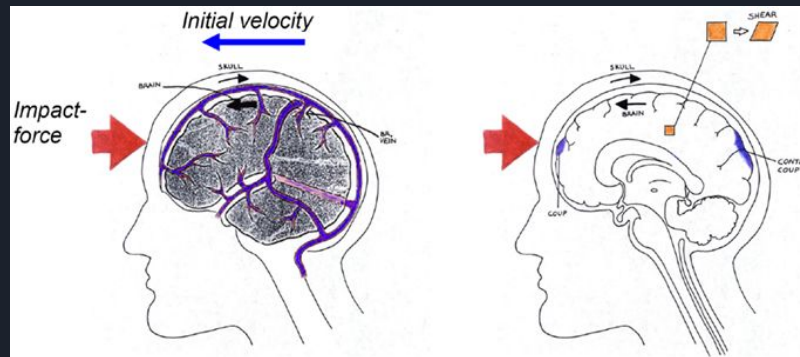
How the Experiment was Tested:

- **Experiment 1: Without Helmet**
  - Impact Condition:
    - Radius of Skull: 8.8 cm
    - Applied Pressure (N/m^2): -200 (y-direction), -500 (z-direction)
- **Experiment 2: With Helmet**
  - Materials (from MatWeb):
    - Polystyrene EPS Foam
    - Carbon Fiber Outer Shell

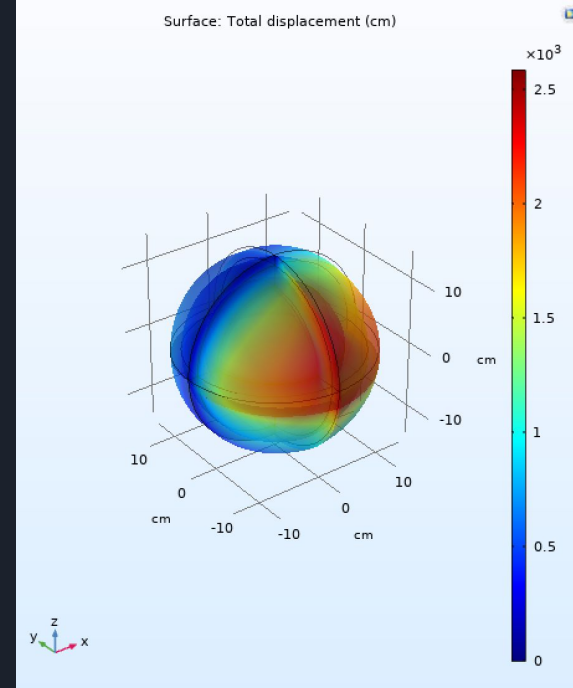| Property	Polystyrene EPS Foam	Carbon Fiber Outer Shell	Skull
Density (kg/m^3)	100	1.43	1.5
Young's Modulus (MPa)	80	52	5000
Poisson's Ratio	.1	.07	.3

What We Analyzed:

WIthout Helmet:
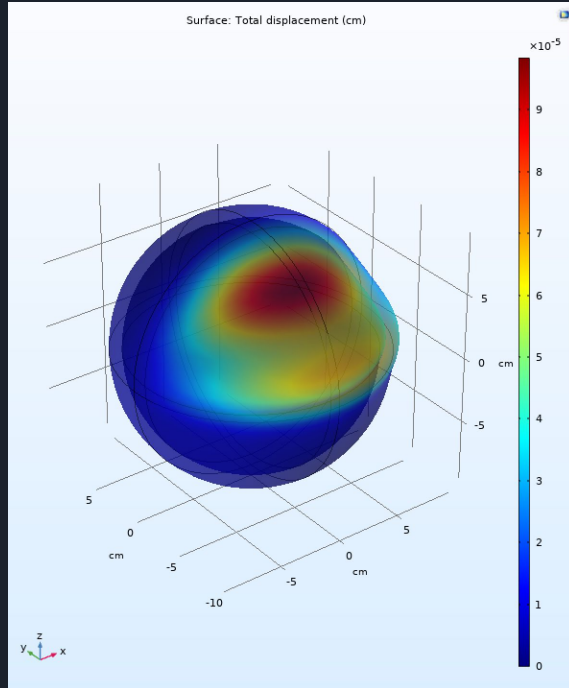
WIth Helmet:

Results/Discussion:

- Bare Skull vs Skull with a Helmet Result:
    - Helmets significantly decrease the consequences on the human skull
- Other Factors to be Considered:
    - Other factors to be considered (cushioning/distribution of skin/hair)
    - Data will vary according to helmet model (thickness/hardness/flexibility)
    - Necessary to run more tests varying the materials and dimensions

Questions?

Sources:

- https://www.statista.com/statistics/191002/number-of-registered-motorcycles-in-the-us-by-state/
- https://www.cdc.gov/motorvehiclesafety/mc/index.html
- https://www.omicsonline.org/open-access/biomechanical-evaluation-of-motorcycle-helmets-protection-against-head-and-brain-injuries-2090-2697-1000137-94548.html
- https://www.ncbi.nlm.nih.gov/books/NBK224915/
- https://www.simscale.com/projects/ahmedhussain18/human_skull_impact_-_with_and_without_helmet/
- http://article.sapub.org/10.5923.j.safety.20160501.02.html#Sec2
- http://www.matweb.com/

Respective Contributions:

Michelle Nguyễn: Background Research, Presentation, Methodology, Written Report

Chelsea Lang: Background Research, COMSOL Simulation, Methodology, Written Report

Manisha Prakash: CAD Model, Simulation, Written Report

Matthew Woods: Comsol Model, Simulation, Written Report