

Lessons Learned from the Virginia Tech Helmet Ratings

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HELMET LAB
VIRGINIA TECH.

Virginia Tech Helmet Ratings

- **Virginia Tech Helmet Lab**

- Injury biomechanics research
- Research funding: NIH, NOCSAE, IIHS, NCAA, DOD

“What helmets should we buy?”

- Lester Karlin, VT Equipment Manager



Virginia Tech Helmet Ratings

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 - Injury biomechanics research
 - Research funding: NIH, NOCSAE, IIHS, NCAA, DOD
- **Virginia Tech Helmet Ratings**
 - Translational outcome of research to meet public need
 - Initially released in 2011
 - Independent of manufacturer funding
 - Supplemental testing to NOCSAE, only tests certified helmets

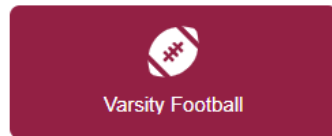
www.vt.edu/helmet

Virginia Tech Helmet Ratings

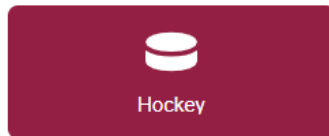


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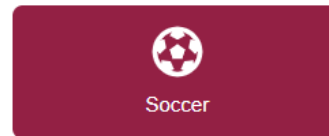
Virginia Tech Helmet Ratings



Varsity Football



Hockey



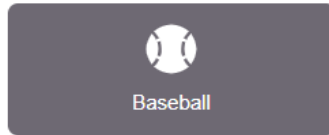
Soccer



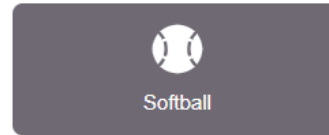
Bicycle



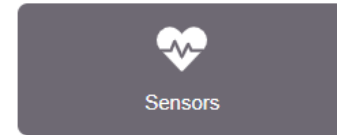
Youth Football



Baseball



Softball



Sensors

Translating Research to Reduce Concussion Risk

Since 2011, Virginia Tech researchers have been providing unbiased helmet ratings that allow consumers to make informed decisions when purchasing helmets. The helmet ratings are the culmination of over 10 years of research on head impacts in sports and identify which helmets best reduce concussion risk. This work is done as part of Virginia Tech's service mission and is 100% independent of any funding or influence from helmet manufacturers.

You can help support the helmet ratings here: [Donate Now](#)

Why rate helmets?

Although all helmets currently being sold satisfy minimum safety requirements specified by standards organizations, not all helmets are created equal. Two helmets that pass the same standard may offer different levels of impact protection. Prior to the Virginia Tech Helmet Ratings, consumers had no way of knowing which helmets were better than others. Given that helmets are a safety product, this information should be available to consumers.

What do the helmet ratings mean?

Simply stated, the helmet ratings identify which helmets best reduce concussion risk. More stars equate to better protection, with 5 stars representing the best available helmets. We encourage athletes to get out of helmets with low ratings and into 4 and 5 star helmets.

How are ratings determined for helmets?

Through a series of impact tests, helmets are evaluated using 2 fundamental concepts: 1) each test is weighted based on how frequently players experience them and 2) helmets that lower head acceleration reduce concussion risk. The impact conditions and weightings are sport-

Updates

Ratings are now available for **youth football helmets**.

Ratings are now available for popular **bike helmets**.

Ratings for **soccer headgear** have just been released.

Our **varsity football helmet ratings** have been updated to evaluate linear and rotational acceleration and now includes all current helmet models.

Virginia Tech Helmet Ratings

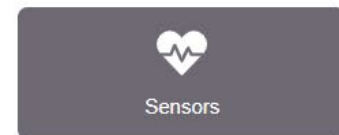
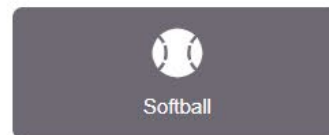
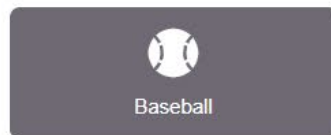
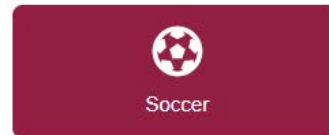
The helmet ratings program has 2 primary objectives

1. Inform consumers of relative differences between helmets in the context of concussion risk reduction
2. Provide manufacturers with a design tool to optimize helmet design to best reduce concussion risk in the real world



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Virginia Tech Helmet Ratings



General STAR Evaluation Approach

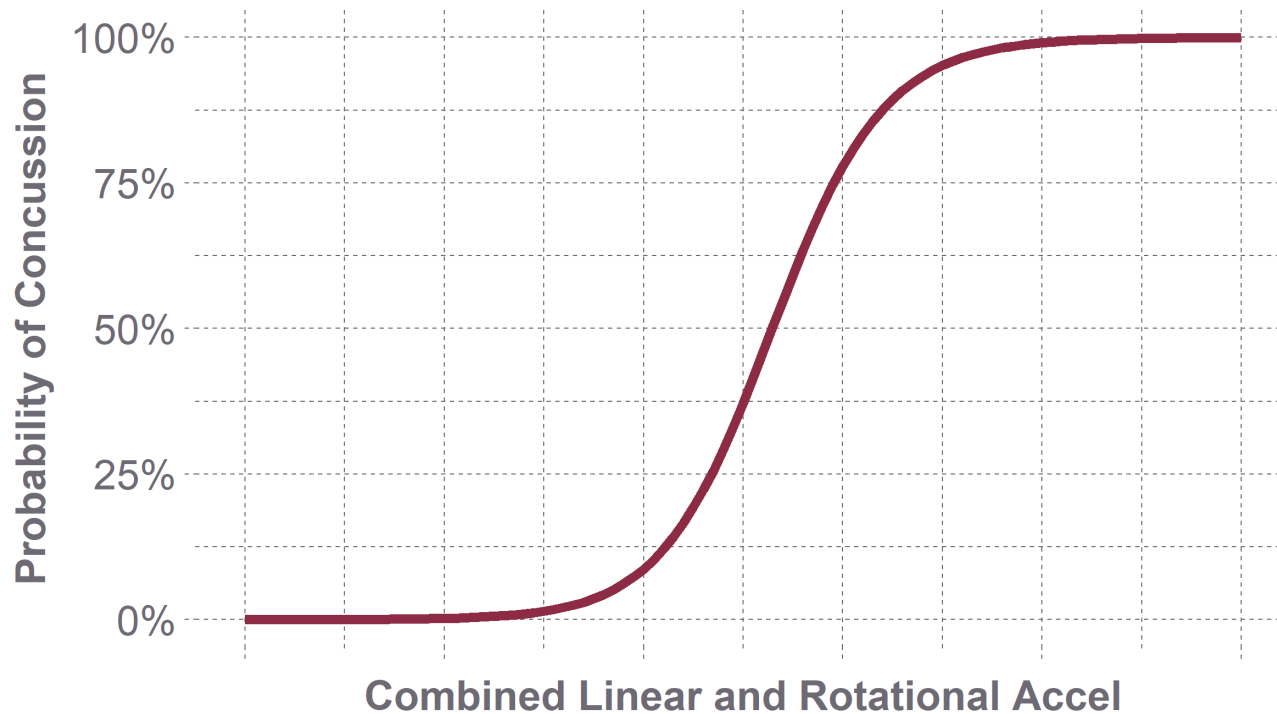
- Characterize sport-specific head impact exposure and concussion risk in the real-world
- Translate and map impact scenarios to sport-specific impact test equipment in the lab
- Evaluate helmets over range of impact locations and severities; summarize results into an overall rating



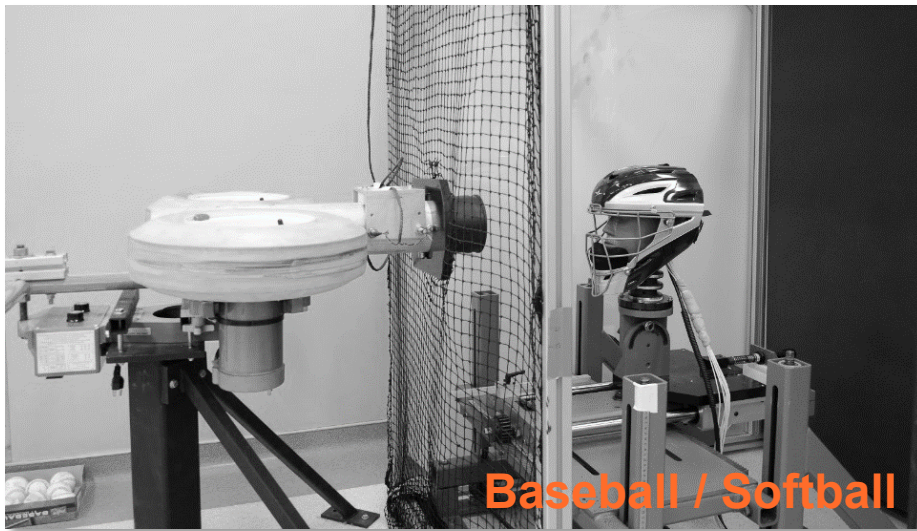
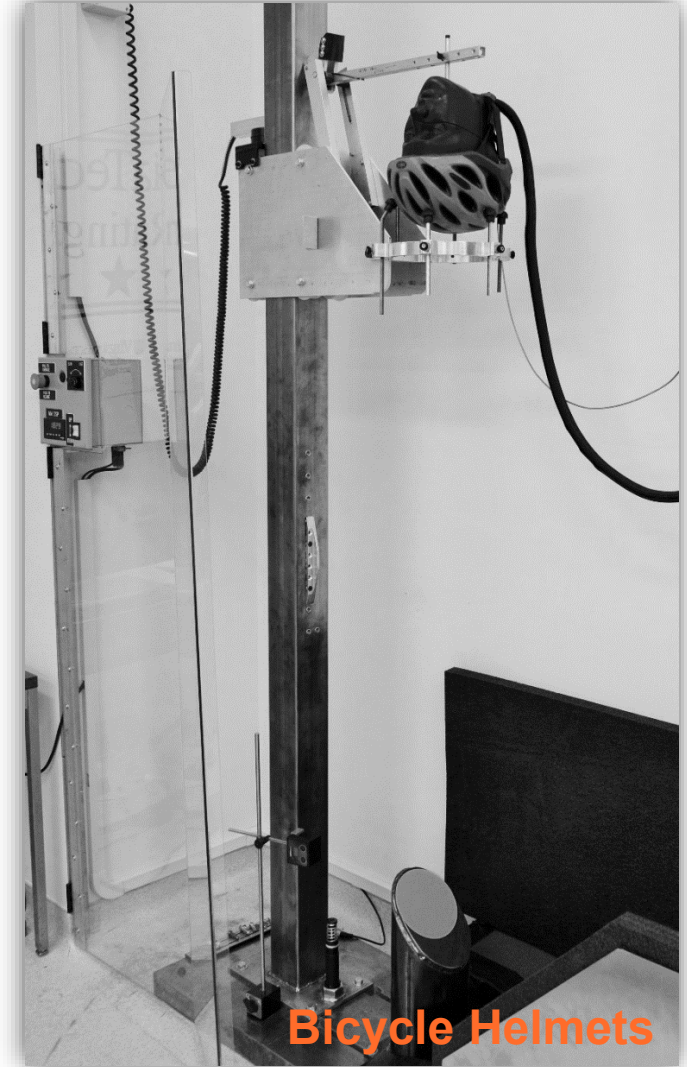
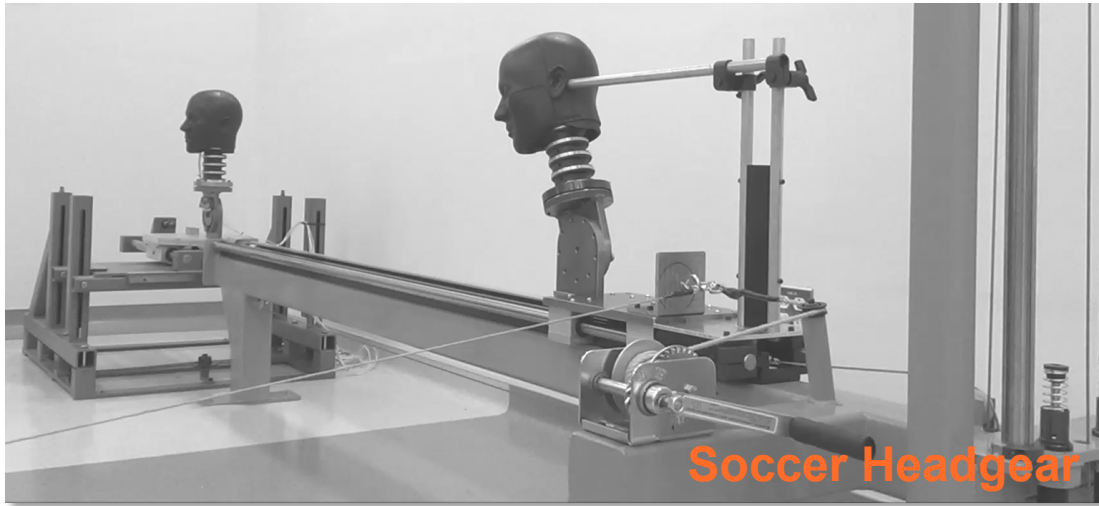
General STAR Evaluation Approach

Fundamental concepts of STAR Evaluation System

1. Tests are weighted based on how often they occur
2. Helmets that lower head acceleration reduce risk

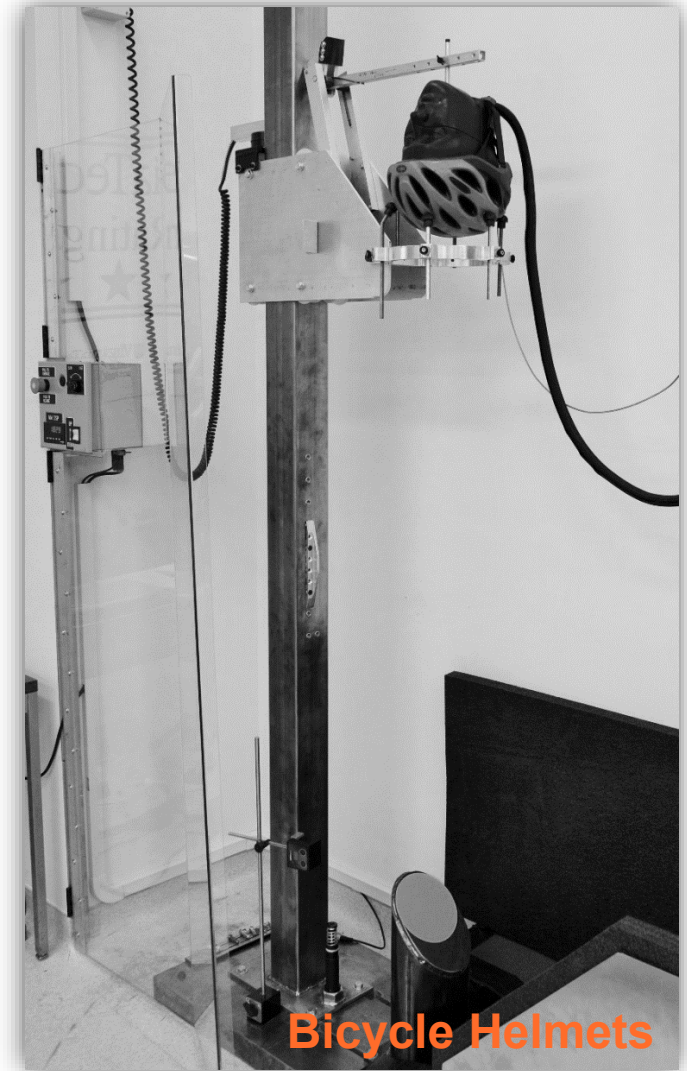


Application-Specific Test Methodologies



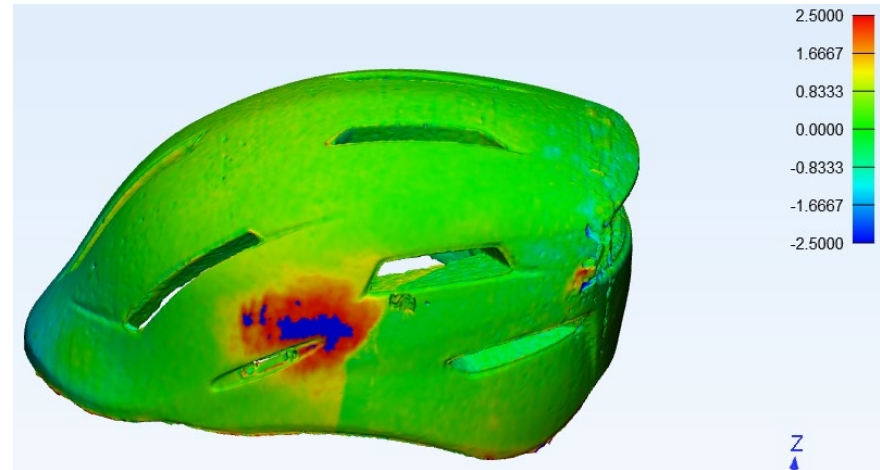
Evaluating Bicycle Helmets

- Oblique impact rig with 45 degree anvil
 - Sandpaper coated (80 grit)
- NOCSAE headforms Three linear accelerometers, tri-axis angular rate sensor at head CG
- No neck – head support ring and lever arm, dual axis inclinometer
- Velocity light gate



Damage Reconstructions

Real-world head impact characterization



- **Accident description:** “biking very fast, potentially hit a pothole, fell off bike”
- **Impact surface:** Road, pavement holes/bumps
- **Helmet surface:** large scrapes (~4.0-5.0 cm long) and slightly pockmarked anterior to max crush
- **Max crush:** 3.9 mm temporal/parietal left

Bicycle STAR: Exposure Locations

Equal weighting for all locations (1-time events)

$$\text{Bicycle STAR} = \sum_{L=1}^6 \sum_{V=1}^2 E(L, V) * R(a, \omega)$$



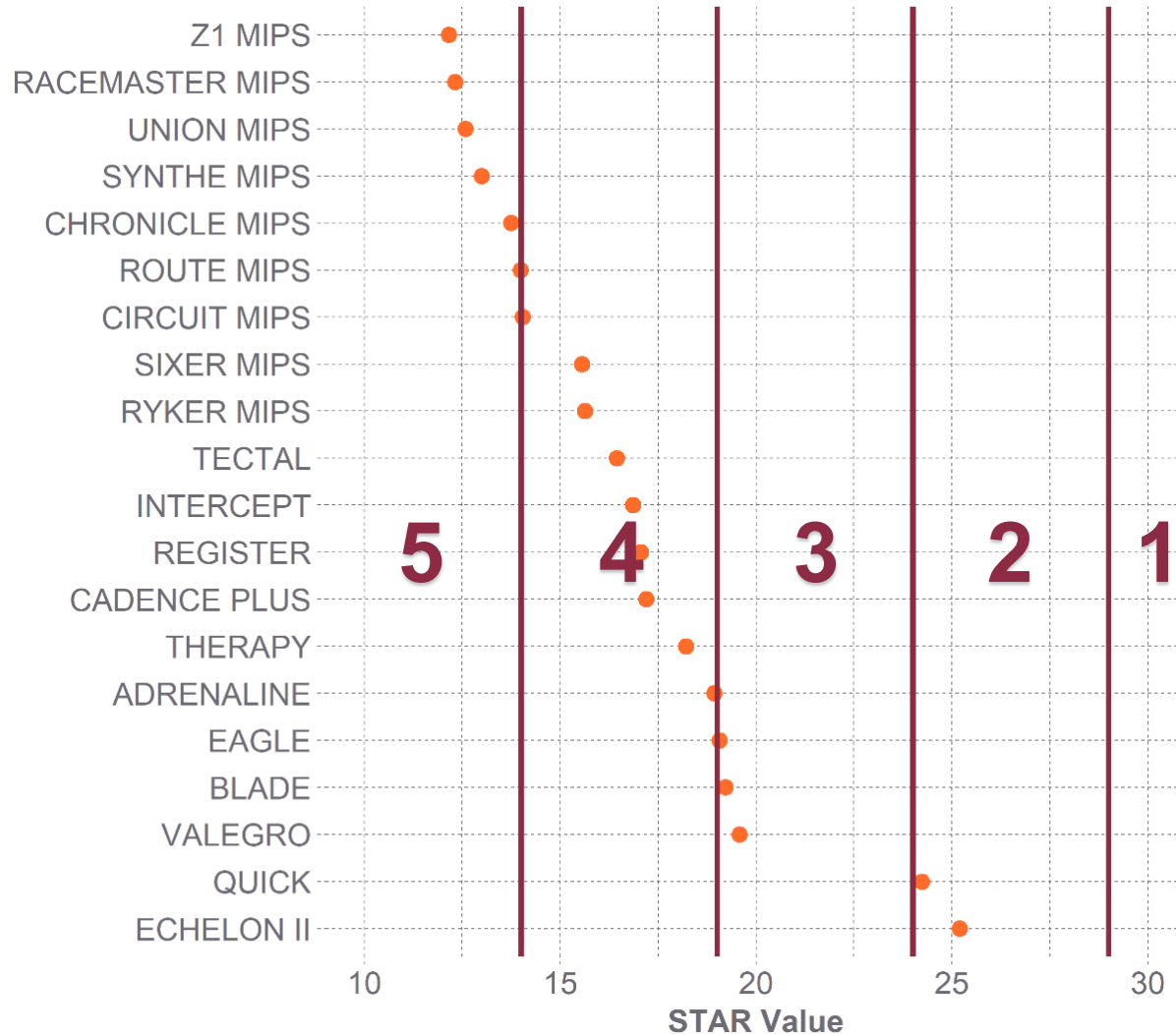
Six impact locations:

- 1 and 4 at helmet rim
 - Commonly impacted location in cyclist accidents
- Each sample impacted once per location
- Minimum spacing: 12 cm

Bicycle STAR: Example Test



Bicycle Helmet STAR Results



115 Bicycle Helmet Models Rated

Bicycle Helmet Ratings

In collaboration with the [Insurance Institute for Highway Safety](#), we have rated a total of 115 bike helmets using the STAR evaluation system. Our bicycle helmet [impact tests](#) evaluate a helmet's ability to reduce *linear acceleration and rotational velocity* of the head resulting from a range of impacts a cyclist might experience. Helmets with more stars provide a reduction in concussion risk for these impacts compared to helmets with less stars.

Wearing a helmet is most important and can be the difference between life and death in the event of a crash. These ratings supplement standards by providing additional information on which helmets best reduce concussion risk. For bike helmets, we recommend any 4 or 5 star helmet. While there are some differences in impact performance within these groups, other factors such as cost, fit, and comfort should be considered when purchasing a helmet.

Share this page on social media: [Tweet](#)

You can help support the helmet ratings here: [Donate Now](#)

- ★★★★★ : Best Available
- ★★★★☆ : Very Good
- ★★★☆☆ : Good
- ★★☆☆☆ : Adequate
- ★☆☆☆☆ : Marginal
- ☆☆☆☆☆ : Not Recommended

Only show helmets that are:

Show All	Road Style	Urban Style	Mountain Style
Skate Certified	Snow Certified	Under \$100	

Search for helmets...



Fox Dropframe Pro (MIPS)

Cost: \$200
Certifications: CPSC



Style: Mountain
Score: 8.9



Lazer G1 MIPS

Cost: \$240
Certifications: CPSC



Style: Road
Score: 9.2



Bontrager Rally MIPS



Notes

A **lower score** offers **better protection**.

Cost shown is MSRP for the helmets at the time of testing.

For proper fit, cyclists should position the helmet rim **1-2 fingers' width above the browline** and **tighten the fit system** to minimize movement of the helmet on the head.

All helmets sold in the US must be **CPSC**-certified. This standard requires protection against catastrophic injuries in extremely severe impacts, which are rare. Several helmets are certified by additional US standards. The ratings indicate helmets that pass standards for **snow** sports (ASTM F2040) or **skate** sports (ASTM F1492).

Documents

See our [test methodology](#).

My Takeaways / Lessons Learned

- **Manufacturer Buy-In**

- While not a standard, we've had an open process
- Responsive to input, questions, and concerns
- Decisions and methods backed by research, representative of real-world events
- Accessible methods
- Resonates with consumers

- **Consumer Buy-In**

- Independent / no conflict of interest
- Easily accessible and points to the research
- Publicizing the ratings

Harmonization vs. Competing Methods

Varsity Football Helmet Ratings

A total of 26 varsity football helmets have been rated using the STAR evaluation system. Our **impact tests** evaluate a helmet's ability to reduce **linear and rotational acceleration** of the head resulting from a range of head impacts a football player might see on the field. Helmets with more stars provide a reduction in concussion risk for these impacts compared to helmets with less stars.

Don't see your helmet listed below? Check out our **legacy football helmet ratings** for older models that are no longer produced.





For varsity football helmets, we recommend any 5 star helmet. While there are some differences in impact performance within this group, other factors such as cost, fit, and comfort should be considered when purchasing a helmet.

Share this page on social media: [Twitter](#)

You can help support the helmet ratings here: [Donate Now](#)

- ★★★★★: Best Available
- ★★★★☆: Very Good
- ★★★☆☆: Good
- ★★☆☆☆: Adequate
- ★☆☆☆☆: Marginal
- ☆☆☆☆☆: Not Recommended

Search for helmets...

	VICIS ZERO2 TRENCH Cost: \$859.00 Weight: 4.7 lb Score: 0.52	★★★★★
	VICIS ZERO2 Cost: \$759.00 Weight: 4.3 lb Score: 0.73	★★★★★
	Schutt F7 LTD Cost: \$975.00 Weight: 5.1 lb Score: 0.75	★★★★★
	Riddell SpeedFlex Diamond Cost: \$499.99 Weight: 4.8 lb Score: 1.69	★★★★★

Notes

A **lower score** offers **better protection**.

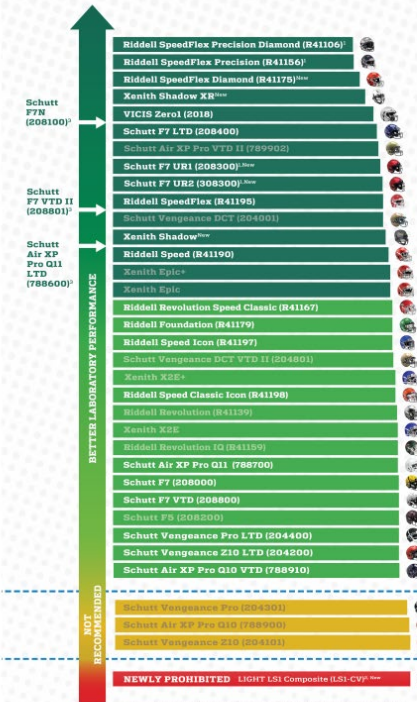
Cost shown is what we **paid** for the helmet at the time of testing.

Weight includes the helmet shell and facemask tested. We chose the **lightest standard facemask** for each helmet.

Documents

See our [test methodology](#).

2020 HELMET LABORATORY TESTING PERFORMANCE RESULTS



THE NFL, IN COLLABORATION WITH THE NFLPA, THROUGH THEIR RESPECTIVE APPOINTED BIOMECHANICAL EXPERTS, ANNUALLY COORDINATE EXTENSIVE LABORATORY RESEARCH TO EVALUATE WHICH HELMETS BEST REDUCE HEAD IMPACT SEVERITY. THE RESULTS OF THOSE TESTS, WHICH ARE GENERALLY SUPPORTED BY ON-FIELD PERFORMANCE, ARE SET FORTH ON THIS POSTER.

The helmet models are listed in order of their performance, with a shorter bar representing better performance. The rankings are based exclusively on the ability of the helmet to reduce head impact severity measures in laboratory testing. Performance variation related to helmet fit, retention, temperature-dependence, and long-term durability are not addressed in these rankings.

All helmets in green are recommended for use by NFL players. Based on a statistical grouping analysis, helmets in the Top-Performing group have been further distinguished into two different green categories. The darker green group represents those that performed better in laboratory testing than the lighter green group. Helmets with poorer laboratory performance were placed in the Not Recommended or Prohibited groups. Players may not wear helmets in the Prohibited group. The information presented here is based solely upon the results of this research and the expert opinions of the scientists involved.

Pursuant to the NFL's rules, players are required to wear helmets that are: (1) certified based on the standards established by NOCSAE (National Operating Committee on Standards for Athletic Equipment); (2) less than 10 years old; and (3) not prohibited pursuant to the NFL and the NFLPA's joint Helmet Laboratory Testing program.

The laboratory test conditions were intended to represent potentially concussive head impacts in the NFL. The results of this study should not be extrapolated to collegiate, high school, or youth football.

NO HELMET SYSTEM CAN COMPLETELY PROTECT AGAINST SERIOUS BRAIN AND/OR NECK INJURIES A PLAYER MIGHT SUSTAIN WHILE PARTICIPATING IN FOOTBALL.

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