Frequently Asked Questions

(revised October 22, 2014)

How do I interpret the STAR value?

There are two fundamental contributions of our study. First, drop tests are weighted so that they represent how often each impact scenario is experienced on the field by players. Second, helmets that better manage the impact energy by resulting in lower head accelerations will likely result in fewer injuries. The STAR value itself is a theoretical calculation that is based on a probabilistic analysis of impact exposure and injury risk. The STAR value should be interpreted as comparative information for consumers and should not be interpreted as a literal number of injuries for any one person. While there are an almost infinite number of ways to test helmets, the overall methodology must be practical. To this end, head impacts measured on the field were generalized to 20 drop test scenarios. Each helmet model had a total of 120 drop tests performed, and the data from these tests were combined to form one overall STAR value. This evaluation system is not perfect, but we believe it is a big step forward. It is important to realize that there are limitations to this study as are clearly noted in the manuscript and handouts, and there are many other factors to consider when looking at one's individual risk. In summary, our study maintains that accounting for impact exposure is a better way to evaluate helmets, and lowering head acceleration is likely to result in fewer injuries on the field.

Will wearing a highly rated helmet prevent me from sustaining a concussion?

No, any player in any sport can sustain a head injury, even with the very best head protection. The rating analysis is based on data trends and probabilities, and therefore, a specific person's risk of concussion may vary. This variation is likely dominated by genetic differences, health history, and impact factors such as muscle activation. With that said, the rating system identifies helmets that may lower a person's risk of concussion.

Only adult helmets were evaluated. Can the results be extrapolated to youth helmets?

Currently, it is unknown how youth helmets perform relative to adult helmets of the same name. Unfortunately, there are no data to indicate whether youth helmets perform better, worse, or the same as their adult counterparts. We anticipate having a paper published within the next year that will provide insight into this question. The STAR evaluation system was developed based on the head impact exposure of collegiate football players. Youth football players are likely to experience a different head impact exposure, which will require a modified evaluation system. We have begun to collect data from youth football players and recently published a journal article in the Annals of Biomedical Engineering describing the first dataset on youth head impact exposure. However, it may be two more years before we release youth specific ratings.

Daniel et al. (2012):
http://www.springerlink.com/content/r1w055654612u47j/?MUD=MP

The Virginia Tech football team wears Riddell helmets. Did Riddell sponsor this project?

No, Riddell did not sponsor this project, nor have we taken any funding from any manufacturer or NOCSAE. This research was conducted by an independent, non-profit research laboratory, without any outside influence from any helmet manufacturer, organization, or the Virginia Tech football team. The Virginia Tech – Wake Forest University School of Biomedical Engineering funded the specific helmet evaluations.

Does the STAR testing protocol represent head impacts that are actually experienced on the field?

Yes, the STAR testing protocol is based on 10 years of research where football players' helmets were instrumented with accelerometers (sensors that measure acceleration). From these data, we could determine how frequently, where on the helmet, and how hard football players' helmets were impacted. This information was then correlated to drop tests and weighted appropriately to reflect head impacts that players typically experience. Furthermore, the drop system and head form used for testing produces acceleration traces are similar to those that were measured directly from football players. The STAR testing protocol is a detailed representation of the head impacts experienced by football players.

Why test helmets in the laboratory?

The laboratory is very controlled environment to perform experiments and is the international benchmark for developing safety systems. In fact, all consumer products that undergo safety testing have tests performed in laboratories. The most comparable evaluation system to ours is the New Car Assessment Program (NCAP), where automobiles are tested in a laboratory using crash test dummies and automobiles are given a star rating based on the likelihood of injury of the occupants. Furthermore, FMVSS 208 and the Insurance Institute for Highway Safety (IIHS) also test automobiles in laboratory environments to evaluate occupant safety. Similar to the STAR evaluation system, these systems are not perfect. However, these systems have resulted in automobiles becoming safer through the testing of their performance in laboratories and making these data publicly available. Our hope is that we see this effect with head protection in football. Our system is a parallel analysis of the NCAP process, but for helmets. To learn more on NCAP: http://www.safercar.gov/Vehicle+Shoppers/5-Star+Safety+Ratings/2011-Newer+Vehicles

Has the STAR methodology been scientifically peer-reviewed?

Yes, a journal article entitled "Development of the STAR Evaluation System for Football Helmets: Integrating Head Impact Exposure and Risk of Concussion" has been published in the Annals of Biomedical Engineering (http://www.springerlink.com/content/q38r02386n43h3k2/) describing the development of the methodology of the STAR evaluation system.

Can you use on-field concussion data in NFL or college to validate your system?

One can only do this if you know the head impact exposure of all players, so that you compare apples to apples. In other words, you can only compare on-field concussion rates in players with different helmets if you know the exposure of each group of players (ie, how many head impacts and at what severity). For example, if Helmet #1 is worn by starting linebackers in the NFL and they have 5 total concussions in one year, while Helmet #2 is worn by backup quarterbacks who sustain 0 concussions that year, it is incorrect to say that Helmet #2 is better than Helmet #1 since the exposure for those groups is very different. In theory, if you knew the real exposure of all the players, then this is possible, but it is very difficult to control for all factors.

To date there have been three peer-reviewed studies that answer this question looking at on-field data. First, a high school study generally agreed with our findings (Collins et al., 2006, Neurosurgery, vol 58(2), pp 275-286). Collins et al. (2006) found a 31% reduction in relative concussion risk for players wearing Riddell Revolution helmets when compared to players wearing Riddell VSR4 helmets. Second, we published a study in 2012 (Duma and Rowson, Annals of Biomedical Engineering) where we examined 308 Virginia Tech football players over a 9 year period. We found a statistically significant 85% reduction in concussion risk for players in the Revolution compared to the VSR4. Third, we recently completed a multi-institutional analysis that found a similar statistically significant reduction in concussion risk between these two helmets. These three clinical studies confirm the findings of the STAR rating system.

Collins et al. (2006):
http://journals.lww.com/neurosurgery/Abstract/2006/02000/Examining_Concussion_Rates_and_Return_to_Play_in.9.aspx

Duma and Rowson (2012):
http://link.springer.com/article/10.1007%2Fs10439-012-0660-y

The STAR testing protocol only evaluates linear head acceleration. Why is rotational head acceleration not considered?

While all head impacts result in both linear and rotational accelerations, our study only evaluates linear acceleration for several reasons. Primarily, there is no currently accepted methodology to test for rotational acceleration. Additionally, the STAR methodology utilizes only linear acceleration, as currently there are substantial data from multiple researchers on linear accelerations relating to concussion risk. In these data, concussions are correlated with, and can be characterized by, linear head acceleration. Furthermore, our data show that linear and rotational head accelerations are highly correlated in many helmeted head impacts. In general for these impacts, lowering linear acceleration will lower rotational acceleration. There are situations where the linear and rotational accelerations may not correlate as well, but until this is understood and tested for, this remains a limitation of not only this study but many impact studies on headgear of all types.

Moving forward, we have worked with the Department of Transportation's National Highway Traffic Safety Administration to develop combined linear and rotational acceleration injury criteria collected from instrumented football players and recently published a journal article in the Annals of Biomedical Engineering (Rowson and Duma 2013). In the future, we will use this combined risk approach to account for both linear and rotational acceleration components.

Rowson and Duma 2013:

http://link.springer.com/article/10.1007%2Fs10439-012-0731-0

Tolerance to head acceleration varies with duration. Why is impact duration not considered?

While head acceleration tolerance may vary with impact duration over a broad range of general impact scenarios (sports, automobile safety, military applications), all helmeted head impacts in football are extremely similar in duration. These durations typically do not vary enough to require that duration be taken into consideration, and therefore, linear accelerations can be directly compared.

The helmets were only tested at room temperature, even though the mechanical properties of the energy management systems in helmets may vary with temperature. Are there any plans to vary testing temperature in the future?

We published a study in 2012 (Rowson and Duma, Journal of Sports Engineering and Technology) that investigated this question by examining the temperature inside football helmets over various outside weather conditions. Overall, the study found that our laboratory testing conditions are consistent with the range of in-helmet temperatures that are most commonly experienced on the field. Since our laboratory testing conditions are representative of the most common on-field conditions, we do not currently plan to test at different temperatures when evaluating helmet performance.

Rowson and Duma 2012:

http://pip.sagepub.com/content/227/1/12.short

How was the STAR testing protocol developed? Who provided input?

The STAR testing protocol was developed based on 10 years of research in which we monitored head impacts experienced by football players. We characterized all the head impacts one player may experience throughout the course of an entire season into 4 different impact locations and 5 different drop heights that could be tested using a NOCSAE drop tower system. We presented this information to helmet manufacturers, NOCSAE, CPSC, researchers, and others members of the helmet community in February 2011, approximately 3 months before we tested and released the data, so that we could get external feedback. We carefully considered each and every comment and suggestion from the broad research community, but there were no data or technical comments that offered any substantial change. Helmets were then tested and evaluated using the proposed methods.

Why was only one size helmet tested?

It is possible that the same helmet models of different size may produce different results; however, we do not have any data on this, and we only tested helmets that fit on an average sized headform. There are a near infinite number of ways to test helmets (varying temperature, impact location, helmet size, drop eight, etc…), and therefore we made generalizations so that the helmets could be tested in a practical manner.

Why were the helmets tested without facemasks?

We are not evaluating impacts to the facemask of the helmet, and we are only evaluating the ability of the helmet shell and energy management system to reduce linear head acceleration. Furthermore, NOCSAE does not test with the facemask attached to the helmet. Since we use a NOCSAE drop tower system, we removed the facemasks from all helmets to be consistent with NOCSAE protocol. In the future, we may add tests where we test with the facemask attached to the helmet.

Why were only 4 impact locations tested?

As noted above, there are a near infinite number of ways to test helmets, but we had to make several generalizations so that the helmets could be tested in a practical manner. While we don't test every location a helmet may impacted, we do generalize all impacts to 4 locations and weight the influence of each based on impact exposure. The STAR evaluation system is not intended to replace NOCSAE standards, but rather supplement them. All helmets will still be tested in accordance with NOCSAE, which includes additional impact locations, including a theoretically worst-case scenario random location.

How were helmets fit on the head form?

All helmets we tested were fit on the head form by a lab technician using the NOCSAE standards and fitting information. All helmets were fit on the head forms in the same manner using the nose gauge. Furthermore, no padding system was inflated with air to side with conservatism and to ensure all helmets were tested in the same manner. While the NOCSAE standard does allow of manufacturers to stipulate their own positioning requirements, we chose to test all helmets the same way. For example, Ford or GM cannot stipulate how crash test dummies are positioned in their automobiles that tested in the New Car Assessment Program (NCAP), and we wanted to follow that model. It is possible other fitting positions still in keeping with the NOCSAE standard may yield different results.

Why use stars to rate the different helmet models?

When we first proposed our idea to evaluate helmets and make the data public, the most common feedback we received was that we needed to interpret the data for consumers. About 20 years ago, the National Academy of Science generated a report to encourage the simplification of safety evaluations. The National Highway Traffic Safety Administration (NHTSA) subsequently developed a 5 star system based on extensive consumer studies, and this 5 star system was later implemented in the New Car Assessment Program (NCAP). Currently, the safety and performance of many systems in the United States are evaluated on a star system, including automobiles and hospitals. The star system presents the best way for consumers to understand complicated safety analyses.

How were the star ratings assigned to different helmets?

STAR values were assigned a rating based on predetermined thresholds that were determined based on a previous statistical analysis performed for the May 2011 STAR values. This is a similar method to the New Car Assessment Program (NCAP) that the National Highway Traffic Safety Administration uses to rate the safety of new vehicles. NCAP has defined injury risk ranges that are used to determine the number of stars a car is rated with. Moreover, NOCSAE utilizes thresholds for their standards. This approach requires the manufacturer to design their products to ensure random sampling will provide the desired results. Along these same lines, the Virginia Tech Helmet Ratings™ have defined STAR value ranges that are used to determine the number of stars a helmet is rated with. The thresholds are detailed in the methodology documents and are as follows: a 5 star rating is given for STAR values of 0.299 or lower; a 4 star rating is given for STAR values ranging from 0.300 to 0.399; a 3 star rating is given for STAR values ranging from 0.400 to 0.499; a 2 star rating is given for STAR values ranging from 0.500 to 0.699; a 1 star rating is given for STAR values ranging from 0.700 to 0.999; NR is given for STAR values equal or greater than 1.000.