MEMORANDUM

TO: NFL Players
Head Athletic Trainers
Equipment Managers

FROM: Dr. Jeff Crandall, Chairman Engineering Subcommittee
Dr. Thom Mayer, NFL Players Association Medical Director

DATE: July 31, 2015

RE: Helmet Testing Study

The National Football League, in collaboration with the National Football League Players Association, has sponsored a study to assess the performance of football helmets worn by NFL players. The following is a brief description of the study design, analysis, results, and limitations.

Study Design

The helmet study involved laboratory testing of helmets under conditions simulating a subset of the concussion-causing impacts sustained by NFL players during games. The tests did not evaluate on-field, real-time or real-world impacts sustained by NFL players. It is expected that the results of the helmet testing will lead to further research studies with the goal of better understanding the biomechanics of concussion in real-time impacts and, therefore, further improve player safety.

The tests were conducted by an independent helmet testing laboratory. The study formulation, experimental design, and data analysis were performed by members of the NFL Head, Neck, and Spine Engineering Subcommittee in collaboration with two NFLPA appointed consultants, Dr. Barry Myers and Dr. Kristy Arbogast. An independent biostatistician, Dr. Timothy McMurry, was retained to assist in the analysis of the data. The results have been presented to the NFL's Head, Neck and Spine Committee, and to the NFLPA and its Medical Director, Dr. Thom Mayer.

The laboratory testing involved 17 helmet models expected to be used by NFL players during the upcoming 2015 season. A preliminary survey of helmets used by NFL teams was conducted to assess the frequency of helmet model use in the NFL and to ensure that all or nearly all helmet models used by players were included in the testing. Our preliminary survey suggests that more than 99% of players are wearing helmet models that
were tested in this study. Helmets from all leading helmet companies were tested and each manufacturer has had the opportunity to review the results for its products. The test matrix included helmets from five manufacturers - Riddell, Schutt, Rawlings, Xenith, and SG Helmets – and all manufacturers approved the choice of the helmets selected. Helmets were obtained directly from the manufacturers along with a corresponding facemask (Eyeglass and Oral Protection (EGOP) style or equivalent) and a soft chinstrap.

All helmets met the current National Operating Committee on Standards for Athletic Equipment (NOCSAE) certification to protect players against severe traumatic skull and brain injuries and may therefore be used by players. The laboratory testing involved three impact velocities representing conditions associated with concussions and severe impacts sustained during open-field collisions. The helmets were impacted at eight locations, including the facemask, front, side, and rear of the helmet, to represent the most commonly observed points of contact in reviews of NFL game films. At least one helmet of each model was tested in every combination of impact location and velocity. In order to assess repeatability, six helmets were tested multiple times at the same conditions and all repeated tests were included in the analysis.

The laboratory tests were conducted using a linear impactor. Design requirements for the system included the ability to impact at speeds representing on-field collisions, to vary helmet contact locations, and to replicate the response characteristics of a player’s helmet and head following impact. The cap on the end of the impactor mimicked the interior pad and outer plastic shell of a striking player’s helmet. The mass of the impactor approximated the effective mass of the striking player’s head, neck, and upper torso.

The impactor struck large size helmets that were fitted to the Hybrid III head form and neck assembly per manufacturers fitting guides and standardized fit procedures. The Hybrid III is a crash test dummy that has been used in previous evaluations of helmet performance. The inclusion of a flexible neck permitted head rotational and translational kinematics during the impact in order to simulate better the player’s reaction following a collision. The dummy head was instrumented with sensors that measured the severity of the impact forces transmitted to the head.

This study is different from previous helmet testing in that helmet performance was assessed using a combined measure of head impact severity that included the Head Injury Criterion (HIC), rotational head acceleration, and rotational head velocity. Previously, helmet performance has been evaluated using only a single measure of head impact severity, usually based solely on linear head acceleration. However, there is mounting scientific evidence that concussions have a component of their injury caused by rotational motions of the head impact. Other groups such as NOCSAE and Virginia Tech intend to add rotational measures to their testing in the future.

Data Analysis

The performance of the 17 helmets in these laboratory tests was evaluated across all impact velocities and locations and compared with one another. A statistical test was used to group helmets with similar performance scores. Helmets outside a grouping were considered significantly different.
Results

The performance of each helmet is shown graphically on the attached poster. The helmets are listed in rank order based on their performance score. A top group of helmets that performed similarly was identified using a statistical analysis and is shown in green on the poster.

Interpretation and Limitations

The NFL and NFLPA believe the information on helmet performance evaluation has value for NFL players when selecting a helmet. There are a number of limitations to the study, however, that must be considered. First, no helmet system can completely protect against serious brain and/or neck injuries a player might receive while participating in football. Second, the evaluation was a laboratory based study with conditions that are not necessarily representative of the breadth and variety of scenarios that players may experience on the field during a game. For example, the testing conditions of this study simulated player open-field collisions and the representativeness of these collision scenarios to other impact conditions such as those occurring at the line of scrimmage or in pileups remains unknown. In addition, other potential contributing factors for concussion, such as player position, concussion history, and helmet fit were not studied as part of this laboratory-based investigation. Some players may use helmets provided by one manufacturer but facemasks or chinstraps from another. Finally, it is important to emphasize that these results were based on testing intended to represent NFL impacts and thus, the conclusions on helmet performance cannot be extrapolated to collegiate, high school, or youth football.
Questions and Answers related to the NFL/NFLPA Helmet Evaluations

1. Are players required to wear one of the helmets in the top performing group?

No. As in prior seasons, players may wear any helmet that is certified by NOCSAE. All of the helmets tested were NOCSAE certified.

2. Am I unsafe if I don't wear one of the top-performing helmets?

No. All of the helmets tested have been certified by NOCSAE. The laboratory tests conducted in this study demonstrated that some helmets, those in the top performing group, performed better than other helmets in these tests. While the tests were done to replicate impacts experienced in NFL games, it is important to remember that the testing was done in a laboratory, not on the field, and only involved a limited number and type of impacts. The NFL Head, Neck, and Spine Engineering Subcommittee is working in conjunction with other experts to characterize a broader set of collision scenarios experienced by NFL players for use in future helmet evaluations.

3. What, if anything, did this study contribute?

It uses the best laboratory technology to evaluate how helmets manage forces that have been associated with concussion sustained in open-field hits. Importantly, this study is the first of its kind to account for both rotational velocity and rotational acceleration in measuring the performance of the helmets. There is mounting scientific evidence that concussions have a component of their injury caused by rotational motions of the head impact. The NFL and NFLPA believe this data, and the resulting helmet groups, may provide important information to be shared with players about helmet safety. We also know that there is a lot more work to be done and this study, while important, comprises only a part of broader research and education initiatives.

4. If I wear one of the top-performing helmets, how much will it decrease the risk that I will sustain a concussion?

This study assesses the relative performance of helmets in controlled laboratory test conditions and cannot be used to predict a specific reduction in risk on the field. There are many other factors to consider when assessing risk including fit of the helmet, player position, player’s medical history, and type of impact.

5. Was there failure of any helmets?

There were no gross failures of any helmet components but several helmets did sustain damage. Chinstraps tore or pulled through the buckles in a few severe impacts. Buckles came undone on some of the facemask impacts. One of the facemask attachment clips on the Xenith X2E helmet broke in the most severe facemask impact. There was a crack in the liner and some permanent crush of the foam at the rear location of the SG Varsity helmet tested in the most severe condition.
6. I wear a helmet that is not in the top performing helmet group and have been happy with it. The helmet fits, it is comfortable and I haven't had any problems. What should I do?

If you are satisfied with your current helmet, and it is certified by NOCSAE, there is nothing to prevent you from continuing to use that helmet. If at some point in the future you consider switching helmets, the results of the current study may be considered when making your helmet choice.

7. I am not happy with my current helmet and would like to switch. How do I choose from the helmet ratings?

This study’s helmet evaluation should be regarded as one component used in assessing which helmet works best for a player. The equipment managers of each team are knowledgeable on the fit and performance of helmets. Therefore, it is recommended that you work with your team’s equipment manager to ask questions and ultimately select a helmet that works best for you.

8. I use a facemask from a different manufacturer than my helmet. Was that considered in the testing?

No. The helmets tested included helmets and parts from the same manufacturer.

9. My helmet is a Virginia Tech five star helmet but is not in the top performing group of your study. How can this happen?

There are several differences between the Virginia Tech star rating and this study. First, the test apparatus and hardware used in this study allowed both translational and rotational motion of the head similar to what a player experiences when the helmet is impacted on the field. The Virginia Tech star rating system currently evaluates only translational motion of the head in their football helmet ratings although they have announced plans to evaluate rotational measures in the future. In addition, the open-field conditions chosen for our helmet evaluation represent impacts that are significant or caused concussion in the NFL. The Virginia Tech ratings assess helmets and weight results based on findings from collegiate players wearing instrumented helmets across a broad range of impact severities, including more mild impacts that did not cause concussion. Given these differences, the Virginia Tech ratings are worth considering in conjunction with the findings of this study when you make your helmet choice. Understanding the differences between the two studies and therefore the results should help your decision making.

10. You explained that you considered rotational motion of the head in your analysis of the helmets. Why does this matter?

There is mounting scientific evidence that concussions have a component of their injury caused by rotational motions of the head impact. Both NOCSAE and Virginia Tech have proposals to incorporate rotational metrics in their future testing. In this study, we included two rotational predictors associated with head injury and used both to assess helmet performance.
11. You have said that there is a lot more work to be done. What is the next step?

The NFL and NFLPA are looking at a number of related projects to document on-field performance of helmets. When a player sustains a concussion in a game or practice, information on the player’s position, type of play, contacting surface, and the helmet model is being collected with the NFL Injury Surveillance System. We will periodically compare the on-field performance of helmet models to their corresponding performance in the laboratory testing.

12. Who from the NFL and NFLPA designed the experiments and conducted the analysis?

The experimental design and data analysis was performed by members of the NFL Head, Neck, and Spine Engineering Subcommittee, led by Dr. Jeff Crandall, in conjunction with two NFLPA appointed consultants, Dr. Barry Myers and Dr. Kristy Arbogast. An independent biostatistician, Dr. Timothy McMurry, was retained to help with the analysis of the data. The results were reviewed by doctors on the NFL Head, Neck & Spine Committee and by the NFLPA’s Medical Director, Dr. Thom Mayer.

13. Who performed the testing?

The testing was conducted by an independent testing facility, Biokinetics Inc. of Ottawa, Canada. Biokinetics developed the linear impactor and test hardware that was used in the current study. Biokinetics has over 40 years of impact testing experience and has recognized expertise in helmet testing.