Biomechanical performances of old-fashioned leather and modern football helmets

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Researchers at the Center for Injury Biomechanics at Virginia Tech in Blacksburg, Virginia compared the relative safety afforded by two 1930-vintage leather football helmets and 10 modern football helmets during impacts to players' heads. These researchers found that all 10 modern helmets provided significantly more protection than leather helmets used in the first half of the twentieth century, and demonstrated that differences also exist between modern helmets. Details on their methods and findings are found in "Biomechanical performance of leather and modern football helmets. Technical note," by Steven Rowson, Ph.D., Ray W. Daniel, M.S., and Stefan M. Duma, Ph.D., published today online, ahead of print, in the *Journal of Neurosurgery*.

The authors evaluated leather and modern football helmets by performing a series of 20 drop tests that represent a variety of impacts that could occur during a football game. An anthropometric head form was placed on an adjustable mount suspended from an overhead carriage. Each helmet in turn was placed on the head form, which was dropped in a controlled fashion from heights of 12, 24, 36, 48, and 60 inches onto a standardized anvil to simulate impacts delivered from blows to the head during play. The head form was placed in four different positions before impact simulation—front, side, rear, and top according to which surface of the head form faced downward—so that linear acceleration of the helmeted head form in each position could be measured.

Drop tests were used to measure the performance of two Hutch H-18 leather football helmets and 10 modern football helmets that differed in model, manufacturer, and 2011 Virginia Tech Helmet Rating (measured as 5 stars, best available; 4 stars, very good; 3 stars, good, 2 stars, adequate; 1 star, marginal; and no star, not recommended). Each modern helmet was subjected to all 20 drop tests (4 impact locations at 5 drop heights). Each vintage leather helmet was subjected to 12 drop tests; the 48- and 60-inch drop tests were not undertaken because it was feared that accelerations from those heights might damage the head form when covered by vintage helmets. Drop testing of modern helmets was conducted during an earlier study, at which time the modern helmets were assigned star ratings. Drop testing of vintage helmets was undertaken for the present investigation.

The ten modern helmets were split into two groups: six helmets with a four- or five-star rating in the first group and four helmets with a three-star or lower rating in the second group. The two vintage helmets constituted a third helmet group. Based on the results of the drop tests, the researchers calculated each helmet group's average peak accelerations for each head form position and each drop height.

Rowson and colleagues found that vintage leather helmets were associated with substantially greater peak accelerations for each drop height than all modern helmets. In addition, the researchers found modern helmets reduced the concussion risk by 45% for the 24-inch drop height and 96% for the 36-inch drop height. Modern helmets with lower star ratings had greater peak accelerations for each drop height than modern helmets with higher star ratings, and the differences in peak accelerations between the two modern helmet groups increased with each increase in drop height. All comparisons were statistically significant at a level of p The authors state that the purpose of the technical note is to provide insight as to how a previous study (Bartsch A et al. Impact test comparisons of 20th and 21st century American

football helmets. Laboratory investigation. *J Neurosurg* 116:222, 2012) could find little difference between older and modern helmets with respect to head impact doses and head injury risks at the severity level of subconcussive injury. Rowson and coauthors state that they offer "biomechanical analysis based on helmet testing methodologies that compare relative helmet performance." The source of their disagreement with the Bartsch study centers on the different methods used by the authors of the two studies. Much of the discussion explains how differences in impact testing methodologies can influence the resulting data.

In an editorial companying the paper by Rowson and colleagues ("Editorial. Leather football helmets," by Adam Bartsch, Ph.D., Edward Benzel, M.D., Vincent Miele, M.D., and Vikas Prakash, Ph.D., also published today online, ahead of print in the *Journal of Neurosurgery*), Dr. Bartsch and colleagues defend the study they published in the Journal of Neurosurgery in 2012 and state that differences in results between the two studies are based on the different testing methodologies used by the two groups of researchers and the resulting head motions that were induced. They state that their study simulated both linear and rotational head motion, whereas the drop test used by Rowson and colleagues provided mainly linear head motion. Bartsch and colleagues reiterate that their data demonstrated test conditions akin to common on-field impact scenarios, which cause both linear and rotational head motion. These researchers call for continued examination of experimental protocols that may lead to better quantification of helmet performance during simulated on-field conditions.

In their response to the editorial, Rowson and colleagues discuss points of difference and agreement between the two sets of researchers and their methodologies.

More information: Rowson S, Daniel RW, Duma SM. Biomechanical

performance of leather and modern football helmets. Technical note, *Journal of Neurosurgery*, published online, ahead of print, May 7, 2013; DOI: 10.3171/2013.3.JNS121735.

Editorial: Bartsch A, Benzel E, Miele V, Prakash V. Editorial. Leather football helmets. *Journal of Neurosurgery*, published online, ahead of print, May 7, 2013; DOI: 10.3171/2012.12.JNS122174.