

Comparison of Shell-Facemask Responses in American Football Helmets during NOCSAE Drop Tests

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Abstract : This study compares the shell-facemask responses of four commonly used American football helmets, under the National Operating Committee on Standards for Athletic Equipment (NOCSAE) drop impact test method, to show that the test standard would more accurately simulate in-use conditions by modification to include the facemask. In our study, the need for a more vigorous systematic approach to football helmet testing procedures is emphasized by comparing the Head Injury Criterion (HIC), the Gadd Severity Index (SI), and peak acceleration values for different helmets at different locations on the helmet under modified NOCSAE standard drop tower tests. Drop tests were performed on the Rawlings Quantum Plus, Riddell 360, Schutt Ion 4D, and Xenith X2 helmets at eight impact locations, impact velocities of 5.46 and 4.88 meters per second, and helmet configurations with and without facemasks. Analysis of NOCSAE drop test results reveal significant differences ($p < 0.05$) for when the facemasks were attached to helmets, as compared to the NOCSAE Standard, without facemask configuration. The boundary conditions of the facemask attachment can have up to a 50% decrease ($p < 0.001$) in helmet performance with respect to peak acceleration. While generally, all helmets with the facemasks gave greater HIC, SI, and acceleration values than helmets without the facemasks, significant helmet dependent variations were observed across impact locations and impact velocities. The variations between helmet responses could be attributed to the unique design features of each helmet tested, which include different liners, chin strap attachments, and faceguard attachment systems. In summary, these comparative drop test results revealed that the current NOCSAE standard test methods need improvement by attaching the facemasks to helmets during testing. The modified NOCSAE football helmet standard test gives a more accurate representation of a helmet's performance and its ability to mitigate the on-field impact.

Keywords : football helmet testing, gadd severity index, head injury criterion, mild traumatic brain injury

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