Towards advanced bicycle helmet test methods

R. Willinger[1], C. Deck[1] P. Halldin[2], D. Otte[3]

[1] ICUBE, CNRS-Biomechanics
University Strasbourg
2 r Boussingaults, Strasbourg, France
e-mail: remy.willinger@unistra.fr

[2] KTH and MIPS
University Stockholm
Stockholm, Sweden
e-mail: peter.halldin@kth.se

[3] MUH
University of Hannover
Hannover, Germany
e-mail: dietmar.otte@MUH.de

ABSTRACT

This paper exposes a critical analysis of current bicycle helmet standard tests and proposes an advanced test method. Different key aspects are considered consecutively, i.e. the bicyclist's head impact conditions in terms of velocity vector, head form boundary conditions, the head form itself with its instrumentation, the geometry of the impacted surface, the head impact location and finally the head injury criteria.Based on in deep analysis of bicycle accidents it has been shown that a significant component of the head velocity vector at the time of impact is the tangential velocity. On the other hand it has been shown that the head boundary condition at neck level does not play a significant rôle in the head response following to impact. Therefore it is suggested to consider tangential impacts against a helmeted Hybrif III dummy head, eventually connected to a Hibrid III neck. A critical analysis of the geometry of the impacted surface and the temperature at the time of accidents will be presented as well.
The current ISO head form presents a rigid contact surface with the helmet liner which is quite fare from human scalp-helmet interface. Therefore it is recommended in this proposal, to use a head form with a skin such as the Hibrid III dummy head. This improved head surrogate also presents the advantage to be fitted easily with rotational accelerometers, and to be connected to the Hibrid III neck without further modifications. Finally this head form presents mass and inertia properties much closer to the human head as ISO head form does.
The location of head impact in the current standard presents two key issues : The difficulty to guarantee an impact in line with the head form center of mass and thus to not miss any energy through non recorded rotational phenomenon, and the recommended test line which excludes impacts to the temporal region which is often impacted in real world accidents. It is therefore suggested to prescript specific impact points in a similar way as for motorcycle helmets.
A final and acute issue with current bicycle helmet standard test is the head injury taken into consideration and related to results from the 1950's, as the threshold is still expressed in terms of acceleration amplitude and duration. In order to take into account the linear and rotational acceleration of the head after impact as well as improved model based head injury criteria, a coupled experimental versus numerical method is suggested in order to assess the head injury risk in a more realistic way. In this method the helmeted head form is impacted in the previously descript impact conditions and the six head form acceleration versus time curves are implemented into a FE head model in order to compute the intra-cranial head response and to compare it to the model based head injury criteria. It is believed that the proposed approach would permit the evaluation and optimization of bicycle helmets against biomechanical criteria and under realistic impact conditions.

Keywords: bycicle helmet, test method, impact conditions, head injury criteria