FEI HELMET WORKING GROUP TECHNICAL REPORT - NEW TESTING PROTOCOL *7 December 2023*

Background

As part of the FEI's ongoing work to improve athlete safety, the FEI Helmet Working Group was established in April 2023. The Group was given a remit to review current literature and testing standards in order to evaluate whether additional testing recommendations should be considered with the goal of improving the standards for protective headgear in equestrian sport.

The FEI Helmet Working Group is made up of a panel of international experts from the worlds of engineering, standards, manufacturing, medicine, and horse racing, as well as a representative from elite level Eventing athletes.

The FEI Helmet Working Group is chaired by Dave Vos, PhD. The Group members are:

- Matt Stewart, Head of Innovation, Charles Owen Helmets
- Geoff Sinclair, Chair of the FEI Eventing Risk Management Steering Group
- Madelen Fahlstedt, PhD Mips AB
- Jerry Hill, Chief Medical Adviser British Horseracing Authority
- Sam Watson, Irish Olympic Eventing athlete
- Constantin Coussios, PhD. Statutory Chair in Biomedical Engineering and Director of the Podium Institute in Sports Medicine & Technology, University of Oxford
- Dr. Adrian Mc Goldrick, Former CMO, Irish Horseracing Regulatory Board
- Helena Stigson, PhD Karolinska Institutet, Folksam Insurance Group
- Mark Hart, MD, Chair of the FEI Medical Committee.

Purpose of this document

The purpose of this document is to outline the rationale for reduced energy transmission to the brain by a new testing protocol for equestrian helmets that better reflects real life rider fall scenario and helps reduce risk of concussion injury.

1. Rationale

1.1 Data set

In order to have a measure of when we have achieved success, it is helpful to consider risk of concussion in various equine sports.

The data from the FEI Eventing Risk Management Group is the most comprehensive of the equestrian disciplines.

In 2022, FEI Eventing worldwide, the following rough numbers apply regarding concussion:

- Rider fall rate of 1 in ~24 starts (2022: 21,470 starters, 912 rider falls) across all levels and competitions
- Rider concussion rate of 1 in ~69 falls, or more accurately, 1 in 1263 starts

- Concussion rate of 1 in 16 falls associated with minor[1] injury, with 1 minor injury every 9 falls
- Concussion rate of 1 in 3 falls associated with serious[2] injury, with 1 serious injury every 42 falls.

1.2 Targets

A reasonable target likelihood of concussion per start could arguably be to reduce from 1 in 1263 to 1 in 2500 starts, i.e., a roughly 50% reduction in concussion rate.

This would represent significant progress in helmet performance and might well be achievable through judicious selection of the performance characteristics and thresholds. We recognize the goal is aggressive and will work with the broader community with timely review and adjustment of performance requirements over time along the road to reaching this objective.

1.3 First principles perspective on a fall

- Impacts from a fall are most often comprised of both forward and vertical velocity
- Helmets need to perform well in all of these impact cases, i.e., vertical motion only, as well as vertical plus horizontal motion
- This translates into the observation that additional test load cases to reduce risk must include combined linear and rotational components. Rotational strain is well established as the leading risk domain for concussion so this is a very important step for progress.

1.4 First principles perspective on allowable transmitted loads for helmets

- Knowledge about combined translation/rotation loads have been in the literature since early 2000s timeframe driven by instrumented concussion event measurements in American football, but requirements to address this critically essential aspect have not been included in equestrian helmet standards
- The helmet should attempt to reduce transmitted loads to below concussion thresholds
- Helmet test drop height 2.2m
- Combined translational plus rotational transmitted load test. Impact on a 45 deg anvil with high friction surface
- Transmitted loads to headform for the 45 deg anvil test not to exceed 150g translational and 5500rad/s/s angular acceleration.

2. Conclusion: recommended additional requirements for equestrian helmets

1) Meet at least two of latest versions of the helmet standards PAS, ASTM, EN, Snell;
2) Use latest test headform;
3) Meet combined translation/rotation 45 deg anvil test from 2.2m drop height, with no greater than 150g and 5500rad/s/s transmitted accelerations;
4) Include multiple test locations on the helmet;
5) Use a testline that represents the union of helmet head testline coverage defined in the various standards,
6) Incorporate compression (crush) load cases.

[1] Minor injury: one or more of the following injuries: sprains, bruises, and cuts judged not to be severe, treated on site -
[2] Serious injuries: can be categorised as those that, in the opinion of the referring doctor, would require hospital admission for immediate treatment. Examples: major fractures (including all compound fractures, but excluding simple fractures of clavicle and wrist), crush injuries with suspicion of pneumothorax, ruptures spleen etc.

These summary points have been unanimously agreed to by this group. Many items are already being incorporated, and are complimentary to the above-mentioned standards bodies' activities, and in addition provide strong guidance about adjusting threshold levels accounting for translational and rotational loads resulting from impact with both forward and downward motion, by adding the use of the angled anvil test.

The Group's desired outcome with this document is to reduce risk of equestrian sport concussion injury by encouraging the development of higher performance products, through collaboration with the standards bodies to include the above points in their qualification tests for improved rider safety.

Selected references:

1. Clark JM, Adanty K, Post A, Hoshizaki TB, Clissold J, McGoldrick A, Hill J, Annaidh AN, Gilchrist MD. Proposed injury thresholds for concussion in equestrian sports. Journal of science and medicine in sport. 2020 Mar 1;23(3):222-36.
2. Brain injury prediction: Assessing the combined probability of concussion using linear and rotational head acceleration. Rowson and Duma. BMES, Jan 2013
3. No evidence for a cumulative impact effect on concussion injury threshold. Eckner et all. Journal of Neurotrauma 2011
4. Table 1: "Published linear and angular accelerations thresholds for concussion" (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10330964/table/T1/?report=objectonly) from Tiernan S, Meagher A, O'Sullivan D, et al. Concussion and the severity of head impacts in mixed martial arts. Proceedings of the Institution of Mechanical Engineers, Part H: Journal of Engineering in Medicine. 2020;234(12):1472-1483. doi:10.1177/0954411920947850

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