BÄST I TEST
Folksam
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# 15 Equestrian Helmets 2018 Tested by Folksam

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Folksam

**This is why we test equestrian helmets**

Approximately half a million Swedes rides a horse regularly. For Folksam it is important that our customers who are preforming this activity are well protected if an accident should occur. The equestrian helmets of today meet the essential requirements regarding personal protective gear. As a consumer, it is difficult to know what characterizes a safe helmet. Our aim is to help consumers in their choice and to influence manufacturers to design safer helmets. That is the reason behind our engagement in consumer tests of helmets.

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## Summary

Folksam has tested 15 equestrian helmets on the Swedish market for children and adults. All helmets included in the test have previously been tested and approved according to the CE standard, which means that the energy absorption of the helmets has been tested with a perpendicular impact to the helmet. This does not fully reflect the scenario in an equestrian accident. In a fall from the horse or horse kick, the impact to the head will be oblique. The intention was to simulate this in the tests since it is known that angular acceleration is the dominating cause of brain injuries. The objective of this test was to evaluate helmets sold on the Swedish market. Four physical tests were conducted, shock absorption with straight perpendicular impact and three oblique impact tests. Computer simulations were made to evaluate injury risk.

In seven helmets a linear acceleration lower than 200 g were showed, which corresponds to a low risk of skull fracture. The simulations indicated that the strain in the grey matter of the brain during oblique impacts varied between helmets from 16% to 51%, where 26% corresponds to 50% risk for a concussion. The two helmets equipped with Multi-directional Impact Protection System (MIPS) performed in general better than the others. However, all helmets need to reduce rotational acceleration more effectively. A helmet that meets the current standards does not necessarily prevent concussion. In total three helmets obtained the Folksam best in test or good choice label: Back on *Track EQ3 Lynx, Back on Track EQ3* and Charles Owen Ayr8. The helmet Back on Track EQ3 Lynx performed best and was 30% better than the average helmet. Both the *Back on Track EQ3 Lynx and Back on Track EQ3* are fitted with MIPS (Multi-directional Impact Protection System) with the intention to reduce the rotational energy.

The current European certification test standard do not cover the helmets' capacity to reduce the rotational acceleration, i.e., when the head is exposed to rotation due to the impact. The present study provides evidence of the relevance of including rotational acceleration in consumer tests and legal requirements. The results have shown that rotational acceleration after impact varies widely among helmets in the Swedish market. They also indicate that there is a link between rotational energy and strain in the grey matter of the brain. In the future, legal helmet requirements should therefore ensure a good performance for rotational forces as well. Before this happens, consumer tests play an important role in informing and guiding consumers in their choice of helmets. The initial objective of the helmet standards was to prevent life threatening injuries but with the knowledge of today a helmet should preferably also prevent brain injuries resulting in long-term consequences. Helmets should be designed to reduce the translational acceleration as well as rotational energy. A conventional helmet that meets current standards does not prevent an equestrian from getting a concussion in case of a head impact. Helmets need to absorb energy more effectively.

## Method

In total, 15 conventional helmets were selected from the Swedish market. To ensure that a commonly used representative sample was chosen, the range helmets available in shops and in online shops were all considered. The test set-up used in the present study corresponds to a proposal from the CEN Working Group's 11 "Rotational test methods" (Willinger et al. 2014). In total, four separate tests were conducted (Table 1). A finite element (FE) model of the brain was used to estimate the risk of brain tissue damage during the three oblique impact tests.

Table 1. INCLUDED TESTS

| TEST | VELOCITY | ANGLE | DESCRIPTION |
| --- | --- | --- | --- |
| Shock absorption test | 6.0 m/s | 0° | The helmet was dropped from a height of 1.8 m to a horizontal surface correlated to the interim European Standard VG1 (01.040: 2014-12) test protocol. |
| Oblique impact A. Contact point on the upper part of the helmet. | 6.3 m/s | 45° | A test that simulates an actual equestrian accident. Rotation around X-axis. |
| Oblique impact B. Contact point on the side of the helmet. | 6.3 m/s | 45° | A test that simulates an actual equestrian accident. Rotation around Y-axis. |
| Oblique impact C. Contact point on the frontal side of the helmet. | 6.3 m/s | 45° | A test that simulates an actual equestrian accident. Rotation around Z-axis. |
| Computer simulations | - | - | As input into the FE model, the measured rotational and translational accelerations from the HIII head in the three tests above were used. |

### Shock absorption test

The helmet was dropped from a height of 1.8 m to a horizontal surface according to the European standard (the temporary VG1 01-040 2014-12 test protocol) which sets a maximum acceleration of 250 g (Fig. 1). The shock absorption test is included in the test standard for helmets, in contrast to the oblique tests. The ISO head form was used and the test was performed with an impact speed of 6.0m/s. The helmets were tested in a temperature of 18°C.

The test was performed by Research Institutes of Sweden (RISE) which is accredited for testing and certification in accordance with the interim European Standard VG1 (01.040: 2014-12).

Figure 1. The method used in shock absorption test. The head's initial angle was 26$^{o}$.

### Oblique Tests

In three oblique tests the ISO headform was replaced by the Hybrid III 50th percentile Male Dummy head. The reason for this choice was that the Hybrid III 50th percentile male dummy head has much more realistic inertia properties and it allows for measurements of the linear and rotational velocity and acceleration. A system of nine accelerometers was mounted inside the Hybrid III test head according to the 3-2-2-2 method described by Padgaonkar et al. (Padgaonkar et al. 1975). Using this method it is possible to measure the linear accelerations in all directions and the rotational accelerations around all the three axis X, Y and Z. The accelerometer samples were obtained at a frequency of 20 kHz and all the collected data were filtered using an IOtechDBK4 12-pole Butterworth low-pass filter. This is further described by Aare and Halldin (2003). The helmeted head was dropped against a 45° inclined anvil with friction similar to asphalt (grinding paper Bosch quality 40). The impact speed was 6.25m/s. The Hybrid III dummy head was used without an attached neck. Two helmets were tested in each test configuration to minimize variations.

Figure 2. The oblique test A with rotation around X-axis.

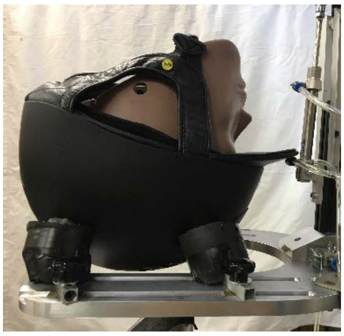

Figure 3. The oblique test B with rotation around Y-axis.

Figure 4. The oblique test C with rotation around Z-axis

## FE Model of the brain – Computer simulations

Computer simulations were carried out for all oblique impact tests. The simulations were conducted by KTH (Royal Institute of Technology) in Stockholm, Sweden, using an FE model that has been validated against cadaver experiments (Kleiven and Hardy 2002; Kleiven 2006) and against real-world accidents (Kleiven 2007; Patton et al. 2013). It has been shown that a strain above 26% corresponds to a 50% risk for concussion (Kleiven and Hardy 2002). As input into the FE model, X, Y and Z rotation and translational acceleration data from the HIII head were used. The FE model of the brain used in the tests is described by Kleiven (Kleiven 2006; Kleiven 2007).

## Rating of helmets

The safety level of the helmets was rated relative to each other. Since the most common brain injuries often occur in oblique impacts the three oblique tests were influencing the rating to a higher extend. The overall result was calculated according to the equation below where T1 is the relative result in shock absorption and T2-4 are the relative results in the oblique impact tests.

$$\frac{T_1 + \frac{2 * (T_2 + T_3 + T_4)}{3}}{3}$$

## Results

All helmets scored lower than 250 g in resultant acceleration in the shock absorption test (Table 2). The Charles Owen Wellington Classic (153 g) performed best of the helmets, and Kask Dogma Star Lady (243 g) preformed worst of the helmets.

Table 2. SHOCK ABSORPTION - LINEAR ACCELERATION

| Helmet | Translationsacceleration (g) |
|---|---|
| Back on Track EQ3 | 207 |
| Back on Track EQ3 Lynx | 186 |
| Charles Owen Ayr8 Leather Look | 172 |
| Charles Owen Wellington Classic | 153 |
| Charles Owen YR8 Sparkling | 195 |
| Equipage Priority | 220 |
| GPA First Lady 2X | 237 |
| Hansbo Ridhjälm HS Gold | 209 |
| Horka Horsy | 229 |
| Horka Red Horse | 198 |
| Kask Dogma Star Lady | 243 |
| KEP Cromo | 231 |
| Samshield Shadowmatt +5SW | 221 |
| Uvex Perfexxion II | 191 |
| Uvex Suxxeed Velours | 196 |
| Mean/Median | 206/ 207 |

Table III shows the tests that reflect the helmet's protective performance in an equestrian accident with oblique impact to the head (rotation around the X-axis, Y-axis and Z-axis). The mean value of the rotational accelerations varied between the three tests and the lowest strain was measured in the oblique test with an impact to the side of the helmet (rotation around X-axis). The simulations indicated that the strain in the grey matter of the brain during oblique impacts could vary between helmets, from 17% to 27% in the test with rotation around X-axis, 16% to 42% in rotation around Y-axis and 26% to 51% in rotation around Z-axis. The threshold for 50% risk of concussion was only exceeded by one helmet (Equipage Priority) when the impact caused a rotation around the X-axis. Only two helmet did not give results that exceeded the threshold for a 50% risk of concussion during the impact with rotation around Y-axis. When impacting the frontal part of the helmet (rotation around the Z-axis) the threshold was exceeded in 14 of 15 tests. Helmets equipped with MIPS performed, in general, better than the others.

In total three helmets obtained the Folksam best in test or good choice label: Back on *Track EQ3 Lynx, Back on Track EQ3* and Charles Owen Ayr8. The helmet Back on Track EQ3 Lynx performed best and was 30% better than the average helmet.

Table 3. OBLIQUE TESTS (ROTATION AROUND THE X, Y AND Z-AXIS)

| | **OBLIQUE IMPACT A (X-AXIS)** | | | | | **OBLIQUE IMPACT B (Y-AXIS)** | | | | | **OBLIQUE IMPACT C (Z-AXIS)** | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Helmet** | **T. ACC. [g]** | **R. ACC. [krad /s²]** | **R. V [rad/s ]** | **Strain [%]** | **Risk of concussion [%]** | **T. ACC. [g]** | **R. ACC. [krad/s²]** | **R. V [rad/s]** | **Strain [%]** | **Risk of concussion [%]** | **T. ACC. [g]** | **R. ACC. [krad/s²]** | **R. V [rad/s]** | **Strain [%]** | **Risk of concussion [%]** |
| **Back On Track Eq3** | 124.7 | 4.41 | 23.4 | 17 | *22* | 131.7 | 3.60 | 21.9 | 19 | 27 | 109.3 | 7.36 | 32.5 | 40 | 85 |
| **Back On Track Eq3 Lynx** | 140.2 | 4.41 | 17.6 | 17 | *20* | 136.2 | 3.12 | 18.9 | 16 | 19 | 116.5 | 5.21 | 24.2 | 26 | 47 |
| **Charles Owen Ayr8 Leather Look** | 108.1 | 5.11 | 26.5 | 21 | 30 | 134.5 | 5.90 | 28.6 | 31 | 63 | 123.7 | 8.81 | 35.6 | 46 | 93 |
| **Charles Owen Wellington Classic** | 102.0 | 4.81 | 26.3 | 21 | 31 | 156.9 | 7.93 | 34.4 | 39 | 84 | 151.8 | 11.87 | 39.0 | 51 | 96 |
| **Charles Owen Yr8 Sparkling** | 125.4 | 5.19 | 27.2 | 22 | 34 | 140.3 | 5.32 | 29.3 | 31 | 64 | 130.3 | 8.85 | 33.4 | 44 | 92 |
| **Equipage Priority** | 153.1 | 8.81 | 30.9 | 27 | 52 | 150.4 | 7.86 | 32.6 | 38 | 81 | 123.0 | 10.58 | 35.6 | 46 | 93 |
| **Gpa First Lady 2x** | 121.9 | 7.66 | 27.1 | 24 | 41 | 133.0 | 8.48 | 35.5 | 40 | 86 | 114.6 | 9.64 | 36.9 | 47 | 94 |
| **Hansbo Ridhjälm HS Gold** | 154.7 | 8.04 | 29.2 | 25 | 44 | 160.1 | 8.32 | 32.3 | 37 | 80 | 128.7 | 10.56 | 35.2 | 46 | 93 |
| **Horka Horsy** | 103.8 | 6.49 | 31.1 | 26 | 49 | 148.7 | 7.52 | 33.8 | 38 | 83 | 118.6 | 9.91 | 39.2 | 49 | 95 |
| **Horka Red Horse** | 137.1 | 7.18 | 31.7 | 27 | 50 | 147.8 | 7.98 | 32.4 | 37 | 81 | 126.7 | 10.04 | 35.7 | 45 | 93 |
| **Kask Dogma Star Lady** | 136.9 | 6.87 | 25.3 | 21 | 32 | 141.3 | 7.57 | 32.9 | 37 | 79 | 123.9 | 7.04 | 24.6 | 30 | 61 |
| **Kep Cromo** | 126.5 | 5.46 | 24.7 | 20 | 29 | 143.4 | 7.27 | 32.5 | 37 | 80 | 114.8 | 8.47 | 34.6 | 44 | 92 |
| **Samshield Shadowmatt** | 106.9 | 5.41 | 27.5 | 23 | 37 | 164.0 | 9.68 | 36.2 | 42 | 89 | 112.2 | 9.57 | 35.6 | 46 | 93 |
| **Uvex Perfexxion II** | 123.9 | 7.46 | 28.4 | 24 | 41 | 140.9 | 9.56 | 37.3 | 42 | 88 | 98.0 | 7.94 | 33.6 | 43 | 90 |
| **Uvex Suxxeed Velours** | 139.2 | 6.45 | 26.8 | 22 | 33 | 141.2 | 6.81 | 31.1 | 35 | 75 | 108.0 | 8.49 | 38.2 | 47 | 94 |
| **Mean** | 127.0 | 6.251 | 26.9 | 22 | 36 | 144.7 | 7.130 | 31.3 | 34 | 72 | 120.0 | 8.957 | 34.3 | 43 | 87 |
| **Median** | 125.4 | 6.453 | 27.1 | 22 | 34 | 141.3 | 7.571 | 32.5 | 37 | 80 | 118.6 | 8.854 | 35.6 | 46 | 93 |

Table 1. Overall results

| Hjälm | Overall result |
|---|---|
| Back on Track EQ3 | 16% |
| Back on Track EQ3 Lynx | 30% |
| Charles Owen Ayr8 Leather Look | 8% |
| Charles Owen Wellington Classic | 4% |
| Charles Owen YR8 Sparkling | 4% |
| Equipage Priority | -10% |
| GPA First Lady 2X | -12% |
| Hansbo Ridhjälm HS Gold | -6% |
| Horka Horsy | -13% |
| Horka Red Horse | -6% |
| Kask Dogma Star Lady | 1% |
| KEP Cromo | -4% |
| Samshield Shadowmatt +5SW | -9% |
| Uvex Perfexxion II | -4% |
| Uvex Suxxeed Velours | 0% |

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