BRA VAL

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2019

Bicycle Helmets for Children 2019 Tested by Folksam

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This is why we test bicycle helmets

Every day three cyclists in Sweden sustain head injuries, which are some of the most severe injuries a cyclist can experience. Data from real-life crashes show that bicycle helmets are very effective to reduce injuries. Two out of three head injuries from bicycle accidents could have been avoided if the cyclist had worn a helmet.

We are committed to what is important to our customers and to you. When we test and recommend safe bicycle helmets we believe this can help to make your life safer and we provide tips on how to prevent injury.

How does a bicycle helmet obtain our good choice label?

Helmets which obtain the best overall results in the bicycle helmet test by Folksam are given our good choice label. The good choice symbol may only be used by products which have obtained the best scores in one of our tests.

Helena Stigson

Helena Stigson, PhD
Associate Professor
Traffic Safety Research

folksam.se/cykel

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Why is Folksam testing bicycle helmets?

Every week approximately six children sustain a head injury and seek medical care at hospital after a bicycle accident in Sweden (Axelsson and Stigson 2018). In total 74 percent of the head injuries occur in a single bicycle crash. Even though only 14% of the head injuries occur when a motor vehicle was involved, these often result in the most severe injuries. The risk of sustaining a head injury is mitigated if cyclist is using helmets. This has been demonstrated by epidemiological studies showing that bicycle helmets can reduce head injury risk by up to 69% (Olivier and Creighton 2016). All helmets included in the test are 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 (EN1078 2012). This does not fully reflect the scenario in a bike accident. In a fall or a crash, the impact to the head will be oblique (Willinger et al. 2014; Fahlstedt 2015; Bland et al. 2018). The intention was to simulate this in the test 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 for children. In total Folksam has tested seven bicycle helmets, Table 1.

Table 1.*Included helmets*

Bike helmets	Green buckle	Rotational technologies	Price (SEK)
Abus Smiley 2.0	Yes	-	350
Abus Youn-I MIPS	No	MIPS	750
Bell Sidetrack MIPS Y	No	MIPS	700
Etto Kid Rider	No	-	200
Met Genio	Yes	-	500
Tec Boo	Yes	MIPS	1000
Tec Lelle	Yes	MIPS	1000

Method

Six physical tests were conducted, two shock absorption tests with straight perpendicular impact, three oblique impact tests and test of the retention system on the helmets with green buckle, Table 2. Computer simulations were made to evaluate injury risk.

Shock absorption test

The helmet was dropped from a height of 1.5 m to a horizontal surface according to the European standard (EN1078 2012) which sets a maximum acceleration of 250 g. The shock absorption test is included in the test standard for helmets, in contrast to the oblique tests. The test was performed by Research Institutes of Sweden (RISE), which is accredited for testing and certification in accordance with the European standard.

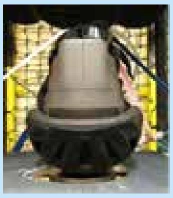
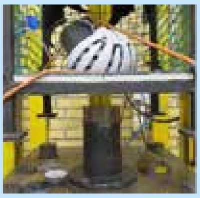
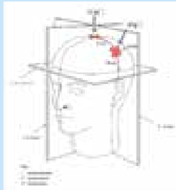
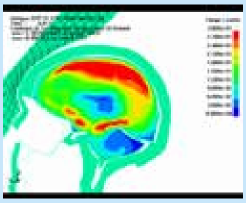
Oblique Tests

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. 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). The test was performed by Research Institutes of Sweden (RISE).

Test of release force of the green bucket for young children in accordance with EN 1080
The self-release system opening force according to the requirements in EN 1080:2013, clauses 4.6 was tested (EN1080). Three samples per helmet model were tested. According to the EN1080 the retention system shall be released by a force exceeding 90 N but not exceeding 160 N.

Computer simulations with FE Model of the brain
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 experimental testing were used. The FE model of the brain used in the tests is described by Kleiven (Kleiven 2006; Kleiven 2007).

Table 2. *Included tests*

Included test	
Shock Absorption Test (EN 1078) *The helmet was dropped from a height of 1.5 m to a horizontal surface correlated to the European Standard EN1077 test protocol. The ISO head form was used, and the helmets were tested in a temperature of 18°C. The head was impacted at two different locations. One at the top of the head and one at the side of the head, see figure. Velocity 4.7 m/s*	  
Oblique Impact – Rotation around X-axis *Contact point on the side of the helmet resulting in a rotation around X-axis. Initial position of the headform X-, Y- and Z-axis 0° Hybrid III 50th percentile Male Dummy head form was used. Velocity 6.3 m/s*	
Oblique Impact – Rotation around Y-axis *Contact point on the upper part of the helmet resulting in a rotation around Y-axis. Initial position of the headform X-, Y- and Z-axis 0° Hybrid III 50th percentile Male Dummy head form was used. Velocity 6.3 m/s*	
Oblique Impact – Rotation around Z-axis *Computer simulations were carried out for all oblique impact tests. As input into the FE model, the measured rotational and translational accelerations from the HIII head in the three tests above were used. A strain above 26% corresponds to a 50% risk for concussion.*	
Computer Simulations *Computer simulations were carried out for all oblique impact tests. As input into the FE model, the measured rotational and translational accelerations from the HIII head in the three tests above were used. A strain above 26% corresponds to a 50% risk for concussion.*	
Retention System Test (EN 1080) *The green buckle was tested occurring to the EN 1080. Three helmets were tested for each helmet model. When tested according to 5.5 in EN 1080 the headform shall be released from the helmet by a force exceeding 90 N but not exceeding 160 N.*	

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 extent. The overall result was calculated according to the equation below where T1 and T2 are the relative result in shock absorption and T3-5 are the relative results in the oblique impact tests.

$$\frac{\frac{T_1 + T_2}{2} + \frac{2 * (T_3 + T_4 + T_5)}{3}}{3}$$

Results

In total two helmets obtained the Folksam Good Choice label: TEC Boo and Tec Lelle, Table 3. These helmets performed up to 44% better than the average helmet. Both the helmets are fitted with MIPS (Multi-directional Impact Protection System) with the intention to reduce the rotational energy. These two were also fitted with a green buckle.

***Table 3**. Overall results*

Helmets	Overall result	Folksam's label
Abus Smiley 2.0	-29%	
Abus Youn-I MIPS	8%	
Bell Sidetrack MIPS Y	1%	
Etto Kid Rider	-26%	
Met Genio	-31%	
Tec Boo	33%	Good Choice
Tec Lelle	44%	Good Choice

All helmets scored lower than 250 g in resultant acceleration in the shock absorption test (Figure 1). The lowest values were measured for the two helmets Tec Boo (158g) and Tec Lelle (155g).

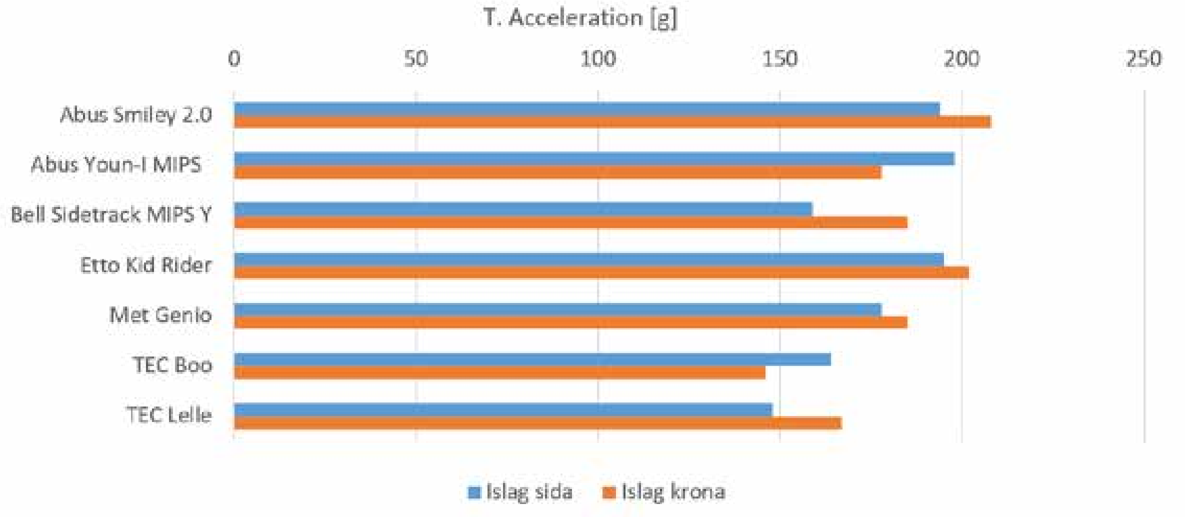


***Figure 1**. Shock Absorption measuring linear acceleration*

Table 4 shows the tests that reflect the helmet's protective performance in a bike accident with oblique impact to the head (rotation around the X-axis, Y-axis and Z-axis). The simulations indicated that the strain in the grey matter of the brain during oblique impacts could vary between helmets, from 10% to 33%. In total three helmets got a result that was below the threshold for a 50% risk of concussion in all the three tests. In general, helmets equipped with MIPS performed better than the others.

***Table 4**. 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)				
Bicycle helmet	T. ACC. [g]	R. ACC. [krad / s^2]	R. V [rad/s]	BrIC	Strain/Risk of concussion [%]	T. ACC. [g]	R. ACC. [krad / s^2]	R. V [rad/s]	BrIC	Strain/Risk of concussion [%]	T. ACC. [g]	R. ACC. [krad / s^2]	R. V [rad/s]	BrIC	Strain/Risk of concussion [%]
Abus Smiley 2.0	173.3	9.6	35.3	0.17	25/45	155.8	8.9	36.4	0.68	29/58	131.0	8.5	34.5	0.15	29/56
Abus Youn-I MIPS	143.3	7.4	27.8	0.22	20/29	119.9	6.1	29.6	0.55	22/33	106.2	7.0	26.4	0.08	20/29
Bell Sidetrack MIPS Y	151.7	7.0	30.0	0.23	20/28	129.5	6.7	32.4	0.61	25/44	116.4	7.4	38.1	0.12	29/58
Etto Kid Rider	127.7	9.0	38.4	0.24	27/51	124.3	8.4	38.2	0.71	30/61	146.8	8.7	38.3	0.25	29/58
Met Genio	145.3	9.8	39.8	0.22	29/58	123.1	9.7	41.5	0.78	33/71	136.5	7.4	30.0	0.07	25/44
Tec Boo	120.9	5.2	22.6	0.25	15/17	112.0	2.9	19.5	0.37	13/13	124.0	7.3	32.9	0.16	26/47
Tec Lelle	108.1	4.4	22.5	0.22	14/15	113.7	3.0	19.2	0.36	11/11	118.4	6.4	31.1	0.19	23/38
Tec Lelle med mössa	99.7	3.1	19.6	0.15	10/10	113.9	2.8	19.3	0.36	11/10	121.4	7.5	39.0	0.26	30/61
Mean	133.8	6.9	29.5	0.21	20/32	124.0	6.1	29.5	0.55	22/38	123.8	8.0	35.6	0.22	29/57
Min	99.7	3.1	19.6	0.15	10/10	112.0	2.8	19.2	0.36	11/10	123.9	8.9	34.7	0.18	27/51
Max	173.3	9.8	39.8	0.25	29/58	155.8	9.7	41.5	0.78	33/71	124.8	7.4	31.4	0.15	25/45

When the retention system of the helmets with a green buckle were tested, all helmets except from Met Genio fulfilled the requirements, Table 5. All three tests with the helmet Met Genio exceeded the threshold of 160 N. The headform was released from the helmet by a force of 246 to 292N.

***Table 5**. Maximum force during the retention system test (EN 1080)*

Helmets with Green Buckle	Maximum Force (N)
Abus Smiley 2.0	156
Met Genio	292
Tec Boo	150
Tec Lelle	146

Discussion

The current European certification test standard does 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 the helmets ability to reduce rotational acceleration in consumer tests as well in legal requirements. The results have shown that rotational acceleration after impact varies widely among helmets on 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 loading as well. Before this happens, consumer tests play an important role in informing and guiding consumers in their choice of helmets. Since 2012 Folksam have conducted eleven consumer helmet tests (seven bicycle helmet tests, two equestrian helmet tests and two ski helmet tests). During this time the proportion of helmets fitted with additionally new technologies aimed to reduce rotational acceleration have been more common. In the present test four out of seven had some of these technologies. In general, these helmets performed better than the others. However, all helmets need to reduce rotational acceleration more effectively. 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 acceleration. A conventional helmet that meets current standards does not prevent a cyclist from getting a concussion in case of a head impact. Helmets need to absorb energy more effectively.

There has been an increase in child helmets with green buckles in Sweden, and in this test four out of seven child helmets were fitted with it. This is reassuring since the recommendation in Sweden is that children up to seven years of age should be using a helmet with a green buckle. However, one of the helmets did not fulfil the requirements. Therefore, Folksam has notified the Swedish Consumer Agency (Konsumentverket) of the outcome of the test.

References

Axelsson, A. and H. Stigson (2018). "Identifying Reasons for Injuries in Bicycle Crashes and the Effect of Helmet Use Among Children in Sweden". 7th International Cycling Safety Conference, (Barcelona, Spain).

Bland, M. L., C. McNally and S. Rowson (2018). "Differences in Impact Performance of Bicycle Helmets During Oblique Impacts." Journal of Biomechanical Engineering 140(9).

EN1078 (2012). European Standard EN1078:2012. Helmets for Pedal and for Users of Skateboards and Roller Skates.

EN1080 "Småbarnshjälmar - Impact protection helmets for young children."

Fahlstedt, M. (2015). Numerical Accident Reconstructions - A Biomechanical Tool to Understand and Prevent Head Injuries. School of Technology and Health, Neuronic Engineering Huddinge, Sweden, KTH Royal Institute of Technology. Doctoral Thesis.

Kleiven, S. (2006). "Biomechanics as a forensic science tool - Reconstruction of a traumatic head injury using the finite element method." Scand J Forens Sci.(2): 73-78.

Kleiven, S. (2006). "Evaluation of head injury criteria using a finite element model validated against experiments on localized brain motion, intracerebral acceleration, and intracranial pressure." Internal Journal of Crashworthiness 11(1): 65-79.

Kleiven, S. (2007). "Predictors for traumatic brain injuries evaluated through accident reconstructions." Stapp Car Crash J 51: 81-114.

Kleiven, S. and W. N. Hardy (2002). "Correlation of an FE model of the Human Head with Experiments on localized Motion of the Brain – Consequences for Injury Prediction." 46th Stapp Car Crash Journal: 123-144.

Olivier, J. and P. Creighton (2016). "Bicycle injuries and helmet use: a systematic review and meta-analysis." International Journal of Epidemiology.

Patton, D. A., A. S. McIntosh and S. Kleiven (2013). "The biomechanical determinants of concussion: finite element simulations to investigate brain tissue deformations during sporting impacts to the unprotected head." J Appl Biomech 29(6): 721-730.

Willinger, R., C. Deck, P. Halldin and D. Otte (2014). "Towards advanced bicycle helmet test methods". International Cycling Safety Conference 2014, (Göteborg, Sweden).