BRA VAL

Folksam

2021

Bicycle Helmets 2021
Tested by Folksam

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Folksam

This is why we test bicycle helmets

Every day several cyclists sustain head injuries, which are some of the most serious injuries a cyclist can sustain. Studies from real-life crashes show that bicycle helmets are very effective in reducing serious and fatal 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 serious injuries.

How does a bicycle helmet obtain our "Recommended" label?

Helmets that obtain the best overall results in the bicycle helmet test by Folksam are given our "Recommended" label. The "Recommended" symbol may only be used for products that have obtained a score at least 15% better than the median value for all tested helmets and the helmet also needs to get a better score than the median for the rotational and translational tests individually.

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Traffic Safety Research

Why does Folksam test adult bicycle helmets?

Annually in Sweden over 1000 cyclists have to visit an emergency care centre due to a head injury after a bicycle crash (Stigson 2015). For Great Britain in 2018, the road casualty statistics indicate that 4205 pedal cyclists suffered a serious injury or fatality — more than 11 per day. The hospital data for England Scotland and Wales reveal that 18,546 pedal cyclists were admitted to hospital as the result of a transport-related accident between April 2018 and March 2019. Of these, based on previous matching of hospital and police-reported data, 78 percent are likely to have sustained a head injury (Talbot et al. 2014). Thus, in Great Britain it is likely that 40 cyclists a day are admitted for head injuries. In total 70 percent of the head injuries occur in a single bicycle crash (Stigson 2015). Even though less than a fifth of the head injuries occur when a passenger car was involved, these crashes often result in the most severe injuries.

The risk of sustaining a head injury is mitigated if cyclists are using helmets. This has been demonstrated by epidemiological studies showing that bicycle helmets can reduce head injury risk by up to 69 percent (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 collision, 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 European market for teenagers and adults. In total, 15 conventional bicycle helmets were selected from the Swedish and the UK market, Table 1. To ensure that a commonly used representative sample was chosen, the range of helmets available in bicycle/sports shops and in online shops were all considered. Before selecting the included helmets, The Road Safety Trust asked manufacturers to provide information regarding new best-selling helmets and new innovative products. All but one of the helmets were equipped with technologies aimed at reducing rotational acceleration (11 with MIPS (Multi-directional Impact Protection System), one with MIPS in combination with Koroyd, a sort of honeycomb structure, and two with WaveCel).

Table 1. Included helmets

Bike helmets	Rotational Technologies	Price (SEK)	UK Price – approx. (GBP)
ABUS Pedelec 2.0 MIPS	MIPS	1600	£130
Bell Sixer	MIPS	1500	£150
Bontrager Starvos	WaveCel	1200	£100
Bontrager XXX WaveCel	WaveCel	2600	£200
Fox Speedframe Pro ELV	MIPS	1600	£139
Giro Helios Spherical	MIPS	2500	£230
Kask Mojito 3 WG11	-	1500	£130
Lazer Armor	MIPS	900	£75
Lazer Urbanize MIPS	MIPS	1500	£100
Poc Kortal	MIPS	2500	£220
Scott Arx Plus	MIPS	1600	£80
Scott Centric Plus	MIPS	2700	£150
Smith Network	MIPS + Koroyd®	1700	£140
Specialized Align II	MIPS	700	£45
Specialized Chamonix	MIPS	900	£70

Method

Five physical tests were conducted, two shock absorption tests with straight perpendicular impact and three oblique impact tests (Table 2). The tests were performed by Research Institutes of Sweden (RISE), which is accredited for testing and certification in accordance with the European standard. Computer simulations were subsequently carried out to evaluate the risk of concussion.

Shock Absorption Test

The helmet was dropped from a height of 1.5m onto a horizontal surface according to the European standard (EN1078 2012), which sets a maximum acceleration of 250g. The shock absorption test is included in the test standard for helmets, in contrast to the oblique tests. The helmet was impacted at two different locations: one at the top of the head and one at the side of the head, see Table 2.

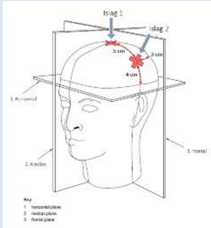
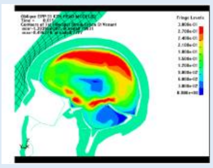
Oblique Tests

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 an additional test under consideration within the CEN Working Group's 11 "Rotational test methods" (Willinger et al. 2014).

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 percent corresponds to a 50 percent 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 Contact point on the upper part of the helmet resulting in a rotation around Y-axis. Initial position of the headform X- and Z-axis 0° and 65° around Y-axis. Hybrid III 50th percentile Male Dummy head form was used. Velocity 6.3 m/s	
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 percent corresponds to a 50 percent risk for concussion.	

Rating of Helmets

The safety level of a helmet was rated relative to the median value for the test results of all the helmets included in test runs conducted in 2020 and 2021. In previous tests, the safety assessment has only been made by relating the helmets' measured values to the median value from that test series. This year, however, the median calculation has been made by using measurement data from two latest test runs to provide a more stable calculation basis and to reduce the influence of an individual helmet on the median calculation. Since the most common brain injuries often occur in oblique impacts, the three oblique tests influenced the rating to a greater extent. The overall result was calculated according to the equation below, where T1 and T2 are the relative results in shock absorption and T3-5 are the relative results in the oblique impact tests. To obtain the best overall result and thereby be awarded our "Recommended" label, the helmet needs to perform better than the median in both the shock absorption test and the oblique impact test.

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

Results

In total, two helmets obtained the Folksam "Recommended" label: Scott Arx Plus and Specialized Align II, Table 3. These helmets performed 21-25 percent better than the average helmet. Both these helmets are fitted with systems (Multi-directional Impact Protection System, MIPS) designed to reduce rotational energy.

Table 3. Overall results

Helmets 2021	Overall result	Folksam Recommended
ABUS Pedelec 2.0 MIPS	13%	
Bell Sixer	-9%	
Bontrager Starvos	-4%	
Bontrager XXX WaveCel	-13%	
Fox Speedframe Pro ELV	18%*	
Giro Helios Spherical	17%*	
Kask Mojito 3 WG11	-52%	
Lazer Armor	17%*	
Lazer Urbanize MIPS	-20%	
Poc Kortal	3%	
Scott Arx Plus	25%	Recommended
Scott Centric Plus	10%	
Smith Network	21%*	
Specialized Align II	21%	Recommended
Specialized Chamonix	-21%	

* The helmet's results were worse than the median in at least one of the tests.

All helmets scored lower than 250g in resultant acceleration in the shock absorption test (Figure 1). The lowest values were measured for POC Kortal (119g impact to the crown and 133g impact to the side of the helmet).

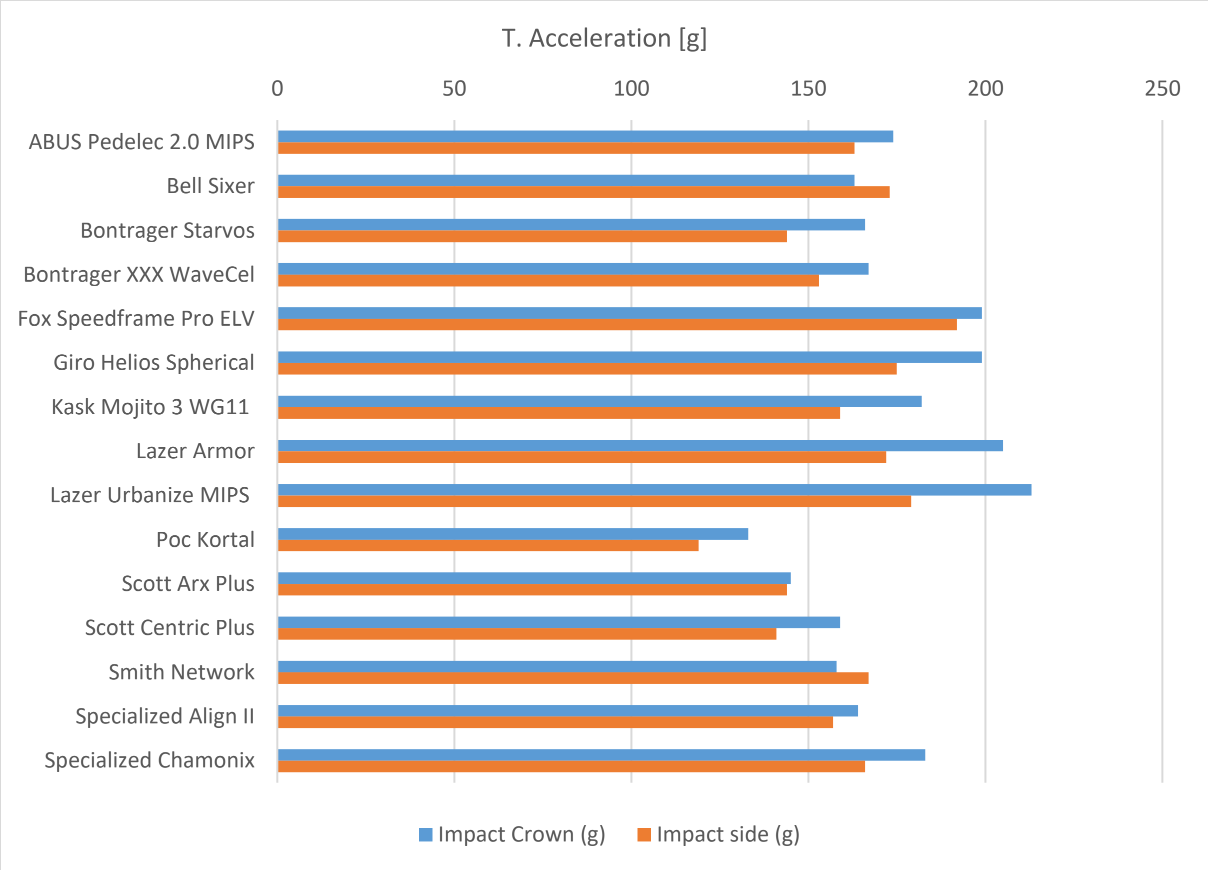


Figure 1. Shock absorption measuring linear acceleration

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 15 percent to 41 percent. Only one helmet, Scott Arx Plus, got a result that was below the threshold for a 50 percent risk of concussion in all the tests.

Discussion

With the aim of guiding consumers in the purchase of the safest bicycle helmets and influencing helmet design and the safety standard, this test series was conducted by Folksam Insurance Group in Sweden with funding support from The Road Safety Trust in the UK. In the spring of 2021, The Road Safety Trust organised a virtual international workshop to discuss existing helmet test protocols and to encourage further development of a star rating system for cycle helmets. Folksam was the first organisation around the world to initiate the consumer testing of bicycle helmets aimed at examining helmet performance in both direct and oblique impact. Today, several new test protocols exist. From a consumer perspective there are both pros and cons with harmonising test protocols and ratings. However, our hope is that more organisations will be able to join future test series. A large international consumer test consortium has the potential to effectively raise the safety standard of helmets. Folksam initiated consumer tests of bicycle helmets in 2012 because the certification test standards of helmets are not sufficient, as it does not cover the helmets' capacity to reduce rotational acceleration, i.e., when the head is exposed to rotation due to impact. In the current European certification tests, however, only the energy absorption in a perpendicular impact is evaluated, with the helmet being dropped straight onto a flat anvil and onto a kerbstone anvil. The pass-fail criteria used in the test standard is relatively high (250g), mainly with a focus on avoiding skull fractures. However, concussion occurs in many bicycle accidents, often as a result of the brain being subjected/exposed to rotational forces in the event of either direct or indirect forces towards the head. In general, 8 percent of concussions result in long-term or permanent symptoms, such as memory disorders, headaches and other neurological symptoms. This clearly shows the importance of preventing these injuries. Therefore, an improved test method, including oblique impacts, was used to also mirror a common bicycle accident where the cyclist falls to the ground, striking the head at an angle creating a rotation of the head, with concussion as a common injury outcome.

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 on the European market. They also indicate that there is a link between rotational energy and strain in the grey matter of the brain. In future, certification helmet requirements should therefore ensure a good performance for rotational loading as well as direct loading. Before this happens, consumer tests can play an important role in informing and guiding consumers in their choice of helmets. Since 2012 Folksam have conducted fourteen consumer helmet tests (ten bicycle helmet tests, two equestrian helmet tests and two ski helmet tests). During this time the proportion of helmets fitted with additional new technologies aimed at reducing rotational acceleration has increased even though this was not required to pass the certification test. In the 2021 test round, all but one helmet had some of these technologies. Previous tests have shown that helmets equipped with technologies aimed at reducing rotational acceleration performed in general better than the others. However, all helmets need to reduce rotational acceleration more effectively. The initial objective of the helmet standard EN 1078 was to prevent life threatening injuries, but with the knowledge we have today, helmets should preferably also prevent brain injuries that have long-term consequences. Therefore, helmets should be designed to reduce translational acceleration as well as rotational acceleration. A conventional helmet that meets current EN 1078 standard does not prevent a cyclist from sustaining a concussion in the event of a head impact. In addition to an improved performance regarding protection of rotational loading, helmets also need to absorb energy more effectively. The safety standard EN 1078 that needs to be met for any bicycle helmet sold in the EU to obtain the CE mark should be seen as a minimum requirement. The potential outcome is that bicycle helmets meeting the EN 1078 standard requirements may not sufficiently protect in real-life collisions or falls.

This report was part funded by The Road Safety Trust, an independent grant-giving charity working hard to reduce the numbers of people killed or injured on UK roads by providing independent funding for vital research and practical interventions into new approaches to road safety.

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)**					
BICYCLE HELMET	T. ACC. [g]	R. ACC. [rad /s^2]	R. V [rad/s]	BrIC	Strain [%]	Risk of Concussion [%]	T. ACC. [g]	R. ACC. [rad /s^2]	R. V [rad/s]	BrIC	Strain [%]	Risk of Concussion [%]	T. ACC. [g]	R. ACC. [rad /s^2]	R. V [rad/s]	BrIC	Strain [%]	Risk of Concussion [%]
ABUS PEDELEC 2.0 MIPS	123.2	3867.5	14.2	0.24	16	18	135.36	5730.60	26.00	0.46	27	50	118.4	7219.4	22.3	0.51	30	61
BELL SIXER	109.0	5225.3	26.3	0.42	20	29	112.4	6696.2	33.1	0.59	35	75	97.5	5947.5	26.7	0.62	32	67
BONTRAGER STARVOS	107.6	6325.4	27.8	0.46	20	30	90.4	4403.4	31.8	0.56	28	56	102.8	8949.7	31.6	0.71	39	84
BONTRAGER XXX WAVECEL	121.2	5785.6	24.3	0.40	22	34	104.1	5724.4	31.7	0.56	32	66	123.2	8878.8	28.6	0.63	39	84
FOX SPEEDFRAME PRO ELV	105.8	4124.7	19.4	0.37	16	18	108.0	4101.4	21.7	0.39	22	33	103.5	5347.2	20.7	0.43	27	49
GIRO HELIOS SPHERICAL	103.7	5534.4	17.6	0.28	16	20	115.9	6970.3	18.2	0.33	18	24	133.8	6812.5	24.0	0.52	31	64
KASK MOJITO 3 WG11	123.2	11630.4	37.1	0.60	34	72	114.2	7810.7	37.9	0.68	41	88	122.8	7838.9	29.2	0.66	37	81
LAZER ARMOR	125.5	4267.3	18.1	0.31	15	17	119.3	3716.9	19.9	0.36	20	30	108.0	5453.2	23.6	0.52	31	63
LAZER URBANIZE MIPS	147.3	7235.8	22.1	0.36	23	37	116.5	6731.9	29.4	0.53	33	70	131.3	7245.2	24.1	0.53	33	71
POC KORTAL	89.5	4555.4	22.5	0.39	17	22	102.8	5420.5	32.6	0.58	33	71	92.0	5974.3	31.5	0.73	37	81
SCOTT ARX PLUS	113.7	4854.8	19.4	0.32	18	23	86.3	3373.6	22.8	0.41	22	34	94.9	4161.4	18.8	0.44	25	44
SCOTT CENTRIC PLUS	101.0	7065.9	28.1	0.46	22	35	114.9	4513.5	24.2	0.43	25	43	104.0	4225.8	20.1	0.45	27	50
SMITH NETWORK	118.8	5926.7	24.2	0.38	19	25	118.4	3726.7	22.0	0.39	20	28	96.3	4364.8	19.5	0.40	26	48
SPECIALIZED ALIGN II	117.7	4830.4	20.4	0.33	16	20	132.7	8045.6	21.8	0.40	22	34	115.7	7932.8	23.3	0.46	29	57
SPECIALIZED CHAMONIX	126.2	7394.7	26.7	0.43	26	46	119.7	6694.3	31.8	0.57	33	71	124.7	6633.2	23.8	0.51	32	66

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