Foreword by The Road Safety Trust

REPORT: Child Bicycle Helmets 2021
Tested by Folksam

Some bicycle helmets for children offer significantly more protection than others

It is important that, when consumers purchase safety equipment, they spend their money wisely. Consumer testing can greatly assist in this by informing prospective purchasers about the objective performance of alternative products. An example of such testing is the car safety rating scheme of Euro NCAP, which has helped to inform consumer choice and to motivate vehicle manufacturers to improve the safety of their products.

The UK Department for Transport sponsors a safety rating scheme for motorcycle helmets called SHARP, but no comparable information is easily available to UK purchasers of bicycle helmets. All bicycle helmets for children sold in the EU and the UK have to meet a minimum safety standard, EN 1078, in order to obtain the CE mark[1], but the impact testing required by that standard is considered to be rather lax (see e.g. The Dome Standards Overview and Bicycle Helmet Research Foundation). Thus, helmets that meet the minimum requirements may not perform adequately in real-life crashes. Prospective purchasers of bicycle helmets therefore cannot be sure that a given helmet will provide a high degree of protection.

The EU test protocol focuses on helmet retention and on direct impact to the surface of the helmet with a target of reducing the risk of skull fracture. It does not examine oblique impacts, which result in rotation of the head and consequent concussion injury to the brain. Over the last few years, a number of new test protocols have been developed that examine helmet performance both in direct impact and in oblique impact. Examples are the tests carried out in the USA by Virginia Tech on behalf of the Insurance Institute for Highway Safety and the tests carried out in Sweden by Folksam Insurance Group for 2020.

At the same time, there have been developments in helmet design targeted at providing protection to wearers from the rotational energy that results from oblique impact. The best known of these is the Multi-directional Impact Protection System (MIPS) technology, developed in Sweden, but there are also a number of other systems with similar objectives. Helmets with MIPS have a liner that aims to reduce rotational motion of the head by allowing slippage of the helmet interior with relation to the surface of the head, thus reducing the risk of severe brain injury.

[1] A new mark called UKCA is replacing the CE mark, but for the time being the CE mark is still valid in Great Britain.

Aware of the lack of consumer information to UK purchasers of bicycle helmets, and of the claims made for the better safety performance of helmets with MIPS and similar systems, The Road Safety Trust has part-funded Folksam for its tests of child helmets in 2021. It must be stressed that it has only been possible to test a few helmet models; no conclusions should be drawn about the performance of helmets that were not included in this round of tests.

However, the results do provide much food for thought. Two helmets performed significantly better than others overall and have been given the "Recommended" label in the report by Folksam. One, the Lazer Gekko MIPS, is available on the UK market. This helmet costs around £50, and the results for it confirm that good safety performance does not require high expense.

All the tested helmets incorporate technology for protection against rotational forces, either in the form of MIPS or an alternative. The results demonstrate that not all the child helmets with such protection perform equally.

We hope that these test results will help to inform purchasing decisions by UK consumers, and also encourage helmet manufacturers to raise their game and bring to market new helmet models that perform at least as well as the best existing models.

Foreword written on behalf of the Road Safety Trust by Oliver Carsten, Trustee and Chair of the Road Safety Initiatives Committee.

Bicycle Helmets for Children 2021 Tested by Folksam

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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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Associate Professor
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THE ROAD SAFETY TRUST
Making Roads Safer

Folksam

Why does Folksam test child 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 2019). For Great Britain in 2019, the road casualty statistics indicate that 472 child cyclists suffered a serious or fatal injury, i.e. nine per week. In total 74 percent of the head injuries occur in a single bicycle crash. Even though only 14 percent 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 the cyclist is wearing a helmet. 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 a collision, 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 European market for children. In total, nine conventional child bicycle helmets were selected from the Swedish and the UK market, Table 1, although one of them (Biltema Skate-cykelhjälm barn MIPS) is only available in Sweden. 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 helmets were equipped with technologies aimed at reducing rotational acceleration (eight with MIPS [Multi-directional Impact Protection System] and one with SPIN [Shearing Pads INside]). The recommendation in Sweden is that children up to seven years of age should be using a helmet with a green buckle. Therefore, child helmets with green buckles, a self-release system tested and approved according to CE standard EN 1080 (EN1080), were also selected. In this test, two out of nine child helmets were fitted with it.

Table 1. Included helmets

Bike helmets	Green buckle	Rotational technologies	Price (SEK)	UK Price – approx. (GBP)
Biltema Skate-/cykelhjälm barn MIPS	Yes	MIPS	430	
Giro Tremor MIPS	No	MIPS	600	£60
Giro Hale MIPS	No	MIPS	600	£45
Lazer Gekko MIPS	Yes	MIPS	600	£50
Lazer Petit DLX MIPS	No	MIPS	750	£59
POC POCITO CRANE MIPS	No	MIPS	1000	£95
POC POCito Omne SPIN	No	SPIN	900	£80
Scott Spunto junior Plus	No	MIPS	900	£50
Specialized Shuffle Child Led MIPS	No	MIPS	650	£50

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.

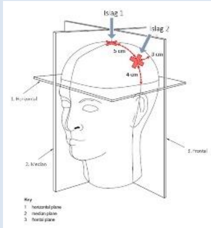
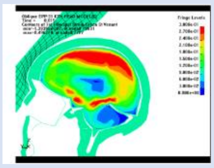
Oblique Tests

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 a proposal from 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 5th percentile female 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 5th percentile female 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 5th percentile female 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% 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 2019 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 child helmets obtained the Folksam "Recommended" label: Biltema Skate-/cykelhjälm barn MIPS and Lazer Gekko MIPS, Table 3. The Biltema Skate child helmet is only sold in Sweden, so the only 'recommended' child helmet available in the UK from these extended safety tests is the Lazer Gekko MIPS helmet at £50. Both helmets performed up to 33 percent better than the average helmet and are fitted with MIPS designed to reduce rotational energy. They are also fitted with a green buckle.

Table 3. Overall results

Child Helmets 2021	Overall result	Folksam Recommended
Biltema Skate-/cykelhjälm barn MIPS	33%	Recommended
Giro Tremor MIPS	10%	
Giro Hale MIPS	-9%	
Lazer Gekko MIPS	24%	Recommended
Lazer Petit DLX MIPS	-13%	
POC POCITO CRANE MIPS	2%	
POC POCito Omne Spin	13%	
Scott Spunto junior Plus	7%	
Specialized Shuffle Child Led MIPS	-2%	

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 Scott Spunto junior Plus (151g Impact side) and Biltema Skate (174g impact crown).

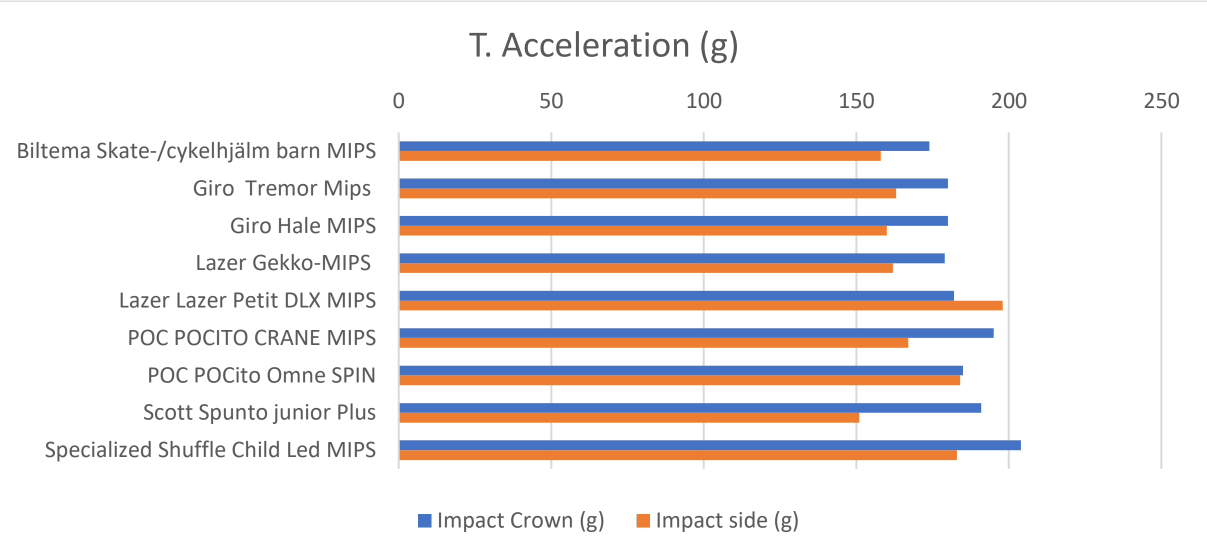


Figure 1. Shock Absorption measuring linear acceleration

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 8 percent to 53 percent. For six out of nine helmets (Biltema Skate-cykelhjälm barn MIPS, Giro Tremor MIPS, Lazer Gekko MIPS, POC POCito, POC POCito Crane MIPS and Scott Spunto junior Plus) the result was below the threshold for a 50 percent risk of concussion in all three tests.

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. [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 [%]
BILTEMA SKATE-/CYKELHJÄLM BARN MIPS	146.9	4270.8	9.7	0.20	8	8	157.5	4884.8	17.2	0.31	12	12	102.7	4935.8	23.0	0.51	22	34
GIRO TREMOR MIPS	109.1	6726.7	20.8	0.37	12	12	103.3	6419.4	31.6	0.56	23	36	102.0	6160.6	23.8	0.54	22	34
GIRO HALE MIPS	127.5	8506.1	29.7	0.48	17	22	132.4	9023.9	26.8	0.48	20	30	120.8	9011.1	28.2	0.65	28	53
LAZER GEKKO MIPS	108.2	3843.2	18.4	0.33	10	9	121.1	5945.0	22.0	0.39	15	17	109.9	5793.3	25.8	0.59	24	41
LAZER PETIT DLX MIPS	153.8	6788.6	21.0	0.36	11	11	130.3	10175.9	34.3	0.61	27	53	154.4	8513.2	27.5	0.63	27	50
POC POCITO CRANE MIPS	136.3	6894.7	25.9	0.42	14	14	148.8	8923.8	27.9	0.50	21	31	105.7	7361.3	26.9	0.62	25	45
POC POCITO OMNE SPIN	147.3	7672.8	17.6	0.33	9	8	144.7	7249.5	27.8	0.50	20	28	146.8	6876.9	26.0	0.61	25	43
SCOTT SPUNTO JUNIOR PLUS	146.8	10070.4	29.4	0.48	16	19	99.0	5040.6	26.9	0.48	18	24	79.5	4633.7	25.8	0.58	22	36
SPECIALIZED SHUFFLE CHILD LED MIPS	128.0	6839.3	22.0	0.36	9	9	128.0	6839.3	22.0	0.36	23	36	113.4	7958.5	32.5	0.76	29	58

Discussion

The current European certification test standard does not cover the helmets' capacity to reduce rotational acceleration, i.e., when the head is exposed to rotation due to 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 European market. They also indicate that there is a link between rotational energy and strain in the grey matter of the brain. In 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 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 designed to reduce rotational acceleration have become increasingly common. For this rest round, all the helmets 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 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.

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Disclaimer: This report has been prepared by Folksam. Any errors or omissions are the author's sole responsibility

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