BÄST I TEST
Folksam
2019

14 Ski Helmets
2019
Tested by Folksam

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Folksam

This is why we test ski helmets

Are you one of the two million Swedes who love snow and downhill skiing? For Folksam it is important that you as a skier or snowboarder are well protected if an accident should occur.

As a consumer, it is difficult to know what characterizes a safe helmet. Our aim is to help you as consumer in your choice of a helmet and to influence manufacturers to design safer helmets. That is the reason behind our engagement in consumer tests of helmets.

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Why is Folksam testing ski helmets?

Approximately two million Swedes are skiing annually (SLAO 2018). Around one thousand of these sustain a head injury after a fall or a crash in the ski slope (SLAO 2013). The proportion is slightly higher (16%) among licensed alpine skiers (Stigson 2019). The helmet use is high (SLAO 2013) and helmets have a good protective effect with a 60% reduction of head injury risk (Cusimano and Kwok 2010). 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 (SS-EN1077 2007). This does not fully reflect the scenario in a ski or snowboard accident. In a fall or a crash, the impact to the head will be oblique (Steenstrup et al. 2018). 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 for children and adults. In total Folksam has tested 14 ski helmets, Table 1. Two of these were racing helmets fulfilling the International Ski federation requirements for being used in alpine ski events (FIS 2013).

Table 1. Included helmets

Ski helmets	Rotational technologies	Price (SEK)
Bliz Head Cover	Inget	900-1300
Everest Alpine MIPS Helmet	MIPS	900
Everest Alpine Helmet	Inget	600
Giro Nine MIPS	MIPS	800-1300
Oakley Mod3 MIPS	MIPS	1000-1500
POC Obex SPIN	SPIN	1700-2200
POC Skull Orbic X* SPIN	SPIN	1400-1800
Salomon Cruiser 4D	Inget	500-900
Scott Quiver plus MIPS	MIPS	1200
SHRED U Bumper Noshock	RES	2000
Smith Aspect MIPS	MIPS	1000-1300
Sweet Protection Rambler MIPS	MIPS	1500-1700
Sweet Protection Volata MIPS*	MIPS	2600
Tecnopro Pulse alpinhjälm	Inget	800

** Racing helmets fulfilling the International Ski federation requirements for competition*

Method

Four physical tests were conducted, shock absorption with straight perpendicular impact and three oblique impact tests (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 (SS-EN1077 2007) 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.

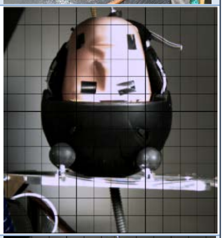
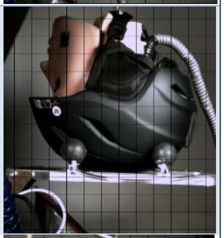
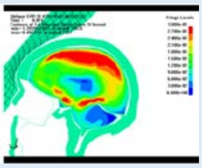
Oblique Tests

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).

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 tests	
Shock absorption test (EN1077) 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's initial angle was 0°. 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% corresponds to a 50% risk for concussion.	

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

In total three helmets obtained the Folksam best in test or good choice label: Everest Alpine MIPS Helmet, Giro Nine MIPS and the racing helmet Sweet Protection Volta MIPS, Table 3. The helmet Everest Alpine MIPS performed best and was 30% better than the average helmet. All the three helmets are fitted with MIPS (Multi-directional Impact Protection System) with the intention to reduce the rotational energy.

Table 3. Overall results

Helmet	Model	Overall result	Folksam's label
Bliz	Head Cover	-18%	
Everest	Alpine MIPS Helmet	30%	Best in Test
Everest	Alpine Helmet	-14%	
Giro	Nine MIPS	22%	Good Choice
Oakley	Mod3	9%	
POC	Obex SPIN	-20%	
POC	Skull Orbic X SPIN	5%	
Salomon	Cruiser 4D	-10%	
Scott	Quiver plus MIPS	6%	
SHRED	U Bumper Noshock RES	-17%	
Smith	Aspect MIPS	5%	
Sweet Protection	Rambler MIPS	2%	
Sweet Protection	Volata MIPS	22%	Good Choice
Tecnopro	Pulse alpinhjälm	-20%	

All helmets scored lower than 250 g in resultant acceleration in the shock absorption test (Figure 1). The two racing helmets (POC Skull Orbic X SPIN och Sweet Protection Volta MIPS) performed much better than all the other conventional helmets.

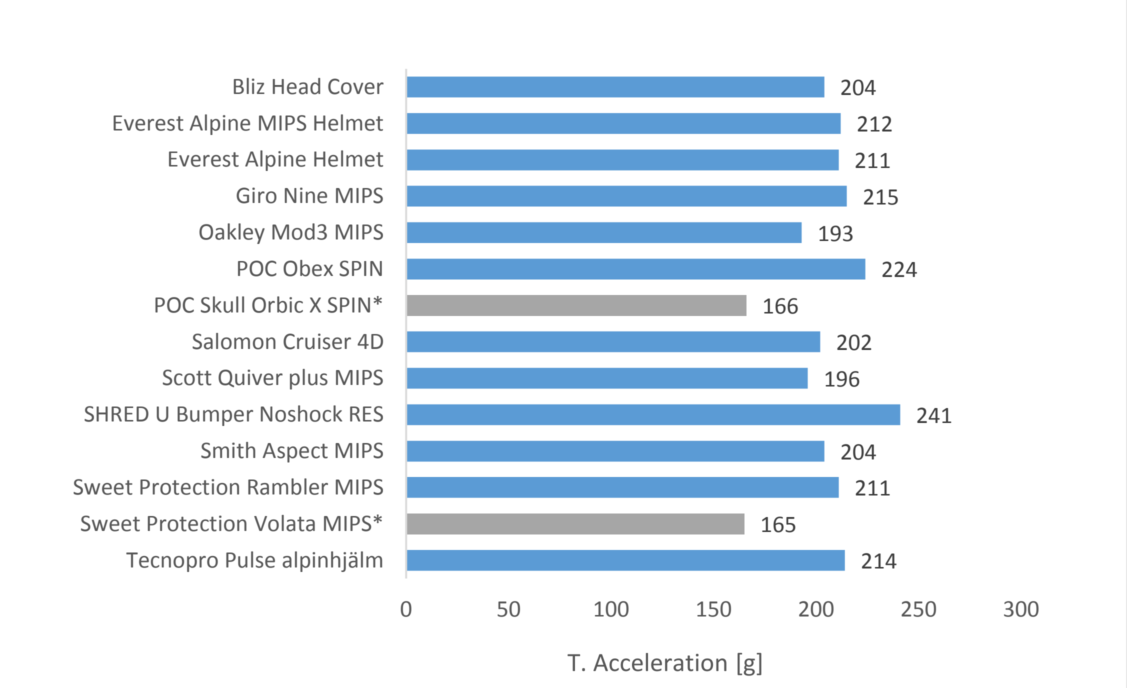


Figure 1. Shock Absorption measuring linear acceleration

Table 4 shows the tests that reflect the helmet's protective performance in a ski or snowboard 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 19% to 40%. Only two helmet did not give results that exceeded the threshold for a 50% risk of concussion in any of the three tests. Helmets equipped with MIPS performed, in general, 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)				
Helmet	**T. ACC. [g]**	**R. ACC. [krad /s²]**	**R. V [rad/s]**	**BrIC**	**Strain / Risk of concussion [%]**	**T. ACC. [g]**	**R. ACC. [krad/s²]**	**R. V [rad/s]**	**BrIC**	**Strain / Risk of concussion [%]**	**T. ACC. [g]**	**R. ACC. [krad/s²]**	**R. V [rad/s]**	**BrIC**	**Strain / Risk of concussion [%]**
Bliz Head Cover	149.4	10.5	34.2	1.00	30/61	140.8	9.4	37.3	1.04	42/89	138.1	8.3	28.5	0.82	34/74
Everest Alpine MIPS Helmet	113.4	4.2	20.7	0.55	20/29	116.3	3.1	20.0	0.51	18/24	113.6	3.3	19.8	0.51	23/39
Everest Alpine Helmet	143.1	10.6	33.1	0.98	29/57	130.1	8.3	36.1	0.99	40/86	123.6	7.7	27.3	0.78	32/67
Giro Nine MIPS	112.2	4.3	19.1	0.52	20/28	108.0	3.9	24.1	0.62	23/39	116.0	4.2	22.7	0.60	26/48
Oakley Mod3 MIPS	118.2	4.8	23.3	0.62	20/30	104.9	5.6	31.4	0.82	33/69	115.2	5.5	26.0	0.70	31/65
POC Obex SPIN	135.1	8.7	33.4	0.94	28/56	126.5	8.9	39.8	1.08	43/91	117.2	7.3	29.4	0.82	36/77
POC Skull Orbic X* SPIN	112.7	5.3	28.5	0.75	22/36	107.6	6.1	35.5	0.92	37/79	88.9	6.0	27.6	0.75	33/71
Salomon Cruiser 4D	138.2	8.8	32.3	0.92	28/55	121.8	6.8	36.5	0.96	39/84	140.5	7.9	27.8	0.80	31/64
Scott Quiver plus MIPS	112.0	5.7	27.4	0.73	22/35	117.4	6.0	31.3	0.82	34/72	98.6	4.9	26.0	0.68	30/61
SHRED U Bumper Noshock	148.3	7.1	29.3	0.81	25/44	170.0	11.0	37.8	1.09	42/89	151.7	10.2	30.2	0.91	35/77
Smith Aspevt MIPS	125.1	5.8	26.3	0.71	21/32	118.4	6.7	32.6	0.87	36/77	124.9	6.1	25.7	0.71	30/61
Sweet Protection Rambler MIPS	131.7	6.7	28.2	0.78	27/42	139.9	4.8	25.8	0.68	26/49	114.2	5.1	24.4	0.66	31/64
Sweet Protection Volata MIPS*	114.8	3.8	21.7	0.56	18/23	113.7	4.3	29.5	0.74	29/57	108.5	5.5	25.7	0.69	30/61
Tecnopro Pulse alpinhjälm	152.4	11.0	34.9	1.03	30/61	144.3	10.0	38.6	1.08	43/90	131.6	8.8	28.6	0.84	34/73
Mean	129.1	7.0	28.1	0.78	24/42	125.0	6.7	32.6	0.87	35/71	120.0	6.4	26.4	0.73	31/64
Min	110.2	3.7	18.6	0.50	18/23	102.2	3.0	19.4	0.49	18/24	88.5	3.1	18.5	0.48	23/39
Max	155.4	11.1	35.3	1.04	30/61	170.1	11.0	40.2	1.12	43/91	152.3	10.3	30.4	0.92	36/77

Discussion

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 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 nine consumer helmet tests (five 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 ten out of 14 had some of these technologies. The helmets equipped with MIPS performed in general 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 skier or snowboarder from getting a concussion in case of a head impact. Helmets need to absorb energy more effectively.

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