Bicyle helmets

SWOV fact sheet, May 2024

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Summary

A bicycle helmet is intended to protect cyclists against head and brain injuries when they are involved in crashes. Research shows that in case of a crash helmeted cyclists are 60% less likely to sustain serious head/brain injuries and 70% less likely to sustain fatal head/brain injuries than cyclists not wearing a helmet. Bicycle helmet effectiveness may even increase by more extensive testing procedures.

Currently, 5% of male cyclists and 3% of female cyclists in the Netherlands wear helmets. If all cyclists in the Netherlands were to wear helmets, an estimated annual number of 100 to 110 road deaths and between 1,700 and 1,900 serious road injuries could be prevented.

In the Netherlands, the rate of a bicycle helmet use is one of the lowest worldwide. In countries where bicycle helmets are mandatory, the rate of helmet use is (obviously) much higher, but even in countries where helmets are not mandatory, cyclists wear them much more often than in the Netherlands. The three main reasons for Dutch cyclists not to wear a helmet are 1) that helmets are considered uncomfortable, 2) that helmets are considered unnecessary, and 3) that they are inconvenient to take along. Parents say that another reason for their children not to wear a helmet is that their peers do not wear one either. In foreign research, cyclists mention similar reasons for not wearing bicycle helmets.

Although no Dutch organisation or interest group is against encouraging voluntary helmet use, there is virtually no support in the Netherlands for making bicycle helmets mandatory. The main reason given is that mandatory helmets would (strongly) reduce the popularity of cycling. However, the evidence is limited and far from unequivocal.

1 How do bicycle helmets protect against head injuries?

In case of a fall or a crash, a helmet protects the head by the energy-absorbing foam lining of the helmet. This foam lining crushes and reduces the impact on the brain. The foam-lined interior is connected to the smooth hard exterior of the helmet. The smooth shell ensures little road surface friction and it can skid so as to prevent neck injuries. The hard shell ensures that the impact of the fall is spread over a broader surface area. The interior of the helmet is fitted with soft padding for comfort. The straps closing under the chin ensure the helmet stays on in case of a fall. Head rotation during a fall may be reduced by an extra layer in the helmet that moves along with the head (the so-called Multi-Directional Impact Protection Systems - MIPS) [1] [2]. Also see the question *How may the protection offered by bicycle helmets be improved and are there any alternatives to bicycle helmets?*

To achieve optimum protection the helmet should be a good fit and should be properly attached and fastened to the head [3] [4]. The effectiveness of a helmet decreases as the impact speed increases. Thus, a bicycle helmet is most effective for falls and lower-speed collisions.

In Europe, a bicycle helmet should at least comply with European technical standards (see the question *What requirements should a (good) bicycle helmet comply with?*). For the speed pedelec, a separate, sturdier helmet has been developed that protects a larger part of the head (see the question *Is a helmet mandatory on a pedelec or speed pedelec?* or SWOV fact sheet *Pedelecs and speed pedelecs*).

2 How often are bicycle helmets worn in the Netherlands?

In the Netherlands, 5% of male cyclists and 3% of female cyclists wear helmets. This was found from observations of over 14,000 cyclists in 13 different cities in the Netherlands in the summer of 2023 [5]. The study also showed that helmet use increases with age. Among cyclists aged 12 to 18, 1% wear helmets, among cyclists aged 18 to 24 helmet use amounts to 2%, among 25- to 50-year-olds 4% and 7% among the over-50s. Among children under 12, 4% wear helmets. Helmet use on pedelecs (8%) is higher than that on regular bicycles (3%).

So, in general, bicycle helmets are not a familiar sight in Dutch streets. Bicycle helmet use is much lower in the Netherlands than in other countries. For example, a worldwide survey [6] shows that 87% of Dutch adult cyclists say they have cycled without a helmet at some point in the past 30 days, the highest percentage of all 32 participating countries. The average in the 20 participating European countries was 69%, 51% in the United States and 30% in Australia.

Incidentally, this means that in the previous month 13% of the Dutch respondents did wear a helmet, a significantly higher percentage than was found in the Dutch observational study

mentioned above. The difference is presumably explained by the fact that while the vast majority of sports cyclists/racing cyclists in the Netherlands do wear helmets [7], this group is underrepresented in urban environments, i.e. where the observations took place. Furthermore, cyclists who occasionally, but not always, use a helmet say they do so mainly on longer bicycle trips [8], again a group presumably underrepresented in the observational study.

3 In which countries is bicycle helmet use mandatory?

Globally, there are 28 countries that have some form of bicycle helmet requirement (see *Figure 1*; [9]). Sometimes helmets are mandatory for all cyclists, sometimes only for children or young people, sometimes only in certain situations.

- For everyone, everywhere: in Argentina, Australia, Chile, Finland, Japan, Malta, Namibia, New Zealand, Nigeria, Slovakia, United Arab Republics, South Africa and in some provinces/states of Canada and the United States;
- For children/young people (between up to 12 and up to 18 years old), everywhere: in Estonia, France, Iceland, Israel, Jersey, Croatia, Latvia, Lithuania, Austria, Slovenia, Spain, Czech Republic, South Korea, Sweden, some Canadian provinces and some US states;
- Situation-dependent: for adults in Israel and Spain only on roads outside urban areas, except - in Spain - when cycling uphill.

Not all countries impose fines if cyclists do not wear helmets; for example, Finland and Japan do not impose fines.

Figure 1. Countries where bicycle helmets are mandatory for at least some age groups. Source: [9]

Although no Dutch organisation or interest group is against encouraging voluntary helmet use anymore [8], there is virtually no support in the Netherlands for a general bicycle helmet requirement [10].

4 Why do cyclists choose not to wear bicycle helmets?

The three main reasons for Dutch cyclists not to wear a helmet are 1) that helmets are considered uncomfortable, 2) that helmets are considered unnecessary, and 3) that they are inconvenient to take along. This is evident from a survey among approx. one thousand adult cyclists ([8]; *Table 1*). A large share gave other reasons (partly supplementary); mostly that they do not have a helmet, but often elaborating on their view that they do not think a helmet is necessary. The arguments here were that they usually cycle at low speeds, mostly in towns or cities, that they have good bicycle control, and that they mostly travel a known route or a small distance. Elaborations of practical objections included that wearing a helmet results in headaches, that a helmet is too warm to wear, and that a helmet is dangerous because you can't hear anything anymore.

Table 1. Reasons given by Dutch adult cyclists (N=944) for (sometimes) not wearing a helmet (multiple responses possible). Source: [8]

What's the reason you don't always wear a bicycle helmet?	
I don't think it is necessary	35%
I keep forgetting	9%
I think helmets are uncomfortable to wear	39%
I think helmets are inconvenient to take along once I have parked my bicycle	33%
I think helmets are ugly	20%
I am embarrassed to wear one	16%
I think it will ruin my hairdo	14%
Other	35%

The above information is about adult cyclists. The evaluation of a bicycle helmet campaign aimed at children in the first four years of primary school, running in the province of Zeeland in 2010-2015, provides some information about children [11] [12]. It showed that for both children and their parents, safety is the most important reason for wearing (or being obliged to wear) a bicycle helmet. The most frequently mentioned reason for children to stop wearing a bicycle helmet is that their peers also cycle without one and that parents do not want their child to stand out.

Other reasons given by parents for not having their child wear a helmet are that the child is careful and cycles quite safely, and that according to them the route to school is safe enough.

International research shows similar reasons for not wearing bicycle helmets when they are not mandatory: not necessary, uncomfortable, ugly, inconvenient. The research was mainly conducted among children and adolescents, see for example [13] [14] [15] [16] [17] [18].

5 How effective are bicycle helmets in preventing (fatal) head injuries among cyclists?

In case of a fall or crash, the use of a bicycle helmet reduces serious head/brain injury by 60% and fatal head/brain injury by 71% on average. These are so-called 'best estimates'. With 95% certainty, the risk reduction for severe head and brain injury is between 54% and 65%, and the risk reduction for fatal head and brain injury is between 44% and 85%. This has become apparent from the most recent meta-analysis by Høye [19]. This study compared injuries of helmeted and non-helmeted cyclists by combining the results of 55 studies from different countries. These studies were mostly case-control studies and met strict scientific requirements. Overall, the protective effect of bicycle helmets was the same for both children and adults [19] [20].

Most studies from the aforementioned meta-analyses have been carried out in the United States, Canada and Australia, and a few in Asia and Europe; none of these in the Netherlands however. In those countries, the infrastructure and traffic composition as well as bicycle use are often different from the Netherlands. It is possible, that bicycle crashes in the Netherlands may be of a different nature, which has consequences for the protective effect of bicycle helmets. However, there is no a priori indication of a larger or smaller effect in the Netherlands. The protective effect of a bicycle helmet was also evident, for example, in a Dutch study analysing the injuries of nearly 2,000 casualties admitted to a trauma centre after a bicycle crash (2007-2017 period; [21]). The small group of cyclists who had worn a helmet at the time of the crash (7.5%) had significantly fewer head and neck injuries, subdural or intracerebral haemorrhages and skull (base) fractures than the casualties that had not worn helmets. Of the casualties who had worn helmets, 2% died; of those without helmets, 6% died. However, this difference was not statistically significant.

The bicycle helmet effectiveness found in the meta-analyses is based on case-control studies. This is the most common way to investigate the effectiveness of bicycle helmets (see below for more information). In addition, biomechanical research and research with computer simulations and time series analyses on the effect of bicycle helmets have also been conducted (again explained below). In general, all these types of research find a significant effect on reducing head and brain injuries resulting from a fall or crash; only in time series analyses does the effect appear to be smaller.

Case-control studies

In case-control studies, the effectiveness of bicycle helmets is determined by comparing cyclists involved in crashes resulting in head/brain injuries (case) to injured cyclists without head/brain injuries (control), and then verify whether the cyclist involved was wearing a helmet. The major advantage of case-control studies is that they concern real crashes that have actually happened. Case-control research into the effectiveness of bicycle helmets is done when there are no data about the (differences in) bicycle kilometres travelled by helmet users and non-users (exposure). Such data generally do not exist. This method has, however, also been criticised, since it could result in an overestimation of the effectiveness of bicycle helmets [22]. Yet, other researchers did not find any evidence of this overestimation ([23] for example). In general, a well-designed case-control study is considered as a reliable indication of the effect of helmets. An experimental design, for example a randomised control study, in which the researcher randomly selects who *is* and who *is not* going to wear a helmet, is inappropriate for ethical reasons. That is why case-control studies are standard in this area of research [20].

Biomechanical research

For biomechanical research, bicycle helmets are tested for shock absorption in a laboratory. During the test, a dummy head with and without a helmet falls down. It is estimated that a bicycle helmet will reduce the risk of serious brain damage in a fall from a height of 1.5 metres from almost 100% to 10%; and in a fall from a height of 2 metres to approximately 30% [24]. In these tests, helmets were used meeting the legal US requirements. The legal requirements for testing bicycle helmets differ by continent (see [25] for an overview of helmet standards).

Computer simulations

In studies using computer simulations, both the impact on the head as well as the possibly protective effect of a helmet are simulated in a model. On the basis of simulations of three types of single bicycle crashes, researchers conclude that helmet use may reduce the risk of concussion by more than 50% and the risk of a skull fracture by more than 90% [26]. Computer simulation of bicycle-car crashes also show that bicycle helmets may reduce the risk of serious injury, on average by 40% [27]. This kind of simulation research shows that not only the impact speed but also the impact location on the head determines the protective effect of a bicycle helmet [27] [28].

Time series analyses

By means of a(n) (interrupted) time series analysis, the effectiveness of an intervention (for example mandatory helmet use) may be determined by the number of casualties before and after the intervention. Several studies have used this method to determine the effectiveness of bicycle helmets, or rather of mandatory helmet use [29] [30] [31]. The studies looked at the share of cycling casualties with head or brain injuries before the intervention and during a series of fixed times after the intervention. In general, this kind of study finds a lower effectiveness than studies with a more experimental design. This will partly be due to the fact that not everyone actually wears a helmet. A disadvantage of this kind of study is that they have a prolonged time scale (several years) and that in this period other factors (such as other road safety measures, bicycle use, change in behaviour) may also have had an effect on the prevalence of head and brain injuries.

6 How many casualties could bicycle helmets save?

If all cyclists in the Netherlands were to wear helmets in 2030, 100-110 road deaths and 1,700-1,900 serious road injuries could then be saved (MAIS3+). If half of all cyclists were to wear helmets in 2030, the savings would be 50 road deaths and 800-900 serious road injuries [32].

This estimate is based on the effectiveness of bicycle helmets as shown in Høye's meta-analysis [19] (see the question *How effective are bicycle helmets in preventing (fatal) head injuries among cyclists?*) combined with the prevalence of (severe) head and brain injuries among cyclists, assuming a current wearing rate of 5%. The estimate of the effectiveness of helmets has exclusively been based on international research. Considering bicycle usage and the available (cycling) infrastructure in the Netherlands, it cannot be stated with any certainty whether the effect in the Netherlands would be the same. There are, however no concrete indications for a different outcome.

Of all cyclists in the Netherlands who are seriously injured in a bicycle crash, one-third (33%) suffer head or brain injuries. In bicycle crashes involving a motor vehicle, nearly half the cyclists suffer head or brain injury (48%); in bicycle crashes not involving a motor vehicle, more than a quarter (28%) do. *Figure 2* shows that serious head and brain injuries are relatively more common among young people.

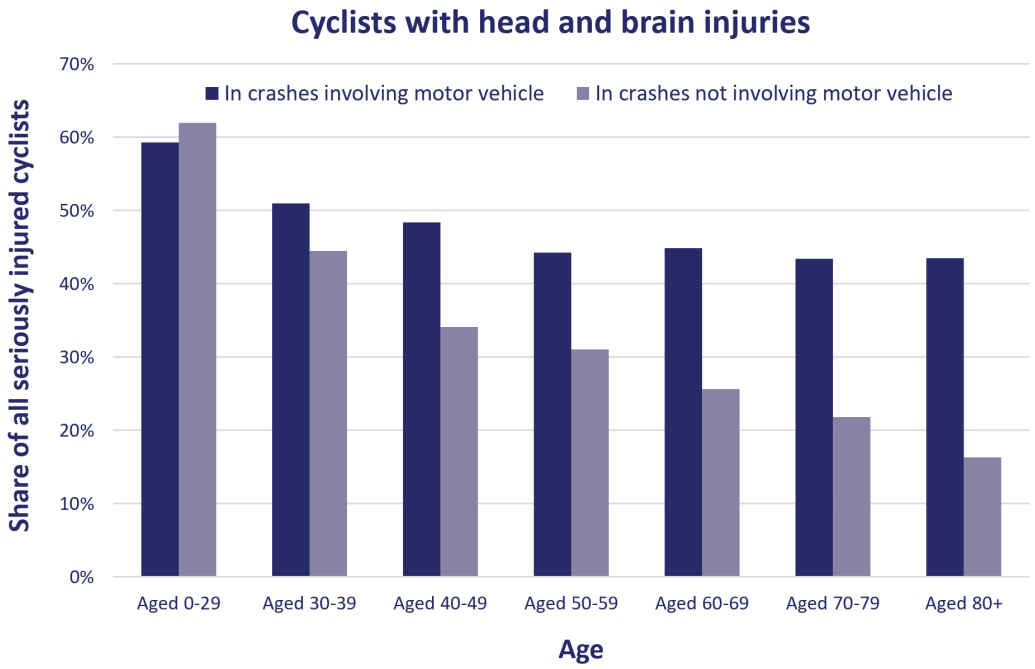

Figure 2. Share of hospitalised cyclists with severe head or brain injuries (AIS 3+) by age group, relative to all hospitalised cyclists with severe injuries (MAIS 3+); average over 2014-2019 (source: Dutch Hospital Data). Do bicycle helmets also have adverse effects?

7 Do bicycle helmets also have adverse effects?

Only a few studies find indications that cyclists wearing helmets will behave less safely, or that other road users will do so in their presence (behavioural adaptation), but most studies do not find any evidence of these unintended adverse effects. The occasionally voiced assumption that bicycle helmets lead to more neck injuries lacks sufficient proof. The effect of (mandatory) helmets on the use of bicycles is not unequivocal. Below, each of these possibly adverse effects is explained.

Behavioural adaptation

Some researchers argue that the positive effects of bicycle helmets are partly offset by cyclists adapting their behaviour (e.g. behavioural adaptation or risk compensation, amongst others in [33). Helmeted cyclists would supposedly feel safer and would, therefore, show riskier cycling behaviour. The opposite effect of associating helmet use with safer cycling behaviour is also found. It is unclear whether cyclists behave more safely because of their helmets or, more probably, whether helmets are used more often by cyclists inclined to cycle safely anyway. Systematic literature reviews [34] [35] show that empirical evidence for behavioural adaptation due to (mandatory) helmet use is not unequivocal.

Other road users may also adapt their behaviour: they may behave differently towards helmeted cyclists than towards unhelmeted cyclists. A British study [36] explicitly examined this. It showed that drivers of motor vehicles kept less distance to cyclists with helmets than to unhelmeted cyclists. A possible explanation is that drivers consider helmeted cyclists to be more skilled than cyclists without helmets, and therefore use smaller safety margins. However, re-analysis showed that the distance was not smaller, which therefore led to different conclusions. Further research is needed to determine how robust this (at this stage) one-off finding is (see [37] [38] for a discussion).

Neck injury

It is assumed that the extra weight of the helmet and possible friction with the road surface [39] increase the risk of neck injuries [40]. Yet, in recent meta-analyses of the effect of bicycle helmets [19] [20], no increased risk of neck injury was found.

Bicycle use

A frequently voiced argument against the mandatory use of bicycle helmets is that this would have an adverse effect [41] on bicycle use. Several international studies do indeed show a decrease in bicycle use after helmets are made mandatory, even though most studies do not find such an effect or only find a temporary effect [35] [42]. Also see the question *What is the effect of helmet use on the popularity of cycling?*.

8 What is the effect of helmet use on the popularity of cycling?

The effect of (mandatory) bicycle helmets on bicycle use is not clear. Several international studies show that bicycle use decreases after helmets are made mandatory, even though most studies do not find such an effect or only find a temporary effect [35] [42] [43]. These international studies have probably little bearing on the expected effect in the Netherlands, since, people use bicycles differently here. Cyclists often find helmets uncomfortable and impractical (see the question *Why do cyclists choose not to wear bicycle helmets?*). Making bicycle helmets mandatory could, therefore, make cycling less popular. This would be an unwelcome development from the perspective of public health (apart from crash involvement), the environment and urban traffic flow.

There are two international review studies of the effect of mandatory helmets on the use of bicycles, both dating from 2018 [35] [42]. The first study [35] shows that the research results are not unequivocal. The researcher states that mandatory helmet use could indeed result in a decrease of the number of cyclists, but that this need not always be the case and that, if the number of cyclists initially decreases, that need not be of long duration. The second study [42] is a mostly qualitative analysis of the literature. Based on their findings, the researchers conclude that there is little to no evidence of a substantial decrease of bicycle use due to the introduction of mandatory helmets. They have examined 23 studies/data sets and conclude that 2 of these studies support the hypothesis that mandatory helmets lead to a decrease of cycling, whereas 13 studies do not, and 8 studies show mixed results.

The abovementioned review studies only concern research done abroad, in particular in Australia and North America. The results probably have little bearing on the expected effect in the Netherlands. Moreover, the only Dutch study on this subject, a study among children aged 6 to 8, did not find any indications of an effect of bicycle helmets on bicycle use [11].

9 How effective are bicycle helmet campaigns?

Bicycle helmet campaigns generally lead to an increase of helmet use, but sometimes the effect is only temporary. Campaigns vary widely in terms of the extent of the effect. This depends among other things on the exact content and duration of the campaign and of course on the extent to which helmets are already worn at the start of the campaign. Moreover, most campaigns are combined with other activities, such as making bicycle helmets readily available or measures such as mandatory helmet use. As a result, the effect of stand-alone mass media awareness campaigns is unknown.

A 2002 review study reports results from 19 studies on campaigns to encourage helmet use [44]. Most of these were conducted in the United States and Canada and focused primarily on children. The studies showed different results, but the researchers conclude that:

- promotional campaigns generally increase helmet use;
- the largest effect is reached among young children and particularly among girls;
- helmet discounts have a positive effect on purchase and usage.

A more recent but smaller-scale meta-study [45] analysed eight studies on the effects of campaigns to encourage bicycle helmet use: three from North America and five from Europe. These showed an overall positive effect of campaigns, but there were large differences in the magnitude of the effect found. Further analyses showed that only the effect of campaigns combined with legislation was statistically significant and that of stand-alone campaigns was not.

One of the studies included in the aforementioned 2023 meta-analysis was the evaluation of the Dutch bicycle helmet campaign “Coole kop, helm op!” (“Wanna look cool, wear a helmet!'”). This campaign was aimed at children in the first four years of primary school in the province of Zeeland and consisted of a large number of different activities. The campaign was found to have a positive effect on helmet use among participating children, albeit only in the first campaign year [11]. In the first campaign year, almost five times as many children (aged 4-8) wore helmets compared to the pre-campaign period: an increase from an average of 3.3% to 15.7%.

Well-known and now often cited in the Netherlands, is the very successful and long-running approach taken by Denmark. In Denmark, as in the Netherlands, helmets are not mandatory. Yet, for many years Denmark has encouraged voluntary helmet use in all kinds of ways. Not only by mass media campaigns, but also by many local activities aimed at specific target groups. The so-called AAA approach in Denmark has three central elements [46]: inform people about the positive effect of helmets on the prevention of brain injury (Awareness), ensure that bicycle helmets are easy to get and cheap to buy (Availability), and improve helmet design and make adults role models for (grand)children (Attractiveness). Between 2004 and 2021, overall bicycle helmet use in Danish cities increased from 6% to 48% and helmet use by children on their way to school from 33% to 80% [46].

The Ministry of Infrastructure and Water Management is committed to encouraging the voluntary use of bicycle helmets, starting with parents of young children, commuters and seniors. In preparation of a possible campaign, both MARE [47] and SWOV [8] carried out exploratory studies of public support and experiences elsewhere on behalf of the ministry. Subsequently, D&B [48] developed a behavioural strategy, based on behavioural science principles. The strategy has three phases: 1) facilitation, 2) motivation and activation, and 3) internalisation.

10 Is helmet use mandatory for (speed) pedelecs?

In the Netherlands, helmet use is not mandatory for pedelecs (pedal assistance up to 25 km/hour), since pedelecs are classified as ‘ordinary’ bicycles. Speed-pedelec riders do have to wear helmets (special speed pedelec helmets or moped helmets; not ordinary bicycle helmets), because a speed pedelec is legally a moped. For more information see SWOV fact sheet *Pedelecs and speed pedelecs*.

11 Which requirements should a (good) bicycle helmet meet?

Bicycle helmets sold within the European Union should comply with European directives. An approved helmet has a CE marking on the inside, followed by the number of the European standard: EN-1078 for adults and EN-1080 for children's helmets. The difference between the two is the way the chin strap is fastened: the chin strap of children's helmets snaps off in case the helmet snags, which prevents the child from choking [49].

In compliance with the European standard, the effectiveness of bicycle helmets is tested by having the helmet impact on a flat surface ('flat anvil') at a speed of approximately 20 km/hour and on a 'curb' surface ('curb anvil') at a speed of approximately 17 km/hour. In this way, the speed at which the head impacts the surface during a fall (single bicycle crash) is reproduced; a fall from a height of 1.5 metres (relating to an impact speed of 20 km/hour) and from 1 metre respectively (relating to an impact speed of 17 km/hour) [50] [51].

According to several researchers [52] [53] [54] [55] [56], the European standard for bicycle helmets, and thus the Dutch standard, is not strict enough. It is also less strict than standards in the United States and Australia, for example. Different organisations, such as ETSC [57], have therefore called for an improvement of the European quality standard for bicycle helmets. Different concrete proposals for new and better bicycle helmet tests have already been made (see the question *How may the protection offered by bicycle helmets be improved and are there any alternatives to bicycle helmets?*).

12 How may the protection offered by bicycle helmets be improved and are there any alternatives to bicycle helmets?

In the Netherlands, bicycle helmets have to comply with the European quality standards (see the question *Which requirements should a (good) bicycle helmet meet?*). According to different researchers [1] [50] [52] [53] [54] [55] [56] [58], the test procedure should be extended to include an 'angled impact' or 'oblique' test. In addition, a cyclist's airbag might offer better and additional protection against head and brain injuries [2] [59]. Finally, there are developments towards intelligent helmets that would not only provide physical protection but would also help prevent crashes. The fact sheet *Cyclists* provides a broader discussion of cyclist safety and measures to improve it.

Extension of test procedure for bicycle helmets

Different researchers [1] [50] [52] [53] [54] [55] [56] [58] advocate extending the test procedure to include an 'angled impact' or 'oblique' test, in which helmet effectiveness is tested by dropping it from a certain height onto a slanted surface. These tests measure the effect of the helmet on head rotation. This is important because this so-called 'rotation effect' is closely related to the occurrence of brain injuries [2] [28] [59] [60] [61]. Today, there are several organisations already carrying out these tests (e.g. Certimoov and Folksam) and there are helmets on the market that offer better protection against rotational forces on the head in case of a fall. These have an extra layer inside the helmet which moves along with the head during impact (so-called Multi-Directional Impact Protection Systems - MIPS) reducing the rotation of the head [1] [2].

A second welcome extension concerns the impact speed during testing, in other words the speed at which a cyclist's head collides with something. Current European standards for bicycle helmets are based on an impact speed of 17 and 20 km/hour and simulate a fall from a bicycle. The speeds in a collision with a motor vehicle may, however, be much higher. In this case, the collision process and the associated impacts are also much more complex and diverse. By also testing the effectiveness of bicycle helmets in these conditions, the quality of helmets may improve.

Finally, it is argued that quality should not be determined solely by testing it on models of heads of the "average man," but that more consideration should be given to differences in anthropometric characteristics between different groups of people [62].

Cyclist airbags

A different current development is the cyclist airbag. This is a kind of collar worn around the neck. In case of a crash the airbag inflates, which not only protects the head but also fixates the neck. Such an airbag had positive outcomes in different tests [2] [59]. This is partly because the airbag reduces rotational forces on the head more than a conventional helmet does.

Intelligent helmets

Several manufactures are developing 'intelligent' helmets. These helmets are not only intended to protect against head and brain injuries but also to prevent crashes. Intelligent helmets may for example, by means of led-signals, show other road users when cyclists are braking and which direction they are turning. One such helmet (the 'Lumos bicycle helmet') is already on the market. Helmets that warn cyclists when a vehicle approaches in their blind spot (the 'Classon bicycle helmet') are still being developed; it is still unclear when they will come onto the market and how effective they will be.

Publications and sources

Below you will find the list of references that are used in this fact sheet; all sources can be consulted or retrieved. Via Publications you can find more literature on the subject of road safety.

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