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FINDINGS

Department for Transport

The Potential for Cycle Helmets to Prevent Injury: A Review of the Evidence

Abstract

There has been much debate in the literature and elsewhere regarding cycle helmets and their potential to prevent injury. This cycle helmet safety research report was commissioned to provide a comprehensive review of the effectiveness of cycle helmets in the event of an on-road accident, building on previous work undertaken for the Department for Transport (Towner *et al*., 2002). The programme of work evaluates the effectiveness of cycle helmets from several perspectives, including a review of current test Standards; a biomechanical investigation of their potential limitations; a review of recent literature; and finally an assessment of the casualties that could be prevented if cycle helmets were more widely used.

Main findings

Assuming that cycle helmets are a good fit and worn correctly, they should be effective at reducing the risk of head injury, in particular cranium fracture, scalp injury and intracranial (brain) injury.

- Cycle helmets would be expected to be effective in a range of accident conditions, particularly:
  - the most common accidents that do not involve a collision with another vehicle, often simple falls or tumbles over the handlebars; and also
  - when the mechanism of injury involves another vehicle glancing the cyclist or tipping them over causing their head to strike the ground.
- A specialist biomechanical assessment of over 100 police forensic cyclist fatality reports predicted that between 10 and 16% could have been prevented if they had worn an appropriate cycle helmet.
- Of the on-road serious cyclist casualties admitted to hospital in England (HES database):
  - 10% suffered injuries of a type and to a part of the head that a cycle helmet may have mitigated or prevented; and a further
  - 20% suffered 'open wounds to the head', some of which are likely to have been to a part of the head that a cycle helmet may have mitigated or prevented.
- Cycle helmets would be expected to be particularly effective for children, because:
  - the European Standard (EN 1078) impact tests and requirements are the same for adult and child cycle helmets – both use a 1.5 m drop height test; and so
  - given that younger children are shorter than older children and adults, their head height would be within the drop height used in impact tests, so a greater proportion of single-vehicle accidents are likely to be covered by the Standard for children.
- No evidence was found for an increased risk of rotational head injury with a helmet compared to without a helmet.
- In the literature reviewed, there is a difference between hospital-based studies, which tend to show a significant protective effect from cycle helmets, and population studies, which tend to show a lower, or no, effect. Some of the reasons behind this were due to:
  - the lack of appropriateness of the control groups used; and
  - limitations in the available data, such as knowledge of helmet use and type of head injury.

Background

In 2008, 115 pedal cyclists were killed and 2,450 reported as seriously injured on Britain's roads, accounting for 9% of all killed or seriously injured (KSI) road casualties (Department for Transport, 2009). Approximately 40% of pedal cyclists admitted to hospital in England suffered head injuries. Cycle helmets are designed to reduce head injuries by absorbing the energy during a head impact and distributing the load.

Cycle helmet wearing rates have increased steadily since 1994 for most cyclist groups. In 2008 they were 34% on major roads and 17% on minor roads, up from 22% on major roads and from 8% on minor roads in 1999.

Research findings

Cycle helmet testing

In most jurisdictions, cycle helmets are tested to ensure a minimum level of performance of the helmet for a range of criteria that affect safety. Typically these include:

- construction requirements;
- impact test requirements;
- retention system (strap) strength and helmet stability;
- definition of the minimum area of the head covered by the helmet; and
- definition of a minimum field of view (to ensure that the helmet does not impede the wearer's vision).

Most cycle helmet standards around the world define similar types of impact test, but the impact severity, pass/fail criteria and number of tests per helmet vary in different standards. This means that helmets certified to one standard may not pass the requirements of another. In addition, cycle helmet standards have changed over time, and so current helmets in the UK may be quite different from those sold in other regions or in previous decades. The results of real-world cycle helmet effectiveness studies must be considered in the context of these regional and temporal differences in cycle helmet standards.

It was found that cycle helmets designed to the Standards currently used in the UK (EN 1078 for child and adult helmets and EN 1080 for younger child helmets) would, based on biomechanical principles, be expected to be effective in many cycle accident conditions. This effectiveness would depend on a range of factors, such as the type of accident (e.g. a fall from a cycle or a collision with another vehicle), the stature and injury tolerance of the rider, and the shape and stiffness of the object struck by the head (e.g. a flat road surface, a kerb, or a deformable car bonnet).

Potential limitations to effectiveness

The report explored a number of claims that cycle helmets may make a head injury worse than if no helmet had been worn. Biomechanical data reviewed in the report show that a helmeted head can fall at least four times as far for the same risk of injury as an un-helmeted head, within the range to which cycle helmets are tested.

There have also been concerns expressed in the literature that cycle helmets may not be effective at reducing injuries caused by rotation of the head, or even that they may make such injuries worse. There are no cycle helmet standard tests for performance in rotational loading conditions. Nevertheless, no evidence was found for an increased risk of rotational head injury with a helmet compared to without a helmet.

Literature review of cycle helmet effectiveness

This report considered in detail the published literature on the effectiveness of cycle helmets, updating the previous review reported by Towner *et al*. (2002). Most of the published research into helmet effectiveness attempts to determine whether the protective effect of helmets is sufficient to affect casualty outcomes in real accidents. There are two primary forms of study into cycle helmet effectiveness that are described in the published literature:

- hospital admissions studies; and
- population studies.

The majority of hospital admissions studies use a case-control design. This design matches helmeted cyclists with un-helmeted cyclists and attempts to discern different injury outcomes from the data that are attributable to the helmet. Population-based studies typically consider aggregate national statistics on cycle accidents and tend to be longitudinal. They compare the trend in cyclist head injuries with the expected trend were helmets to offer a protective effect.

The accurate assessment of the effectiveness of cycle helmets requires detailed and comparable data. Many of the studies reported in the literature suffered from some shortcomings in the information available. Examples included:

- no data being available on the accident characteristics leading to the head injury (e.g. the speed of an impacting vehicle and the first point of contact with the cyclist);
- a lack of detailed data on the type of head injury (e.g. was it an injury a helmet could have prevented?); and
- the level of data reported in most of the studies reviewed being aggregated to a point where it was not possible to reinterpret it to answer criticisms of study design or analysis from the published papers.

Overall, there appears to be a clear difference between hospital-based studies, which tend to show a significant protective effect from cycle helmets, and population studies, which tend to show a lower, or no, effect. This is likely to be due to the difficulties in adequately controlling for confounding variables, as well as limitations regarding how representative the cyclists are in the samples used compared with the whole cycling population.

Furthermore, cycle helmet designs have changed over time; it is difficult to interpret effectiveness measures from other regions in terms of cycle helmets currently on sale in the UK. As a result, it was not possible to quantify the amount of benefit offered by modern cycle helmets in the UK from the literature review alone.

Evidence from in-depth accident studies

In-depth accident data were used to investigate the extent and nature of the head injuries sustained by pedal cyclists, which were then correlated as far as was practicable with the accident circumstances. In conjunction with consideration of the biomechanics of head injury and the mechanics of helmeted head impacts, this information was used to predict the potential effectiveness of cycle helmets at mitigating or preventing a proportion of the more severe types of head injury, i.e. cranium fractures and/or intracranial injury.

The accident databases used were:

- the Hospital Episode Statistics (HES) database for England (1999 to 2005); and
- a police fatal file derived pedal cyclist database (2001 to 2006).

The HES dataset contains very detailed information regarding the injuries sustained, but only superficial information with respect to the nature of the accident. The database contains information about on-road and off-road casualties, but only the on-road were selected for further analysis. However, a limitation of the HES data is that if the location of the accident is not recorded in the patients' records – it is assumed to be a traffic accident (on-road).

The police fatal files provided full reconstruction evidence and allowed, in most cases, the cause of the head injury to be evaluated by expert assessment. Thus, an expert judgement could be made for each fatal case as to the likely potential effect a cycle helmet would have had, if worn.

Therefore, the methods used and the subsequent confidence attributed to the predictions of the potential effectiveness of cycle helmets for fatalities (fatal file) and seriously injured casualties (HES database) varied.

For the HES data it was not possible to state categorically the proportion of casualties that would have been prevented if all had worn cycle helmets. Rather, a target population was identified for whom a cycle helmet could have been beneficial.

An in-depth review of the head injuries suffered by cyclists who were admitted to hospital in England identified that 10% sustained serious cranium fracture and/or intracranial injuries. The majority of this group (7% of the total) only sustained these injuries and had no other head or other body region trauma. Therefore, if cycle helmets had been worn, a proportion of this 7% may not have required hospital treatment at all.

However, a limitation of this work was the lack of evidence regarding whether or not the cyclists were already wearing a cycle helmet.

A forensic case by case review of over 100 British police cyclist fatality reports highlighted that between 10 and 16% of the fatalities reviewed could have been prevented if they had worn a cycle helmet. This predictive analysis was undertaken by biomechanical and vehicle safety experts who excluded cases where:

- the cause of death was not associated with head injury; and
- where the causes of the head injuries were in excess of the potential benefit a helmet could have afforded.

There are limitations associated with the predictive approaches undertaken by this type of study, so conservative estimates of helmet effectiveness were assumed for different accident scenarios.

Conclusions

The project concludes that in the event of an on-road accident, cycle helmets would be expected to be effective at reducing the frequency and severity of injury in a range of accident conditions, particularly the most common accidents that do not involve a collision with another vehicle.

About the project

This research report was commissioned to provide a comprehensive review of the effectiveness of cycle helmets in the event of an on-road accident, building on previous work undertaken for the Department for Transport (Towner *et al*., 2002).

The objectives were to evaluate the effectiveness of cycle helmets from several perspectives:

- review of cycle helmet testing and Standards (including the nature and severity of head injuries that they are designed to protect against; predicted benefit in those types of test conditions);
- a biomechanical assessment of the potential limitations to effectiveness;
- a literature review of effectiveness from real-world studies; and
- an in-depth accident data investigation to identify the potential for cycle helmets to prevent injury.

This report focuses on understanding whether cycle helmets reduce the frequency and severity of injury in the event of a collision. It does not include detailed consideration of whether wearing (or not wearing) a helmet influences the likelihood of being involved in an accident, either through behaviour changes in the rider or in other road users.

Further information

The full report, **The Potential for Cycle Helmets to Prevent Injury: A Review of the Evidence** by D. Hynd, R. Cuerden, S. Reid and S. Adams, is published by TRL (PPR 446).

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