Assessment of current bicycle helmets for the potential to cause rotational injury


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Main BHRF Commentary on this paper

Commentary

Research by Corner, Whitney, O’Rourke and Morgan, 1987, commissioned by the Australian government to support forthcoming helmet laws, found that the standard tests for helmets were deficient as they only considered protection of the brain against a direct blow and not the reduction of angular (rotational) acceleration. Corner et al. also found by experiment that the mass which a helmet adds to the head can actually increase angular acceleration, which is linked to severe injury to the brain. The suggestion in TRL report PPR213 (p. 49) that more severe injuries may occur to a helmeted than an unhelmeted head is consistent with this finding.

The research of Corner et al. provided no surety that helmets would be beneficial and not increase harm, but the Australian authorities did not give due attention to the deficiencies that it found. An official but unpublished commentary on it merely noted the researchers’ view that further research was required and concluded from other (controversial) findings that the report lent further support to the benefits of helmet wearing (VicRoads, 1988). Though Corner et al’s experimental findings have never been publicly challenged and the deficiencies found in standard helmets have not been overcome, Australia went ahead with compelling cyclists to wear them (Curnow, 2003). As more cyclists wore helmets, their risk of severe injury to the brain increased as is apparent in the official statistics for deaths by head injury, shown in Table 1 (Curnow, 2005).

<table>
<thead>
<tr>
<th>Year</th>
<th>All road users</th>
<th>Cyclists</th>
<th>Pedestrians</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>Head</td>
<td>Total</td>
</tr>
<tr>
<td>1988</td>
<td>2868</td>
<td>1085</td>
<td>542</td>
</tr>
<tr>
<td>1994</td>
<td>1787</td>
<td>631</td>
<td>346</td>
</tr>
<tr>
<td>Change 1988/94</td>
<td>-38%</td>
<td>-42%</td>
<td>-36%</td>
</tr>
</tbody>
</table>

Table 1. Deaths of road users in Australia, in total and involving head injury derived from the fatality file of the Australian Transport Safety Bureau

The table shows that from 1988, before the first helmet laws, to 1994, when laws were in force in the whole of Australia, deaths by head injury for all road users decreased by 42% and for pedestrians by 38%, but those to cyclists fell by only 30%. Not only is no benefit from the helmet laws evident, but increased risk relative to other road users is indicated because cycling declined by about one-third after the helmet laws came into force. Clearly the laws did not lead to any net saving in lives (Curnow, 2005).

Tests of oblique impacts in the TRL study were conducted in conditions that were carefully controlled as befits experimental research, but the value of the data on angular acceleration that were obtained are limited by the choices of angle of incidence of 15 degrees and speed upon impact. These equate to a vertical fall of 25 cm and a horizontal speed of 30 km/h. While the speed may be typical of many real life crashes, so are lower speeds and vertical falls of 1 metre or more, so that the angle of incidence would greatly exceed 15 degrees. TRL suggests (page 10) that linear acceleration would then be more important, but research by Andersson, Larsson and Sandberg, 1993, found that in such conditions soft helmets grabbed the surface and produced angular acceleration exceeding 20,000 rad/s². This is likely to be much more injurious than linear impact. Further, most serious injuries to cyclists result from collisions with a moving motor vehicle, which often contributes most of the speed at impact, and occur on widely differing surfaces. In practice, the consequences may differ considerably from those indicated by TRL in this report and may be best measured by data on the lines of Table 1 above.
Even within the limited range of testing carried out by TRL, important uncertainties and inconsistencies are evident in the results. The report acknowledges some of these, such as that there many factors which influence the head rotational response (p. 22); the effects of hard shells (p. 29), wide variations in estimates of tolerance to angular acceleration (pp. 41 and 49), and effects of size and fit of helmets. An inconsistency not acknowledged is between, on the one hand, the conclusion that the greater the linear acceleration in an oblique impact the greater the rotational acceleration (p. 43) and, on the other, the poor correlations shown in the data of Tables 4.8 – 4.10.

The report suggests acceptance of the notion underlying the design of helmets that the main capacity required is absorption of energy. This is mistaken. It is based on a theory of brain injury which does not consider rotation of the head and a false analogy with soldiers’ helmets. Holbourn, 1943 pointed out that, “when the head is struck by a 10 gram bullet travelling at 400 metres per second the dissipation of its high kinetic energy is dominant, but its low mass and momentum produce little rotation.” When a person moving relative to a massive object strikes it, however, change in momentum, not dissipation of energy, is the dominant mechanism. Momentum may then be transferred to the head and appear as a sudden rotation.

The value of helmets is thrown into further doubt by research findings that relate injury to the duration as well as the intensity of angular acceleration. Acceleration of short duration at a high rate causes subdural haematoma (SDH), but it causes diffuse axonal injury (DAI) if it is at a lower rate and of longer duration than are likely to occur as the result of a simple fall from not more than a person’s own height (similar to that used for testing helmets) (Adams et al, 1984). Consequently, researchers have suggested that, although the use of padding in cars and motorcycle helmets decreases the conditions that lead to SDH, the risk of DAI may be increased. They have commented: “Thus it is possible for use of well-meaning protective devices to allow one bad injury instead of another.” (Gennarelli, 1984; Gennarelli and Thibault, 1982)

TRL’s conclusions show considerable uncertainty about the critical issue of whether bicycle helmets of current design can protect against angular acceleration and consequent injuries to the brain. Further, some of the experiments reported show that some helmets can increase angular acceleration.

References

Adams et al, 1984

Andersson, Larsson and Sandberg, 1993

Corner, Whitney, O'Rourke and Morgan, 1987
http://www.cyclehelmets.org/1182.html

Curnow, 2003
http://www.cyclehelmets.org/1146.html

Curnow, 2005
Curnow WJ, 2005. The Cochrane Collaboration and bicycle helmets. Accident Analysis & Prevention
The Bicycle Helmet Research Foundation (BHRF), an incorporated body with an international membership, exists to undertake, encourage and spread the scientific study of the use of bicycle helmets. Also to consider the effect of the promotion and use of helmets on the perception of cycling in terms of risk and the achievement of wider public health and societal goals.

BHRF strives to provide a resource of best-available factual information to assist the understanding of a complex subject, and one where some of the reasoning may conflict with received opinion. In particular BHRF seeks to provide access to a wider range of information than is commonly made available by those that take a strong helmet promotion stance. It is hoped that this will assist informed judgements about the pros and cons of cycle helmets.

For more information, please visit www.cyclehelmets.org.

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