Crash characteristics of helmeted pedal cyclists

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Abstract

The results of a prospective study of pedal cycle crashes are reported. Cyclists were recruited from three major trauma centres in Sydney and through cycle organisations. The main sample criteria were that the cyclist crashed, and that they hit their head while wearing a helmet. Injury and non-injury cases were collected. Case sampling occurred over a period of 18 months. The response rate through hospitals was approximately 14% for those meeting the selection criteria. All cyclists were interviewed and the helmets were examined. Characteristics such as crash characteristics and injury are reported. The relationships between the crash characteristics, helmet use and injury are presented. The paper reports on 98 cases and excludes fatal cases. Half of the cyclists did not experience a head injury.

Introduction

Across Australia it has been mandatory since the early 1990s for pedal cyclists to wear a helmet and pedal cycle helmets sold in Australia must meet the Australian Standard (AS/NZS 2063). There is a growing interest in pedal cycling as a means of healthy recreation and transport. While recognising the potential health and transport benefits of cycling, there are also cyclist safety issues to consider. Current biomechanical knowledge on bicycle helmet performance in relation to head and neck injuries in Australia has stemmed from the works by McIntosh *et al.* [1] [2]. Since the mid 1990s, no further in-depth research has been conducted to investigate Australian helmet performance in real world crashes and reflect on the performance mandated in test standards. Despite the evidence that bicycle helmets are effective in preventing head and brain injury, their use has been challenged due to concerns around the effects of angular acceleration and that they discourage people from cycling [3] [4] [5]. A recent study of bicycling injuries and mortality in Victoria identified that there had been an increase in the incidence of serious injury between 2001 and 2006[6]. The study identified that at least 77% of the injured cyclists were male and that children aged less than 15 years were the largest group represented in emergency department presentations and hospital admissions. More severe injuries were distributed more evenly across all age groups. In short, extremity injuries were the most common less serious injuries, and trunk and/or head/neck/face injuries were the most common serious injuries, with 70% of deaths involving a head injury.

This paper reports on the crash characteristics of pedal cycle cases investigated to date in the study. The aims of the study are, in summary, to identify the performance of pedal cycle helmets in real crashes, compare those with the requirements of the Australian Standard (AS/NZS 2063) and identify areas of potential improvement in the Standard. To achieve these aims, ergonomic issues, biomechanical factors, test methods and helmet performance in crashes are being examined. This is the first paper describing the crash data set, currently in a preliminary phase of completion, and the results may differ marginally from future papers on this topic as they become finalised. In the next phase, in-depth biomechanical crash reconstructions will be performed on these cases. In particular, the relationships between impact severity, impact characteristics, helmet damage and performance, and injury will be studied.

Methods

Pedal cyclists and motorcyclists* were recruited from three trauma centres in the Sydney Metropolitan Area and through advertising on-line and in print media. St. George, Liverpool and Royal North Shore Hospital trauma groups assisted in the recruitment of participants by identifying potential participants and either speaking to them directly about the study or sending a flyer. Fatal crashes were also investigated but are not reported in this paper. Interested cyclists or families were invited to contact the research team at the University of New South Wales. Cyclists could also register their interest on-line. The inclusion criteria were that the participant had been involved in a pedal cycle crash while riding, was wearing a helmet and experienced an impact to the head/helmet during a crash. The injury outcome was not an inclusion criterion. The study was approved by institutional ethics committees. All participants or their representative provided informed written consent.

Each participant was interviewed using a standard protocol. Where possible the helmet was collected, and if not, inspected, measured and photographed. Medical records relevant to the case were retrieved. Injuries and their severity were coded according to the Abbreviated Injury Scale (AIS) 2005 Revisions.[7] During the interview information on the cyclist's demographics, crash characteristics, injury outcome, helmet, and bicycle were collected. The location of the crash was investigated and other information, eg. photographs of vehicle damage, was collected. In this paper a purely descriptive analysis of the population demographics, crash characteristics, and injury outcomes will be presented.

Results

This paper reports on 98 cases. Eighty-nine percent (88.8%) of participants were male. Fourteen percent of cyclists invited by the three hospitals to participate in the combined pedal and motorcycle helmet studies responded and were suitable for inclusion in the study*.

Table 1 presents the age range for the participants. The largest single group were 35-54 year olds. Very few children or teenagers were recruited. The majority of cyclists (74%) had more than 5 years cycling experience. Sixteen percent (16 %) of cyclists were either uninjured or received first aid only. Almost half (48%) were treated at hospital and 35% were admitted due to the severity of their injury/s. The majority of cyclists had no head injury but 35% experienced an AIS 2 head injury (table 2). Upper limb injuries were present in 84% of cases with 39% at the AIS 2 level.

Table 1: Cyclist age

Age Group (yrs)	Count	%
0 - 4	0	0.0%
5 - 9	1	1.0%
10 - 14	3	3.1%
15 - 19	3	3.1%
20 - 34	18	18.4%
35 - 54	59	60.2%
55 - 74	14	14.3%
75+	0	0.0%
Total	98	100.0%

* Motorcyclist cases are not presented in this paper. They are presented in a companion paper.

Table 2: Distribution of maximum AIS severity injury (MAIS) by body region and severity

MAIS	Head	Neck	Thorax	Abdomen	Spine	Upper Limb	Lower Limb
0	51.0%	59.4%	71.9%	93.8%	85.4%	15.6%	42.7%
1	11.5%	35.4%	16.7%	3.1%	13.5%	44.8%	55.2%
2	35.4%	5.2%	6.3%	2.1%	1.0%	38.5%	2.1%
3	2.1%	0.0%	5.2%	1.0%	0.0%	1.0%	0.0%

The distribution of the cases by crash type is presented in table 3. The majority of crashes were single vehicle crashes followed by crashes into another moving vehicle. The crash configuration indicates that many of the crashes involved loss of control (table 4).

Table 3: Crash type

Crash Type	Frequency	%
Single vehicle	52	53.1%
Vehicle to fixed object	9	9.2%
Vehicle to pedestrian	2	2.0%
Vehicle to animal	0	0.0%
Vehicle to moving vehicle	32	32.7%
Other miscellaneous	2	2.0%
Unknown	1	1.0%
Total	98	100.0%

Table 4: Crash configuration

Crash Configuration	Frequency	%
On straight, off roadway to left or right	8	8.1%
On straight, lost control on roadway	17	17.3%
On bend, off roadway to left or right	5	5.0%
Downhill, lost control	11	11.2%
Jump, lost control, bad landing	9	9.2%
On straight, off roadway to left or right into object	1	1.0%
Vehicles from adjacent approaches (intersection)	10	10.2%
Vehicles from opposing directions	6	6.1%
Vehicles from same direction	14	14.3%
Overtaking / Fell in/from vehicle / Parked vehicle runaway into object/parked vehicle / other / unknown	1	5.1%
Total	98	100.0%

Discussion

This is the first analysis of this crash case data set of pedal cycle crashes in which the cyclist wore a helmet. The relationship between helmet design, performance and injury outcome will be the focus of the main analyses; to be presented in the future.

The cyclist population recruited was mainly adults. It differs from the Victorian population which contained children and teenagers, but is similar in the high representation of males[6]. Despite efforts to arrange methods to recruit participants through Sydney's two children's hospitals and ethics approval, no suitable method could be operationalised within resource constraints. Methods to recruit participants using NRMA publications, cycling web sites, newsletters, etc. may not have reached a population of parents of cyclists and there may be some parental reluctance to participate in research.

Half of the crashes were single vehicle, which is consistent with findings from other research [8 1]. A third of crashes involved a second moving vehicle. The findings suggest that cycling safety initiatives must focus on cyclist skills, the environment – including cycle paths, and cyclist-vehicle interactions.

Within the population studied, upper limb injuries were more prevalent and more severe than head injuries. The upper limbs, unlike the head, are not protected and there is a normal reaction to use the arms to retard a fall. This is consistent with the findings from Victoria[6]. Almost half (47%) of head injuries were no greater than a maximum AIS severity 1 or 2, while half of the cyclists did not suffer a head injury, despite the inclusion criterion being that the crash involved an impact to the head. The results strongly indicate the benefits offered by wearing a helmet and support the findings of previous cycle helmet research. It is acknowledged that there are limitations with the data set. Considering the potential impact applied to the unhelmeted head resulting from a fall from a bicycle, the results provide support for policies that promote or mandate helmet wearing, in this case with an emphasis on adults.

In the next stage of the research the head impact characteristics will be estimated and compared to helmet performance and injury outcomes. This will be used to assess the current requirements of the Australian Standard.

Conclusions

The paper presented a preliminary analysis of 98 pedal cycle crashes and the injury outcomes. While the majority of cyclists did not receive a head injury, 2.2% of the sample still received an AIS severity 3 head injury. These results will be used as part of the broader study to examine possible improvements to bicycle helmet performance [and standards] to reduce serious head injury risk further.

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