THE PROTECTIVE EFFECT OF BICYCLE HELMETS - A STUDY OF PAIRED SAMPLES IN A COMPUTER-BASED ACCIDENT MATERIAL IN GOTHENBURG, SWEDEN

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ABSTRACT

A study has been made of the extent to which bicycle helmets afforded protection in respect of the incidence and severity of head injuries in 36 matched pairs of cyclists, where one in each pair had worn a helmet and the other had not. The pairs were matched according to the age and sex of the injured, the type and cause of the accident, the kind of bicycle and the road conditions. Head injuries in the helmet area were less frequent and less severe for the cyclists who had been wearing helmets. The conclusion is that bicycle helmets, even simple ones, could be recommended for cyclists of all categories as they protect against head injuries, at least against head injuries of minor severity.

INTRODUCTION

Bicycling has grown rapidly in popularity in Sweden over the last decade. The annual number of bicycle accidents has increased accordingly and cyclists now constitute the largest number of injured road users in Gothenburg [7]. In a previous study it was found that most of the injuries were to the skull and face [7]. The high incidence of head injuries in bicycle accidents has focused interest on the degree of protection afforded by bicycle helmets. There is also the question whether ordinary bicycle helmets protect as well as motorcycle and moped helmets. The aim of this study was to investigate the degree of protection given by bicycle helmets in urban traffic. The study included helmets which are not especially designed for cyclists such as ice-hockey helmets for example, which are usually worn by children when they are learning to ride a bicycle.

MATERIAL AND METHOD

A computer-based system for the registration and analysis of traffic accident casualties has been in use in Gothenburg, Sweden since 1983. The system process accident and environment data come from police reports and the injury data from hospital records. The data-base contains casualty data from 1650 bicycle accidents during 1983-84 and complementary accident data from those 1100 cyclists who answered a questionnaire. Thirty-six of the 1100 cyclists who answered the questionnaires had been wearing a helmet. Each of these thirty-six cyclists was matched with another cyclist (of the 1100 cyclists) who had not been wearing a helmet at the time of the accident. The matching parameters were: 1. The age of the injured; 2. The sex of the injured; 3. The type, mechanism and cause of the accident; 4. The type of bicycle (standard, sports, racing); 5. The road conditions.

The injury data for theese thirty-six pairs of cyclists were obtained from the data-base after the matching procedure. A comparison was made in each pair for:

1. The number of head injuries in the helmet area.
2. The maximum AIS-score of the head injuries in the helmet area.

The helmet area was defined as the major part of the skull and the forehead (figure 1). Standard statistical methods for paired samples were used for the test of significance [4].

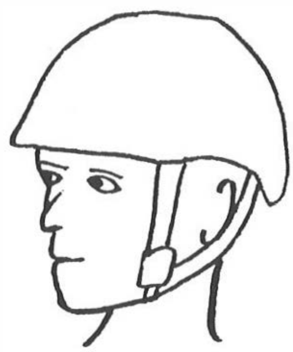


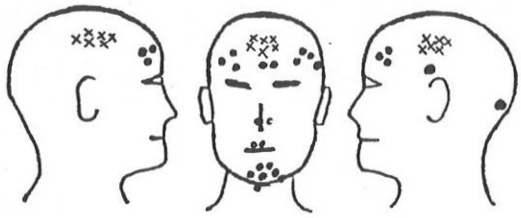
Figure 1. The helmet area of the head.

RESULTS AND COMMENTS

The age and sex of the injured and the accident circumstances are specified in table I. There were 26 pairs of male cyclists and 10 pairs of female cyclists. Almost two thirds of the injured were under 10 years of age and only two pairs were over 30 years old.

The type, localization and severity of the head injuries are specified in table II. The number of injuries in the helmet area was lower in 22 pairs, equal in 10 pairs and higher in 4 pairs for the helmeted cyclists. The maximum severity (AIS) of the injuries in the helmet area was lower in 21 pairs, equal in 9 pairs and higher in 5 pairs for the helmeted cyclists. In respect of the number of head injuries in the helmet area and the maximum severity of the head injuries in the helmet area, there was a significant difference between the helmeted and non-helmeted cyclists with a lower number of injuries (p<0,01) and a lower maximum AIS-score (p<0,01) for the helmeted cyclists. The total number and the localisation of all head injuries in the helmeted and non-helmeted cyclists are shown in figure 2.

Helmeted



Non-helmeted

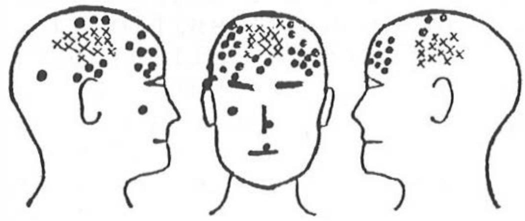


Figure 2. Head injuries in helmeted and non-helmeted cyclists. x indicates a cerebral concussion; • indicates a localized injury.

DISCUSSION

Most studies of bicycle accidents show a high frequency (30-50%) of head injuries [7,8,9,10]. In a previous study we found that the relative incidence of head injuries in injured cyclists in Gothenburg was 57% [3]. The same study showed that the relative incidence of head injuries was almost 80% in children of 4-6 years of age. Most of the injuries were of minor severity and life-threatening head injuries (AIS>3) were noted in only 1% in this study. Studies on fatal bicycle accidents show that almost 90% of the injured sustained head injuries [5,8]. In a study from 1975 Möller showed that more than 10% of injured cyclists were hospitalized because of cerebral concussion [10]. Sequele from head injuries in bicycle accidents should be the study of further analysis.

In a study of bicycle accidents in Stockholm, Sweden, approximately 60% of the head injuries were localized in the helmet area [8]. Thus, the wearing of a helmet should reduce the number and severity of head injuries in cyclists. The mandatory use of helmets for drivers of mopeds and motorcycles has reduced the number of head injuries significantly. However, there are some differences between bicycle and moped- or motorcycle accidents: Cyclists are more often injured in single accidents [7], the speed is probably lower in most bicycle accidents and the helmets used by moped- and motorcycle drivers are stronger and protect a larger area of the head. Very few (2-4%) cyclists in Gothenburg use helmets [6]. Most of the helmeted cyclists are children. We think that a majority of the cyclists regard the available bicycle helmets as uncomfortable and unattractive. There is also some discussion as to just how well the helmets available do protect. Swedish traffic safety authorities are not making any substancial propaganda for the use of bicycle helmets because they are waiting for better ones to be designed [11].

The 1100 cyclists sample in the study is the fraction of the 1650 injured cyclists during 1983-84, who responded a questionnaire. The matching procedure was made only on the 1100 sample, because there was not accidental data enough in the non-respondent group. Some of those who did not answer were probably involved in accidents which might be classified as "not typical traffic accidents", such as children falling off their bicycles when playing. There is a possibility that bicyclists with slight injuries were more frequent in the non-respondent than in the respondent group. If this is the case and if such accidents would have been matched instead of accidents with more severe head injuries the protective effect of the helmets would have been less obvious.

In general a "casualty sample" is an incorrect base for calculating the effect of a protective measure - You must have an injury to get into the material. However, being unable to collect an "accident sample" we must accept this bias and blurring of the results in this study.

A fact that also might blurr the result of this study is that the helmeted group (or their parents) might be more inclined to go and see a doctor. This might include a number of helmeted cyclists with neglectable injuries in the study. However, the number and severity of the injuries to other body regions were the same for the helmeted and non-helmeted group and therefore the blurring of the results probably are small.

The mechanism and cause of accident are perhaps not relevant as primary matching criteria but those circumstances have been documented in order to give a complete picture of the accident. The distance from home/accident place to the casualty room has not been studied. Almost all the accidents occurred in the Gothenburg area and the time to get to the hospital is short (less than 30 minutes) and probably not of major importance in this study in which severe head injuries (AIS≥3) were noted in only one case.

In our study it was not known which kind of bicycle helmet was worn in all cases. Most of the children were wearing ice-hockey helmets and the adults had used different types of specially designed bicycle helmets. The matching degree was not complete in all cases as it is difficult to find two identical accidents. The main matching criteria should be the type of accident and whether there was any impact to the head or not. In some cases there is probably a discrepancy in this respect but, nevertheless, the results of the study clearly show a difference between the number of injuries in the helmet area when helmets were worn and when they were not (figure 2). Most (77%) of the injuries in the former case were minor (AIS=1). Thus the efficacy of a bicycle helmet or even an ice-hockey helmet as protection against head injuries is obvious, at least for minor injuries.

Only one serious (AIS>2) head injury was noted in this study. The cyclist in this case was a non-helmeted woman involved in a collision with a car. The matched cyclist in this pair had been wearing a helmet and there was no head injury, but as it is not certain that there was any head impact in this case, it remains to be proved how well a helmet protects against serious head injuries.

CONCLUSIONS

The result of this study shows that ordinary bicycle helmets as well as simple ice-hockey helmets protect against head injuries, or at least against injuries of minor severity. In common with several other investigators [8,9,10] we would strongly recommend a more widespread use of bicycle helmets. We also think that it is better to use some kind of helmet rather than no helmet at all.

In our opinion, there are several important reasons why children should wear helmets: We know that the frequency of head injuries is very high in the agegroup 4-6 years. Furthermore, if children always get a helmet when they learn to ride a bicycle, they will probably accept it as a matter of course and in this way; there may gradually be instilled a more positive attitude to the wearing of bicycle helmets.

TABLE I ACCIDENT CIRCUMSTANCES

Pair no	Helm.	Sex	Age	Accident type *	Cause of single accidents or direction of impact in collisions	Bicycle type	Road condition
1	yes	M	5	single	loss of control while playing	standard	asphalt
	no	M	5	single	loss of control while playing	standard	asphalt
2	yes	M	5	coll.bicycle	hit from the left	standard	asphalt
	no	M	5	coll.bicycle	hit from the right	standard	asphalt
3	yes	M	5	coll.bicycle	hit from the back	standard	asphalt
	no	M	5	coll.bicycle	hit from the back	standard	asphalt
4	yes	M	54	single	mechanical failure, blocked wheel	racing	asphalt
	no	M	54	single	mechanical failure, blocked wkeel	racing	asphalt
5	yes	M	14	coll.bicycle	frontal collision	racing	asphalt
	no	M	14	coll.bicycle	frontal collision	racing	asphalt
6	yes	F	6	single	loss of control	standard	gravel
	no	F	5	single	loss of control	standard	gravel
7	yes	F	5	single	loss of control while playing	standard	asphalt
	no	F	5	single	loss of control while playing	standard	asphalt
8	yes	M	13	coll.car	hit from the right by wing of the car	sports	asphalt
	no	M	13	coll.car	hit from the right by front of the car	racing	asphalt
9	yes	F	30	coll.car	hit from the left by the side of the car	racing	asphalt
	no	F	30	coll.car	hit from the right by front wing and side of the car	racing	asphalt
10	yes	M	13	coll.bicycle	frontal collision	racing	asphalt
	no	M	13	coll.bicycle	frontal collision	racing	asphalt
11	yes	M	13	coll.bicycle	frontal collision	racing	asphalt
	no	M	13	coll.bicycle	frontal collision	sports	asphalt
12	yes	M	13	coll.bicycle	frontal collision	racing	asphalt
	no	M	14	coll.bicycle	frontal collision	racing	asphalt
13	yes	M	24	coll.bicycle	frontal collision	racing	asphalt
	no	M	25	coll.bicycle	frontal collision	racing	asphalt
14	yes	M	19	coll.bicycle	ran into the back of a bicycle	racing	asphalt
	no	M	20	coll.bicycle	frontal collision	racing	asphalt
15	yes	F	6	coll.bicycle	frontal collision	standard	asphalt
	no	F	6	coll.bicycle	hit from the right	standard	asphalt
16	yes	M	48	coll.moped	frontal collision	racing	asphalt
	no	M	47	coll.bicycle	frontal collision	sports	asphalt
17	yes	M	9	single	loss of control, too high speed	sports	asphalt
	no	M	8	single	too high speed	sports	asphalt

TABLE 1 ACCIDENT CIRCUMSTANCES

Pair no	Helm,	Sex	Age	Accident type	Cause of single accidents or direction of impact in collisions	Bicycle type	Road conditions
18	yes	M	15	single	too high speed	racing	asphalt
	no	M	14	single	too high speed	racing	gravel
19	yes	M	15	single	ran into a post	racing	asphalt
	no	M	14	single	mechanical failure-sudden stop	sports	asphalt
20	yes	F	7	single	loss of control while playing	standard	gravel
	no	F	7	single	loss of control while playing	standard	gravel
21	yes	M	9	single	ran into the bumper of a parked car	standard	asphalt
	no	M	10	single	ran into a high kerbstone	sports	asphalt
22	yes	M	6	single	loss of control while playing	standard	asphalt
	no	M	6	single	loss of control while playing	standard	asphalt
23	yes	F	4	single	loss of control while playing	standard	asphalt
	no	F	4	single	loss of control, too high speed	standard	asphalt
24	yes	M	4	single	too high speed while learning	standard	asphalt
	no	M	4	single	loss of control while playing	standard	asphalt
25	yes	M	5	single	too high speed	standard	asphalt
	no	M	5	single	too high speed	standard	asphalt
26	yes	M	4	single	loss of control, too high speed	standard	gravel
	no	M	5	single	ran into a stone on the road	standard	gravel
27	yes	M	5	single	loss of control while playing	standard	asphalt
	no	M	5	single	loss of control while playing	standard	asphalt
28	yes	F	4	single	loss of control, too high speed	standard	asphalt
	no	F	4	single	loss of control while learning	standard	asphalt
29	yes	M	5	single	ran into a stone on the road	standard	asphalt
	no	M	5	single	ran into a kerbstone	standard	asphalt
30	yes	M	5	single	slippering gravel on the road	standard	asphalt
	no	M	5	single	ran into a hole in the road	standard	asphalt
31	yes	F	5	single	loss of control while playing	standard	asphalt
	no	F	4	single	ran into a dustbin	standard	asphalt
32	yes	F	7	single	ran into a post	standard	asphalt
	no	F	6	single	loss of control while playing	sports	asphalt
33	yes	F	5	single	too high speed	standard	asphalt
	no	F	5	single	too high speed	standard	asphalt
34	yes	M	4	single	loss of control while learning	standard	gravel
	no	M	4	single	loss of control while playing	standard	asphalt
35	yes	M	17	single	loss of control, too high speed	standard	asphalt
	no	M	17	single	blocked wheel	standard	asphalt
36	yes	M	25	single	too high speed	racing	asphalt
	no	M	25	single	too high speed	racing	asphalt

TABLE II TYPE, LOCATION AND SEVERITY OF THE HEAD INJURIES AND CONCOMITANT INJURIES. (Injuries to the helmet area are underlined).

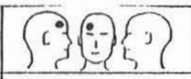
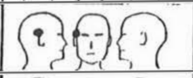
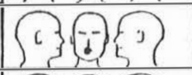
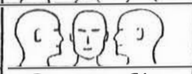
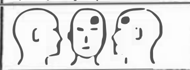
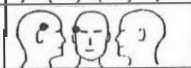
Pair no	Helmet	Type of injury	Severity AIS	Location	Injuries to other body regions	Severity AIS
1	Yes	contusion	1			
	No	excoriation	1		contusion upper extr	1
2	Yes	contusion	1			
	No	laceration	1			
3	Yes	excoriation	1		contusion upper extr	1
	No				contusion abdomen	1
4	Yes	cerebral concussion			contusion upper extr x 3 contusion spine	1, 1, 1 1
	No	laceration	1			
5	Yes	cerebral concussion	2			
	No				contusion upper extr	1
6	Yes	laceration	1			
	No	contusion	1			
7	Yes	laceration	1			
	No	excoriation	1			
8	Yes	excoriation	1		contusion lower extr x 3 excoriation upper extr	1, 1, 1 1
	No	excoriation	1		fracture lower extr excoriation upper extr	3 1
9	Yes				contusion abdomen contusion lower extr	1 1
	No	cerebral concussion contusion laceration	3 1 1		fracture upper extr	2
10	Yes	contusion				
	No				contusion upper extr x 2	1, 1
11	Yes				contusion spine excoriation lower extr	1 1
	No	cerebral concussion	2		fracture upper extr	1
12	Yes				contusion upper extr laceration lower extr	1 1
	No	contusion	1			

TABLE II TYPE, LOCATION AND SEVERITY OF THE HEAD INJURIES AND CONCOMITANT INJURIES. (Injuries to the helmet area are underlined).

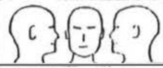
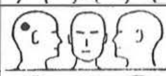
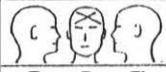
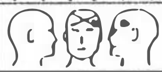
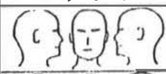
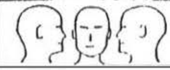
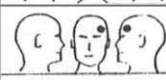
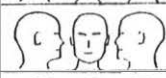
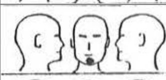
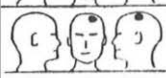
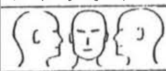
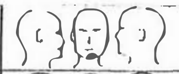
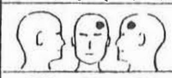
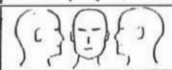
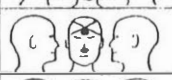
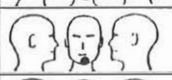
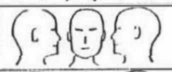
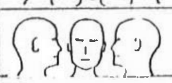
Pair no	Helmet	Type of injury	Severity AIS	Location	Injuries to other body regions	Severity AIS
13	Yes				dislocation upper extr	2
	No	<u>contusion</u>	1		fracture upper extr excoriation upper extr x 2 contusion lower extr x 2	2 1, 1 1, 1
14	Yes	<u>cerebral concussion</u>	2		excoriation upper extr excoriation lower extr x 2	1 1, 1
	No	<u>cerebral concussion</u> <u>laceration</u>	2 1			
15	Yes				contusion abdomen	1
	No	<u>laceration</u>				
16	Yes				fracture lower extr contusion abdomen	3 2
	No	<u>laceration</u>	1			
17	Yes				contusion upper extr	1
	No	laceration	1			
18	Yes				contusion upper extr	1
	No	<u>laceration</u>				
19	Yes				excoriation upper extr x 2 excoriation lower extr x 3	1, 1 1, 1, 1
	No	<u>cerebral concussion</u> <u>laceration</u>	1 1		excoriation upper extr x 2 excoriation lower extr x 2	1, 1 1, 1
20	Yes				laceration lower extr	1
	No	<u>contusion</u>	1		contusion upper extr x 2	1, 1
21	Yes	<u>contusion</u>	1			
	No	<u>cerebral concussion</u> <u>contusion</u>	2 1		excoriation upper extr	1
22	Yes	laceration	1		contusion lower extr	1
	No	<u>cerebral concussion</u> <u>contusion</u>	2 1		excoriation upper extr	1
23	Yes	laceration	1			
	No	<u>laceration</u>	1		excoriation upper extr	1
24	Yes	<u>laceration</u>	1			
	No	<u>cerebral concussion</u> <u>contusion</u>	2 1			

TABLE II TYPE, LOCATION AND SEVERITY OF THE HEAD INJURIES AND CONCOMITANT INJURIES.
(Injuries to the helmet area are underlined).

Pair no	Helmet	Type of injury	Severity AIS	Location	Injuries to other body regions	Severity AIS
25	Yes	laceration	1			
	No	excoriation fracture	1 1		excoriation lower extr x 2 excoriation abdomen excoriation upper extr	1, 1 1 1
26	Yes	excoriation	1			
	No	contusion	1		excoriation upper extr excoriation lower extr	1 1
27	Yes				contusion lower extr	1
	No	laceration				
28	Yes	contusion excoriation fracture	1 1 1			
	No	contusion contusion	1 1			
29	Yes				fracture upper extr	2
	No	cerebral concussion contusion	2 1		fracture upper extr excoriation upper extr excoriation lower extr	2 1 1
30	Yes				laceration lower extr	1
	No	contusion	1		excoriation upper extr excoriation lower extr	1 1
31	Yes	cerebral concussion contusion	2 1			
	No	laceration	1			
32	Yes	cerebral concussion	2			
	No	cerebral concussion	2		fracture upper extr	2
33	Yes	cerebral concussion contusion excoriation	2 1			
	No	cerebral concussion laceration	2 1			
34	Yes	laceration	1			
	No	cerebral concussion contusion	1 1			
35	Yes				excoriation upper extr x 2	1, 1
	No	cerebral concussion contusion	2 1		excoriation thorax	1
36	Yes				fracture upper extr	2
	No				excoriation upper extr x 2 excoriation lower extr	1, 1 1

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