CHILD PEDESTRIAN INJURIES

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ABSTRACT

The importance of pedestrian accidents as a source of injury to children is noted. The methodology of a current at-the-scene study of pedestrian accidents is described and the first results of this study, together with results from a previous study, are used to describe some features of pedestrian accidents. The location of the bumper with respect to lower limb injuries is discussed.

THE PROBLEM

Road accidents are the leading cause of accidental death for children, accounting for 39% of the deaths in 1971. The next most frequent type of accidental death is suffocation.(Figure 1.) (Office of Population Censuses and Surveys 1973). Pedestrian accidents are the most important source of road accident injury to children. In 1971 68% (651) of children killed, 68% (10,404) of children seriously injured and 58% (37,917) of children slightly injured were pedestrians and they accounted for 22% of the pedestrian fatalities, 44% of seriously injured and 49% of the slightly injured pedestrian casualties (D.O.E. 1973).

The definition of a child that has been used here, and will be used throughout the report unless stated otherwise, is a person aged 14 years or under.

ACCIDENT STUDY - METHODOLOGY

The Accident Research Unit (A.R.U.) at Birmingham University is currently engaged upon research into mechanisms of injury in pedestrian accidents. An at-the-scene study of pedestrian accidents was started in November 1973. The central police control room in Birmingham informs the A.R.U. whenever the police are called to a road traffic accident involving a pedestrian during the hours the A.R.U. is on call. At present the A.R.U. is on call from 08.00 to 18.00 one week and 16.00 to 24.00 the following week. The control room is contacted daily at the start of each on call period.

On arrival at the scene the A.R.U. makes itself known to the police officer dealing with the incident and to the driver of the vehicle involved. One member of the team interviews the driver and witnesses whilst the other person records the location and nature of the pedestrian contacts on the vehicle, the final position of the vehicle and the location of skid marks and debris. A detailed photographic record is made of the vehicle and scene.

After the site investigation the appropriate hospital is contacted to obtain injury information and in many cases photographs of the injuries are also obtained. Questionnaires are sent to the witnesses not interviewed at the scene and to those pedestrians not interviewed in hospital to obtain further information, particularly about the height and weight of the pedestrian.

ACCIDENT STUDY - RESULTS

Results from the first 100 accidents are presented here together with results from a previous at-the-scene study (Kolbuszewski et al 1969). It must be stressed that these results are preliminary results from the first six months of a two and a half year study. The representativeness of the sample has not been examined but due to the nature of the study it is thought that the results are indicative of the experience of pedestrians in road accidents.

A total of 184 accidents involving 185 vehicles and 190 pedestrians are considered for analysis. One hundred and seventy seven accidents involved a single pedestrian struck by a vehicle. In six accidents two pedestrians were struck by a vehicle and in one accident a pedestrian was struck by two vehicles.

Table 1 gives details of the vehicles involved. Cars or car derivatives, which are light vans based on a car chassis, struck 77% of the pedestrians in this sample.

Table 2 shows the action of the pedestrian prior to impact and the location of the first contact on the vehicle for vehicles with more than two wheels. Figure 1 gives a key to the locations used in describing the area of first contact of the pedestrian and vehicle. The front (F) of the vehicle was divided into 5 for this analysis. Contact in areas F1 and F5 indicate that the pedestrian was struck by the front corner of the car with subsequent contact on the side of the car. Areas F2, F3 and F4 are of equal width and are each equal to one third the width of the car. Contact in areas F2 or F4 indicates the pedestrian was struck by either the offside or nearside head-light area. Contact in area F3 indicates the pedestrian was struck by the centre of the front.

Fifty three percent (94) of the pedestrians were crossing from the nearside, 35% (62) from the offside, 6% (11) were either stationary or walking along the road and in 10 cases (6%) the actions of the pedestrian were not known. The point of first contact with the vehicle was the front in 100 cases (56%), the front corners in 38 accidents (21%) and the side of the vehicle in 25 accidents (14%). The nearside of the vehicle was contacted more frequently than the offside: there were 44 cases of contact on the nearside and front nearside corner as opposed to 19 on the offside and front offside corner.

An estimate of the speed of impact of the vehicle was made for each case based on such evidence as length of skid marks and skid resistance of the road surface, statements of witnesses and of the driver and typical speeds of other vehicles at the accident site.

The impact speed distribution for cars and light vans is shown in Figure 2. Ninety two percent of the accidents in this sample occurred at impact speeds less than 50 Km/h and 55% occurred at impact speeds of less than 30 Km/h. It must be stressed that this distribution is unlikely to be representative of all accidents as the sample is over represented in serious and fatal injury accidents: the ratio of fatal, serious and slight injury accidents in the sample being 1 : 6 : 3 whilst nationally the figures are approximately 1 : 10 : 20.

The rest of this paper will consider the frontal impact as it is the most common impact type.

At the time of analysis for this paper, injury information was available in 61 accidents where the pedestrian was struck by the front of a car or car derivative. Details are given of the severity of injury by age of pedestrian and impact speed of the vehicle in Table 5. These preliminary results are presented to stimulate discussion and must therefore be treated with caution.

The limited number of cases available - 26 children, 21 adults aged 15 - 59 years and 14 adults aged 60 years and over - seem to suggest that there is an increase in the overall severity of injury with increasing impact speed and that this is due to an increase in the severity of injuries from the vehicle rather than to an increase in the severity of injuries from the road. There would appear to be no correlation between the severity of injuries from the road and impact speed.

Children seem to sustain less severe injuries than adults at comparable impact speeds when considering injuries from the vehicle but there appears to be no difference in the severity of injuries sustained from contact with the road.

Table 6 gives details of the location and severity of the injuries sustained by age of the pedestrian. Only the most severe injury from a body area sustaining more than one injury has been counted if all the injuries were caused by one source i.e. road or vehicle. Where a body area received injuries from contact with the vehicle and contact with the road the most severe injury from each contact has been counted.

When all injuries from all sources are considered the head and face were found to receive more injuries than any other body area and the legs were found to be the next most frequently injured area; 39% of children and 38% of adults received head and face injuries and 32% of both children and adults sustained leg injuries. The importance of head and face injuries to children is shown by considering only non-minor injuries: 60% of children sustaining non-minor injuries sustained head and face injuries whilst only 36% of adults sustained head and face injuries. For lower limb injuries the corresponding figures were 17% and 31%.

Head injuries appear to be caused approximately equally by the road and the vehicle. For children 53% of all head injuries were caused by the road and for adults the corresponding figure was 56%. If only non-minor head injuries are considered then the figures were again 53% for children and 50% for adults.

It was found that most lower limb injuries were caused by the vehicle: 63% of all leg injuries to children and 81% of all leg injuries to adults were from this source. All the non-minor leg injuries to both children and adults were caused by the vehicle contact.

BUMPER LOCATION

Introduction

This study has identified frontal impacts as the most frequent type of pedestrian accident and that injuries to the lower limbs are the most frequent type of injury caused by contact with the vehicle. This is in agreement with the findings of other studies (Robertson McLean and Ryan 1966; Jamieson et al 1971; T.R.R.L. 1972) which have identified the front of the vehicle and in particular the bumper bar as a leading cause of injury in

pedestrian accidents.

It is generally accepted that fractures of the lower leg have less serious consequences than fractures of the femur or knee cap. Kramer et al (1973) in a series of cadaver experiments found that loading of the tibia near to the knee was likely to produce comminuted fractures whilst loading away from the knee produced simple fractures.

The characteristics of pedestrians involved in accidents has been examined to provide information on the optimum location of bumpers.

Age and Injury Severity

In 1971 there were 81,206 pedestrian casualties in the United Kingdom. Injuries officially classified as being slight were sustained by 67% of those casualties, as serious by 29% and as fatal by 4% (D.O.E. 1973). In Figure 3 the age distribution of the involved pedestrians is presented for different levels of injury severity. Children accounted for 22% of the fatalities, 42% of those sustaining fatal and serious injuries and 47% of all injuries.

Figure 4 shows the height of the lower edge of the knee for 5%ile and 95%ile males and females by age and in Figure 5 the width of the knee by height of the lower edge of the knee is given. The data in these figures refers to persons not wearing shoes and is obtained from anthropometric data on school children (D.E.S. 1970; D.E.S. 1972). Using this information and data about the age distribution of involved pedestrians it is possible to determine the knee neight distribution of the casualties. Figure 6 shows the cumulative distributions of the heights of the top and bottom of the knee for fatally and seriously injured pedestrians in 1971. It can be seen from this figure that for 80% of the fatal and serious pedestrian casualties the height of the bottom of the knee was above 31 cms.

Bumper Height

This information can be used to predict what percentage of the involved population would sustain a direct contact on the knee from a bumper of given characteristics. For instance if all vehicles had a bumper the top of which was 50 cms above the ground with width 5 cms then 65% of pedestrians sustaining serious or fatal injury struck by the front of the car would sustain a direct knee contact. If, however, all vehicles had a bumper of width 10 cms the top of which was 35 cms above the ground only 30% would sustain a direct knee contact. Figure 7 shows the relationship between bumper height, bumper width and percentage sustaining a direct knee contact. It must be noted that no allowance has been made for dip of the vehicle under braking or the increase in height of the knee due to wearing of shoes and that this figure shows the case where the pedestrian is not wearing shoes and there is no braking. The effect of these two factors would be to reduce the involvement rate for given bumper characteristics.

At present most vehicles are fitted with narrow bumpers and all the suggestions made to date that direct knee contact should be avoided have been based on the accident experience of these vehicles.

The changeover to vehicles with wider and energy absorbing pro pedestrian bumpers may alter the mechanisms of injury and conclusions from the accident experience of narrow bumpers may not be directly applicable to the new vehicles.

CONCLUSIONS

Pedestrian accidents are an important source of injury to children.

In this sample the majority of pedestrians (78%) were contacted by the front or front corners of the striking vehicle. Cars and car derivatives were the most frequently (77%) involved vehicles.

Children appeared to sustain less severe injuries than adults at comparable impact speeds.

Consideration of the knee height distribution of pedestrians sustaining non minor injuies shows that a bumper height of 45 - 50 cms (18 - 20 ins) results in the maximum number of pedestrians sustaining a direct knee contact from the bumper.

TABLE 1 LEADING CAUSES OF ACCIDENTAL DEATH - CHILDREN 15 yrs 1971

ROAD ACCIDENTS	39%
SUFFOCATION	19%
DROWNING	11%
BURNS	7%
FALLS	6%
OTHER	18%

from 'The Registrar General's Statistical Review - 1971'

TABLE 2 NATURE OF ROAD ACCIDENT FATALITIES - CHILDREN 15 yrs 1971

PEDESTRIANS	67.7%
CYCLISTS	15.6%
VEHICLE OCCUPANTS	16.7%

Note: Vehicle Occupants includes passengers on two wheeled vehicles.

TABLE 3 VEHICLES INVOLVED - BIRMINGHAM STUDY

	NO.	%
CAR OR CAR DERIVATIVE	146	77
LIGHT COMMERCIAL	12	6
HEAVY GOODS VEHICLE	4	2
PUBLIC SERVICE VEHICLE	12	6
MOTOR CYCLE/SCOOTER	10	5
BICYCLE	3	2
OTHER	1	1
NOT KNOWN	2	1

FIGURE 1 LOCATIONS USED IN DESCRIBING AREA OF FIRST PEDESTRIAN CONTACT

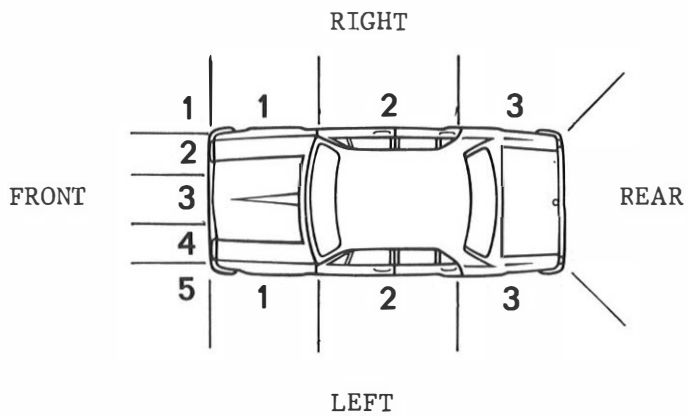


TABLE 4 LOCATION OF FIRST PEDESTRIAN CONTACT ON VEHICLE
ALL VEHICLES EXCEPT TWO WHEELED VEHICLES

LOCATION OF FIRST CONTACT		PEDESTRIAN CROSSING FROM OFFSIDE	NEARSIDE	IN ROAD OR STATIONARY	NOT KNOWN	TOTAL
RIGHT	1	3				3
	2	1		1		2
	3					0
FRONT	1	8	5		1	14
	2	19	8		2	29
	3	22	18		3	43
	4	5	21	2		28
	5	3	19	2		24
LEFT	1		13	1		14
	2		4			4
	3		1	1		2
REAR				1		1
OTHER					1	1
RUN OVER				1		1
NOT KNOWN		1	5	2	3	11
		62	94	11	10	177

FIGURE 2 IMPACT SPEED DISTRIBUTION CARS AND CAR DERIVATIVES

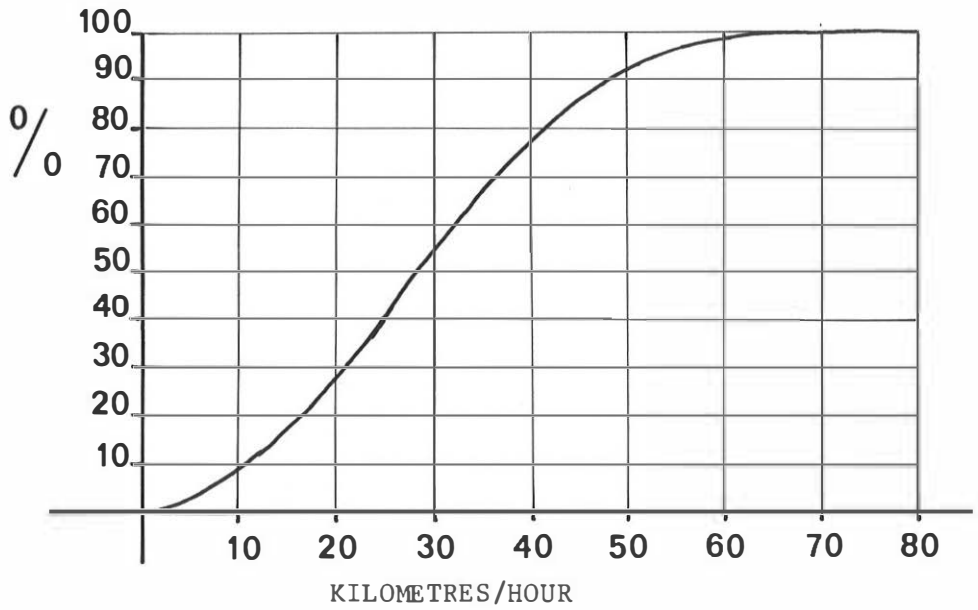


TABLE 5 INJURY SEVERITY BY IMPACT SPEED, AGE OF PEDESTRIAN AND CAUSE OF INJURY - FRONTAL IMPACTS

a) Pedestrian aged 14 yr 26 cases

ALL INJURIES

	1	2	3	4	5	6	7
06							
05							
04						1	
03		1	1		3		
02		1		5	2		
01	2	2	3	1	2		
00	2						

VEHICLE INJURIES

	1	2	3	4	5	6	7
06							
05							
04						1	
03					3		
02				5	2		
01	1	4	4	1	2		
00	3						

ROAD INJURIES

	1	2	3	4	5	6	7
06							
05							
04							
03		1	1				
02		1		1	3	1	
01	2	1	1	4	2		
00	2	1	2	1	2		

b) Pedestrian aged 15 - 59 yr 21 cases

ALL INJURIES

	1	2	3	4	5	6	7
06			1			1	1
05							
04				1			
03			3	2	1		
02		2	2	1			
01		2	2	2	1		
00							

VEHICLE INJURIES

	1	2	3	4	5	6	7
06						1	1
05							
04				1			
03			4	2	1		
02		1	1	1			
01		1	2	2	1		
00		2	1				

ROAD INJURIES

	1	2	3	4	5	6	7
06			1				
05							
04							
03					1		
02		1	3	2			
01		2	3	3	1		1
00		1	1	1		1	

c) Pedestrian aged 60 yr 14 cases

ALL INJURIES

	1	2	3	4	5	6	7
06		1		1	2		
05					1		
04				2			
03			1	3			
02							
01	1	1		1			
00							

VEHICLE INJURIES

	1	2	3	4	5	6	7
06				1	1		
05							
04				2			
03			1	3	2		
02							
01		1		1			
00	1	1					

ROAD INJURIES

	1	2	3	4	5	6	7
06		1			1		
05					1		
04							
03							
02				3			
01	1		1	3	1		
00		1		1			

KEY TO TABLES

Vertical axis is severity of injury sustained by the pedestrian described using the Abbreviated Injury Scale with the modification that all fatalities have been described as severity 06

Horizontal axis is the impact speed of the vehicle. Class 1 is impact speed 0 - 10 km/h, class 2 is 11 - 20 km/h, class 3 is 21 - 30 km/h and so on up to class 7 which includes all impact speeds above 60 km/h.

TABLE 6 LOCATION AND SEVERITY OF INJURY BY AGE OF PEDESTRIAN AND CAUSE OF INJURY - FRONTAL IMPACTS

a) Pedestrian aged 14 yr — 26 cases

	INJURIES FROM THE VEHICLE INJURY SEVERITY (AIS)							INJURIES FROM THE ROAD INJURY SEVERITY (AIS)						
	01	02	03	04	05	06	TOTAL	01	02	03	04	05	06	TOTAL
HEAD	1	6	1				8	1	6	2				9
FACE	3	1					4	6	2					8
NECK							0							0
CHEST							0							0
ABDOMEN	3	3		1			7	1						1
ARMS	3						3	3	3					6
LEGS	10	3	2				15	9						9
BACK	2						2	3						3
							39							36

b) Pedestrian aged 15 - 59 yr — 21 cases

	INJURIES FROM THE VEHICLE INJURY SEVERITY (AIS)							INJURIES FROM THE ROAD INJURY SEVERITY (AIS)						
	01	02	03	04	05	06	TOTAL	01	02	03	04	05	06	TOTAL
HEAD	3		1	1		2	7	2	4				1	7
FACE	4	2					6	4						4
NECK	1			1			2							0
CHEST		1			1		2	1						1
ABDOMEN		2	1		1		4							0
ARMS	1	1					2	3	2	1				6
LEGS	5	2	8				15	5						5
BACK	2	1					3							0
							41							23

c) Pedestrians aged 60 yr — 14 cases

	INJURIES FROM THE VEHICLE INJURY SEVERITY (AIS)							INJURIES FROM THE ROAD INJURY SEVERITY (AIS)						
	01	02	03	04	05	06	TOTAL	01	02	03	04	05	06	TOTAL
HEAD				2		2	4	2	2			1	2	7
FACE		1					1	1						1
NECK					1	1	2						1	1
CHEST			1		1		2							0
ABDOMEN		2					2							0
ARMS		2					2							0
LEGS	2		8				10	1						1
BACK	1						1							0
							24							10

FIGURE 3 CUMULATIVE DISTRIBUTION OF AGE OF PEDESTRIAN CASUALTIES FOR VARIOUS SEVERITIES OF INJURY FOR THE YEAR 1971

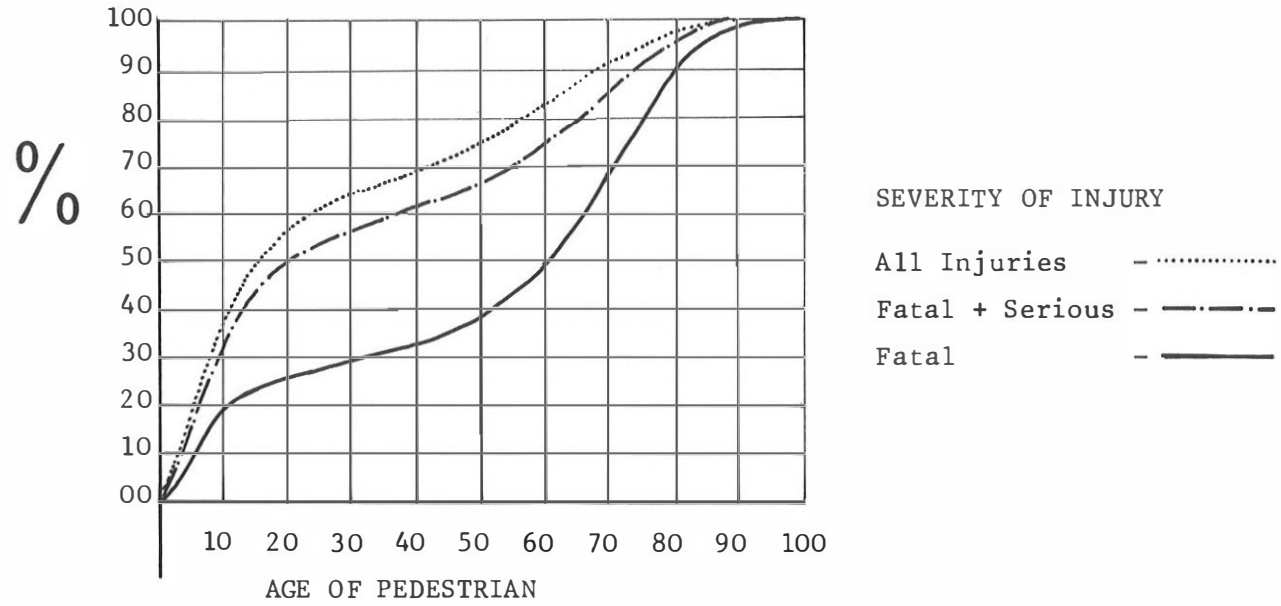


FIGURE 4 HEIGHT OF LOWER EDGE OF KNEE (SOLE TO POPLITEUS) BY AGE

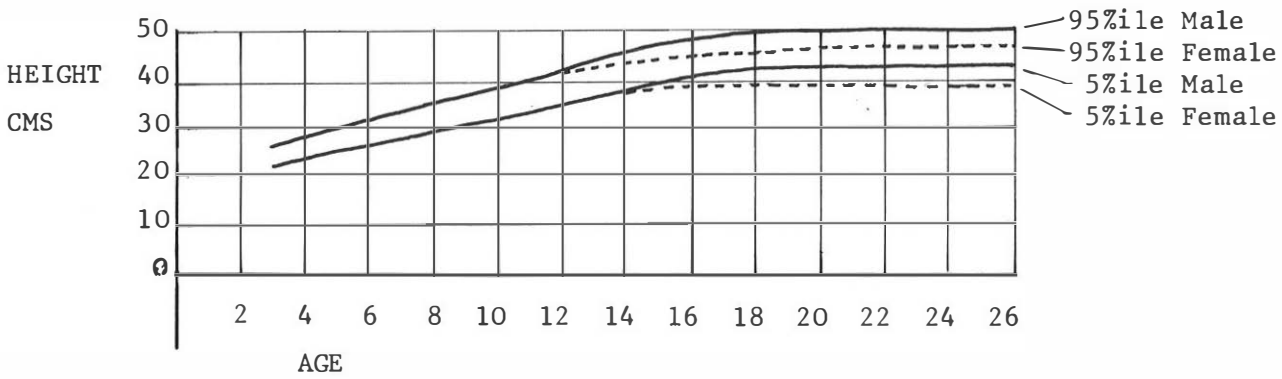


FIGURE 5 WIDTH OF KNEE BY HEIGHT OF LOWER EDGE OF KNEE

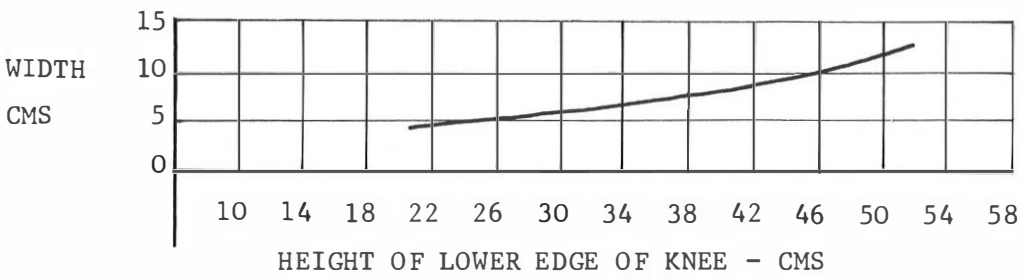


FIGURE 6 CUMULATIVE DISTRIBUTIONS OF THE HEIGHTS OF THE TOP AND BOTTOM OF THE KNEE FOR SERIOUS AND FATAL PEDESTRIAN CASUALTIES - 1971

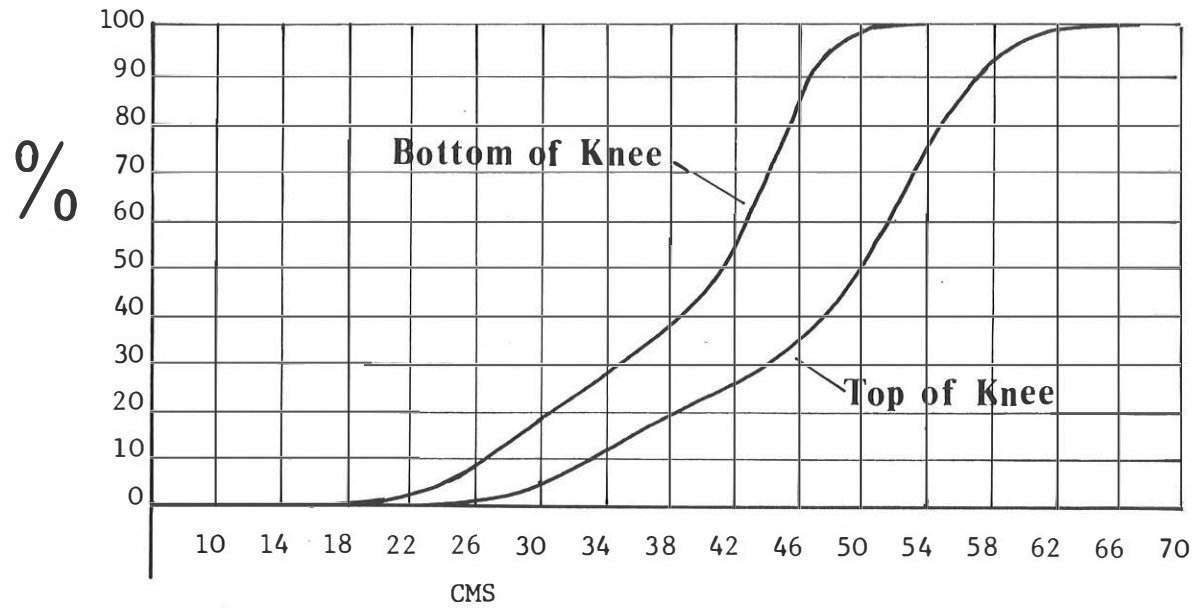
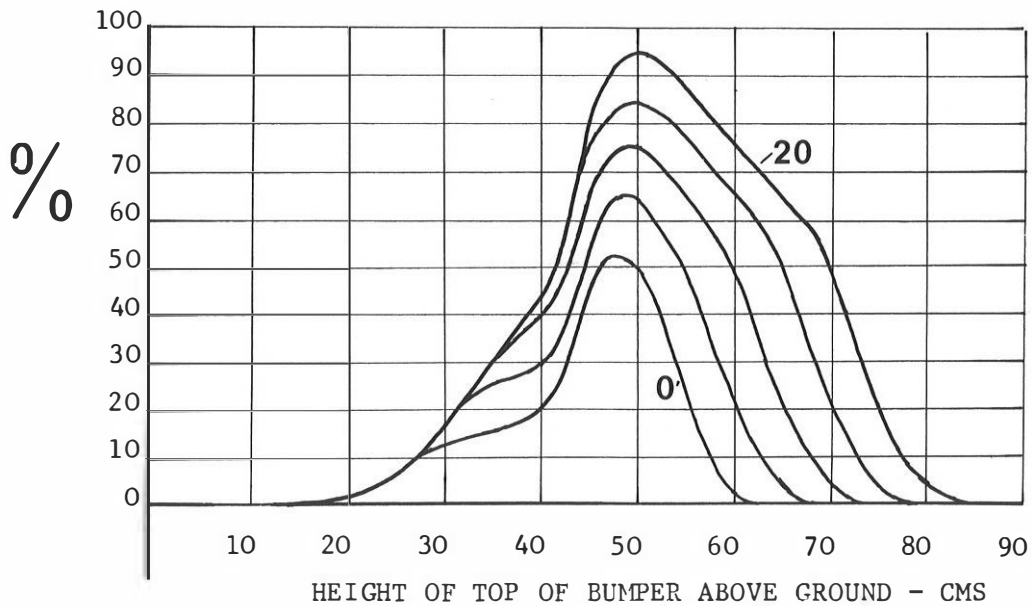


FIGURE 7 PERCENTAGE OF INVOLVED POPULATION (SERIOUS AND FATAL INJURY) SUSTAINING A DIRECT KNEE CONTACT FROM A BUMPER OF GIVEN DIMENSIONS



Note: the effect of varying bumper width is shown by considering bumpers of width 0, 5, 10, 15 and 20 cms.

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