INJURIES OF OLDER PERSONS IN PEDESTRIAN ACCIDENTS

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1. Introduction

From the statistics on traffic accidents can be seen that aged pedestrians sustain fatal injuries in an above average number of accidents. Of 969 pedestrian accidents occuring in the Hannover District in 1973, 221 i.e. 23 % involved persons over 60 years of age. Comparison with the remainder of pedestrian accidents shows a predominance of accidents with severe consequences involving this age group, which accounts for 56 % of deaths (Fig. 1). According to the information proved by the Federal Bureau of Statistics in the Federal Republic of Germany 54 % of the fatally injured pedestrians in 1974 were over the age of 55.
The aim of this paper is to show the effect of the energy on the organism resulting from collisions between pedestrians and vehicle of older people, what are the typical injury types and what grade of injury results as compared to people of younger adults.

2. Our investigation

Our analysis is based on 35 pedestrian accidents involving people between the ages of 15 and 55, and 57 accidents involving people over 55 Years of age. We only considered cases in which the primary point of collision was located at the front of the vehicle. The average age within Group 1 (15-55 years) was 30 and that of Group 2 (> 55 years) was 73 years of age, the individual injuries being classified according to AIS norms and the total injuries according to OAIS. The collision speed was calculated using slide marks, road conditions, point of collision and reduction in speed due to energy creation at the instant of collision, in conjunction with detailed sketches of the accidents and stereo pictures of the scene of the accident. The speed is given in m/s.

3. Results

The average impact speed was almost identical for both groups. For Group 1 the speed was 10.7 m/s and for Group 2, 10.5 m/s. 90 % of the accidents occured with an impact speed of up to 15 m/s i.e. 54 km/h. The percentage distribution of the impact speeds for the two groups can be seen in Fig. 2.

4. Severity of Injury by Impact-speed and Age distribution

For both groups the arrhytmic mean of the collision velocity was calculated for each OAIS grade of injury in order to demonstrate the relationship between the severity of injury and the collision velocity (Fig. 3 & 4). Here can be seen that the points in the central velocity region almost lie in a straight line. It is worth noting that the high OAIS values deviate from this line. As an explanation for this, it must be mentioned that the cases with injury severity OAIS 5 in Group 1 and OAIS 6 in Group 2 involved the oldest members of their respecture groups. Furthermore, the population making up these injury grades were too small, to produce statistically relevant mean values. The Regression-coefficient was calculated for both groups (after omission of the above mentioned values) and entered in Figure 5. It can be seen here that the curves run almost parallel to one another. The inclination of the curve for Group 1 is 0,39 % and for Group 2 0,41 %, the curve for Group 1 lying appreciably to the right of that for Group 2. V_o is a velocity for which usually no injuries are to be expected. This velocity for V_o is a mean value in Group 1 4.9 m/s and in Group 2 1.7 m/s. Furthermore we can see from the curves that an impact speed of at least 3 m/s greater is necessary to produce the same grade of injury in Group 1 as that in Group 2. While the OAIS grades 4 and 5 occured in only 14 % of the cases in Group 1, OAIS 6 not occuring at all, 54 % of those injured from Group 2 had severe injuries between OAIS grades 4-6. Conversely 57 % of Group 1 had less severe injuries (OAIS Grades 1 and 2) compared with 11 % of Group 2. The OAIS grade 3 severity injuries occured almost equally in both groups, 29 % of Group 1 and 25 % of Group 2. The average OAIS grade was 2.4 for Group 1 and 3.7 for Group 2. Figure 6 shows a percentage distribution with respect to OAIS Grades.

5. Injury frequency, Severity of Injury and "Relative Traumtise Degree" in the different body regions by age of pedestrian

The frequency and severity of injury was smaller in Group 1 than in Group 2 for almost all body regions. (see Figs. 7 & 8). The Abdomen was the only region that was affected more in Group 2 with regard to frequency and severity. The "Relative Traumatise Degree" (RTD) was calculated using the injury frequency (%) and severity (AIS_m). (For more information on the RTD, see STÜRTZ and SUREN). In Group 1 the head and the tibia produced the highest RTD, followed a long way behind by the Thigh and Abdomen. Injuries of Thorax, Pelvis and Spine were

less often and less severe.
In Group 2 the head and the tibia had likewise the highest RTD, this being appreciably higher than that of Group 1, further points of injury being the Ribs, the Pelvis, the Spine and upper arm. The mean RTD was 4.4 for Group 1 and 8.3 for Group 2. The RTD increase for the individual body regions with respect to Group 2 can be seen in Table 1.
The human body allows only a few centimetres for the absorption of ingrade energy. As soon as deformation exceeds the dynamic resistance of the human tissue, bones are broken and muscular tissue is broken. In older people the consistence and elasticity of the bone tissue is reduced and deformation is to a lesser extent absorbed by the elastic compliance of the effected areas. The higher grade and frequency of injury in older people is based mainly on the extensive fragmentation of the human skeleton (Fig. 9). Whereas in Group 1 and average of one fracture per injured pedestrian occured, in Group 2 the average was 2.6 fractures per pedestian. It is to be noted here that osseous injuries of the Thorax were considered as a single fracture, independent of their extent. In Group 1 there were no serial fractures of the ribcage present (serial fracture => 3 fractured ribs), whereas in Group 2, of 17 cases of osseous Thorax injuries 12 had also serial ribcage fractures. The pelvis is also more severely and more frequently fractured in Group 2 than Group 1. 43 % of the casualties from Group 1 Sustained fractures of the tibia from which in 80 % of the cases one and in 20 % both, were involved. In Group 2, 67 % sustained fractures of the tibia, 68 % of which were single fractures and 32 % both. 20 % of Group 2 sustained upper arm fractures as opposed to 6 % of Group 1, while 21 % of Group 2 sustained osseous spinal fractures as opposed to 9 % of Group 1. Only 2 cases of fractured skulls arose in Group 1 compared to 13 in Group 2.
In both groups cerebral concussion was the secondmost severe injury both with respect to the frequency and mean severity grade (AIS_m). In Group 1 this was mainly restricted to concussion, whereas in Group 2, 40 % of the casualties were merely concussed, and 28 % suffered severe cerebral injuries such as contusion and cerebral compression. In Table 2 can be seen the cerebral injuries distributed with respect to severity and frequency.

In an accident Kinetic energy is released that exceeds the tolerance bounds of human organisms, this being especially so for older people. As a result there is a greater number of Polytraumatic cases with a correspondingly high lethality. (A Polytraumatic case is a case in which the injured person has sustained 2 or more injuries each of which would result in hospitalisation). 40 % of Group 1 and 67 % of Group 2 were polytraumatic injury cases (Fig. 10).

6. Primary Causes of Death

Whereas in Group 1 only a single pedestrian died as a direct result of injuries recieved in the accident, in Group 2 there were 12 such persons. This is equivalent to a primary lethality of 30 %. It is to be noted however that the percentage of deaths is drastically increased if we include deaths caused by secondary complications such as contusion of the lungs and pneumonia. The primary cause of death in older people is principally haemorrhage shock followed by injuries of the brain and the spinal cord. Haemorrhage shock is in the main caused by the loss of blood resulting from extensive fracturing of the skeletal system. The classification of the primary causes of death can be seen in Table 3.

7. Summary of the Results

1. 90 % of accidents involving pedestians take place at speeds of 15 m/s. The average collision speed was 10.6 m/s.
2. The increase in severity of injury corresponding to the increase in collision velocity is almost linear and parallel in both groups. In order to attain injuries of the same severity as in older people an increase in collision velocity of at least 3 m/s is required for people of a lesser age. The collision velocity V_o, at which no injuries are to be expected, was 4.9 m/s for Group 1 and 1.7 m/s for Group 2.
3. Old people sustain severe injuries a lot more often than the remaining adults. In Group 2, 54 % of those involved in accident had OAIS Severity level 4-6 as opposed to 14 % in Group 1. The mean OAIS severity level was 3.7 for older people, compared with 2.4 in Group 1.
4. In Group 1 the centres of injury were concentrated between two points, namely the head and tibia. In older people the Thorax, Pelvis, Spine and Upper arm are additional centres of injury. The average RTD was 4.4 for Group 1 and 8.3 for Group 2.
5. The increased severity of injury in older people is mainly due to the increased fragmentation of the skeletal system. In old-age the bones are more brittle and less elastic. Broken bones in the extremities and the Pelvis are by far the most severe injuries.
6. In both groups cerebral concussion is the second most severe injury. In younger adults this is in the main single concussion whereas 40 % of the aged had concussion and 28 % more severe cerebral injuries.
7. The increased traumatisation in older people involved in pedestrian accidents is largely reflected by the number of Polytraumatic cases, 40 % in Group 1 and 67 % in Group 2.

8. The primary lethality was 30 % for older people, compared with 2.9 % for younger adults. The major cause of death at the scene of the accident or a short time after admission to hospital is, for old persons, haemorrhagic shock resulting from the loss of blood caused by fractures of the extremities and pelvis. This is followed, as a cause of death, by injuries of the brain and spine.

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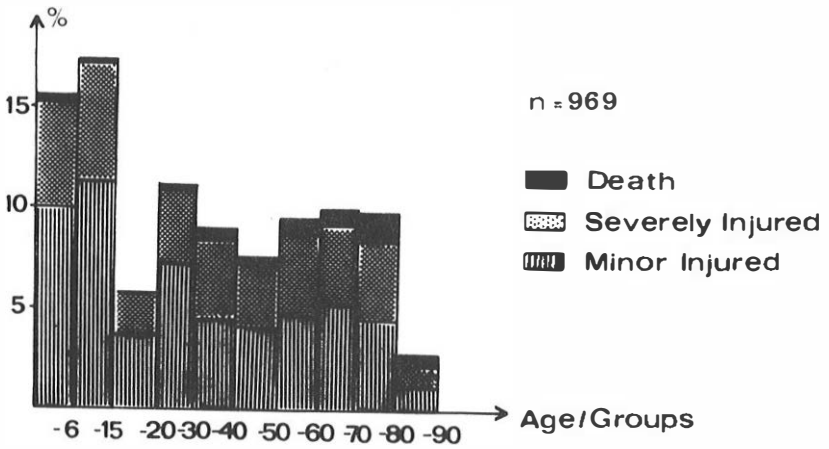

Fig. 1: Pedestrian accidents in Hannover and District 1973

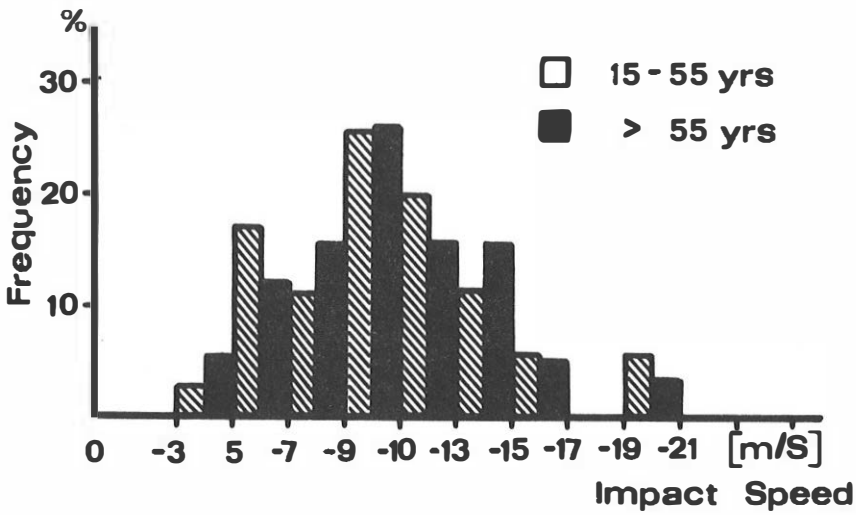

Fig. 2: Percentage distribution of impact velocity for the two groups

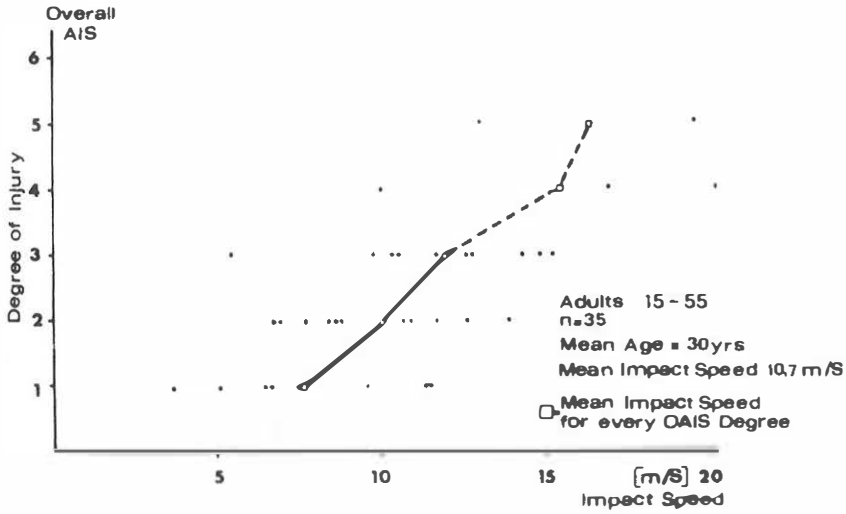

Fig. 3: Distribution of impact velocity for the single OAIS grades and mean impact velocities, for Group 1 (15-55 y.)

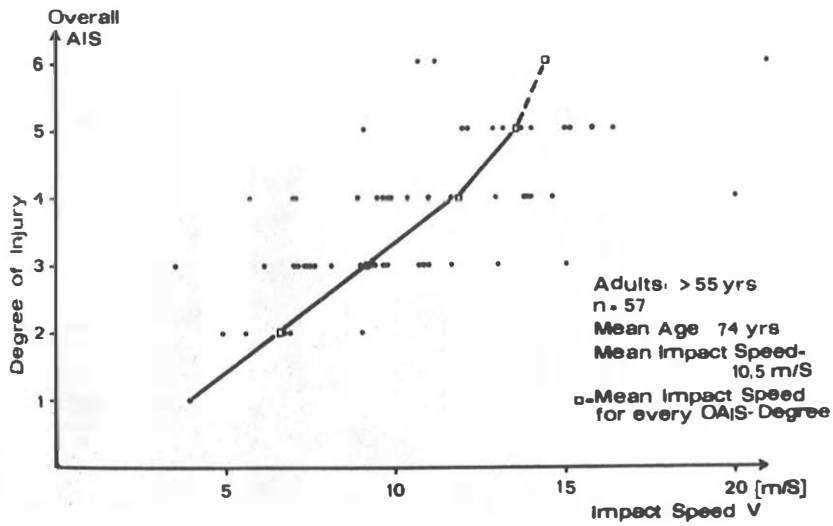

Fig. 4: Distribution of impact velocity for the single OAIS grades and mean impact velocities, for Group 2 (> 55 years)

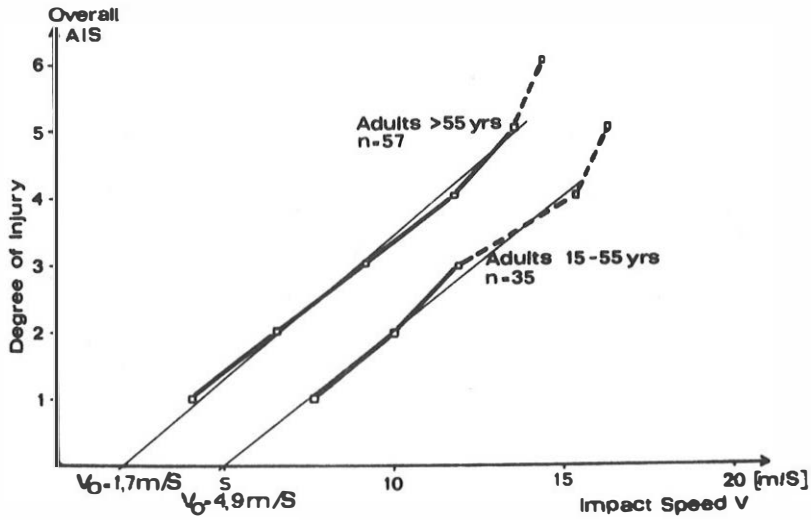

Fig. 5: Comparison of the relation between the injury severity code with regard to OAIS and the impact velocity, for the different groups. The regression lines are drawn neglecting extreme values.

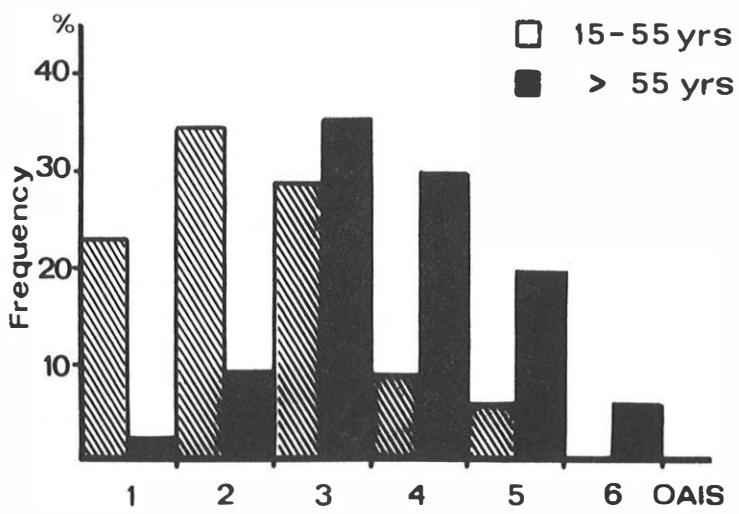

Fig. 6: Percentage distribution of the single OAIS grades for the two groups.

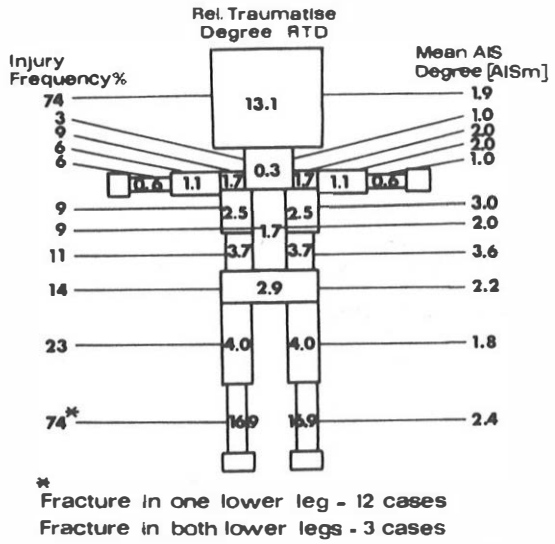

Fig. 7: Frequency of injury (%), Severity of injury (AIS_m) and "Relative Traumatise Deg." for individual body regions in Young adults (n=35)

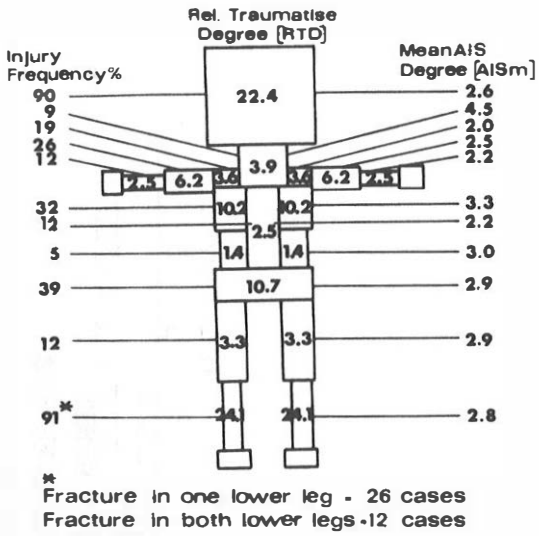

Fig. 8: Frequency of injury (%), Severity of injury (AIS m) and "Relative Traumatise Degree" for individual body regions in the over 55's age-groups (n=57)

Body Region	Group I	Group II	Increase in Number	Increase %
HEAD	13.1	22.4	9.3	41.5
NECK	0.3	3.9	3.6	92.3
UPPER ARM	1.1	6.2	5.1	82.2
FOREARM	0.6	2.5	1.9	76.0
THORACIC/ LUMBAR SPINE	1.7	2.5	0.8	32.0
CHEST	2.5	10.2	7.7	75.5
ABDOMEN	3.7	1.4	2.3*	62.2*
PELVIS	2.9	10.7	7.8	72.9
TIGH	4.0	3.3	0.7*	17.5*
LOWER LEG	16.9	24.1	7.2	29.9

*RTD-increase in group II

Table 1: Increase and decrease of the "Relative Traumatise Degree" for individual body regions in Group 2

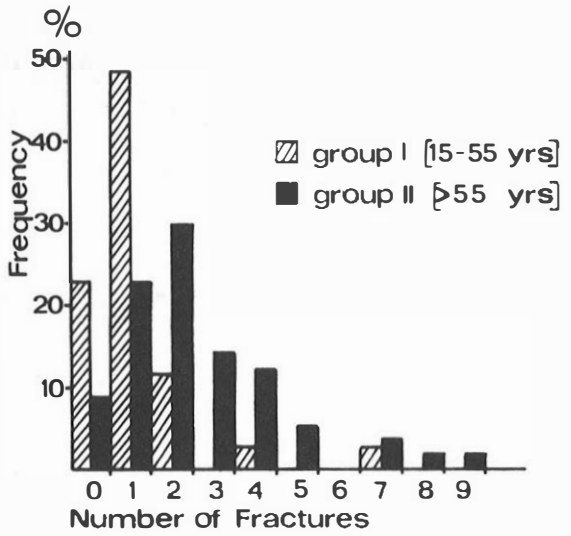

Fig. 9: Frequency of fractures in both groups

Brain injuries	group I	group II
cerebral concussion	49%	40%
cerebral contusion	6%	19%
cerebral compression		5%
intracranial hemorrhage		4%

Table 2: Type and number of brain injuries for both groups.

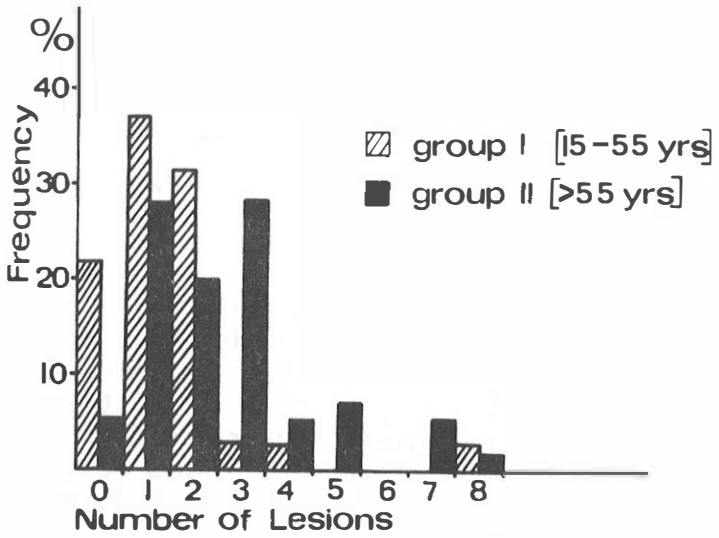

Fig. 10: Number of individual injuries resulting in hospitalization for both groups

Primary causes of death in group II	number
hemorrhagic shock	10
brain injury	4
spinal cord damage	3

Table 3: Number and type of fatal injuries in the over 55's age groups