Spine injuries in vulnerable road users – a technical and medical analysis of 14295 injured pedestrians, bicycle and motorbike users

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Abstract

To elucidate the risk of pedestrians, bicycle and motorbike users, data of two accident research units from 1999 to 2014 were analysed in regard to demographic data, collision details, preclinical and clinical data using SPSS.

14.295 injured vulnerable road users were included. 92 out of 3610 pedestrians ("P", 2.5%), 90 out of 8307 bicyclists ("B", 1.1%) and 115 out of 4094 motorcycle users ("M", 2.8%) were diagnosed with spinal fractures. Thoracic fractures were most frequent ahead of lumbar and cervical fractures. Car collisions were most frequent mechanism (68, 62 and 36%). MAIS was 3.8, 2.8 and 3.2 for P, B and A with ISS 32, 16 and 23. AIS-head was 2.2, 1.3 and 1.5).

Vulnerable road users are at significant risk for spine fractures. These are often associated with severe additional injuries, e.g. the head and a very high overall trauma severity (polytrauma).

NOTATION

"P" pedestrians
"B" bicycle users
"M" motor bike users

INTRODUCTION

The total number of road deaths has markedly decreased during the last centuries. As we showed earlier, likewise the number of vertebral fractures in restrained front seat car occupants has declined[1]. In both car occupants and pedestrians the mean injury severity – depending on the impact velocity – has declined, too[2]; however, little is known how this is reflected in the burden of spine fractures of vulnerable road users.

METHODS

Two accident research units document around 2000 accidents per year according to a statistical sample plan reflecting the overall traffic accident situation in Germany. Specially trained documentation personnel are notified by police dispatchers and arrive on scene, often simultaneously with the rescue personnel. Thus, investigation of the crash (measurements by photography, stereo photography, three dimensional (3D)-laser technique), and clinical injury documentation is performed on site. This case report is then completed at the hospital, where all of the injured victims are taken, with proper documentation of x-ray examination, injury type, and severity. Among the technical measurement techniques, the modern 3D-laser technique, especially, is a quick and exact method to document the exact position of all objects at the crash site. A 3D-data cube with a maximum size of 50 m^3 is generated from the data obtained by the 3D-laser scanner. This data allows an exactly scaled reconstruction of the crash site for later technical analysis of the crash. Slide and skid marks of vehicles, objects, and victims and any kind of deformation of involved vehicles or objects are also measured, and this data are included in the crash analysis. Furthermore, data from a database containing technical features of involved vehicles (size, weight, and detailed structural data comparable to finite element analysis data) are included in the analysis. The inclusion of the described data in a software-based calculation allows an exact estimation of parameters as delta-v or collision speed. In total, the monitoring of the crash research unit includes demographic data, type of road user (car/truck occupant, motorcyclist, cyclist, pedestrian), delta-v (km/h) for motorized vehicle user; vehicle collision speed (km/h) for bicyclists/pedestrians, Abbreviated Injury

Scale (AIS) score, Maximum AIS (MAIS) score, Injury Severity Score (ISS), incidence of serious and/or severe multiple injuries (ISS>16), incidence of serious injuries (MAIS 2–4) or severe injuries (MAIS 5 of 6), and mortality[3,4].
For this study, data from injured pedestrians, bicycle and motorbike users were included. Data sets from 1999 to 2014 were analysed in regard to demographic data, collision details, and preclinical and clinical data.
IBM SPSS Version 23.0 was used for statistical analysis. The student's t-test, Pearson's correlation and multivariate analyses were used as applicable. P-values below 0.05 were considered significant; p-values below 0.001 were considered highly significant.

RESULTS

Demographics

Data from 27.032 traffic accidents was available. Out of them, 14.295 injured vulnerable road users were included. 92 out of 3610 pedestrians ("P", 2.5%), 90 out of 8307 bicyclists ("B", 1.1%) and 115 out of 4094 motorcycle users ("M", 2.8%) were diagnosed with spinal fractures.
The mean age was 56, 53 and 35 years for P, B, M, respectively. 48%, 64% and 92% were males with one person of unknown sex in P and B. There was one child with a thoracic spinal fracture (pedestrian, nine years old) and eight adolescents (three pedestrians, two bikers and three motorcycle users) with spinal fractures.

Types of collisions

Most often, the accident was a collision with a car (68, 62 and 36%) for P, B and M. Details are shown in figure 1-3.

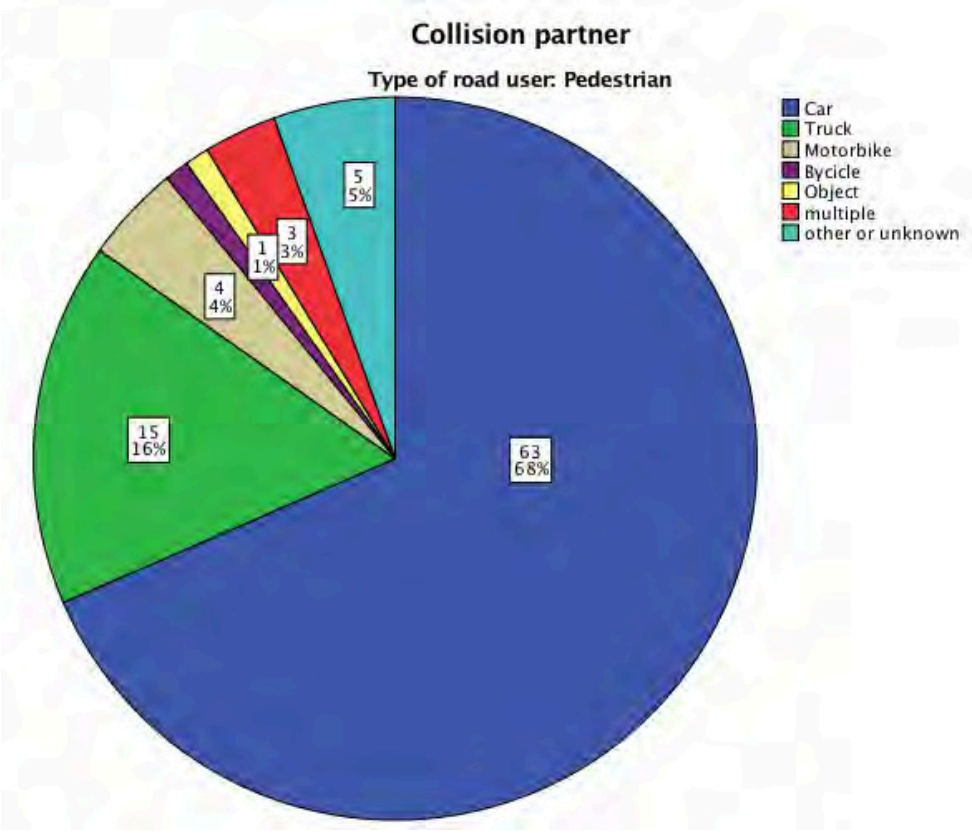

Figure 1

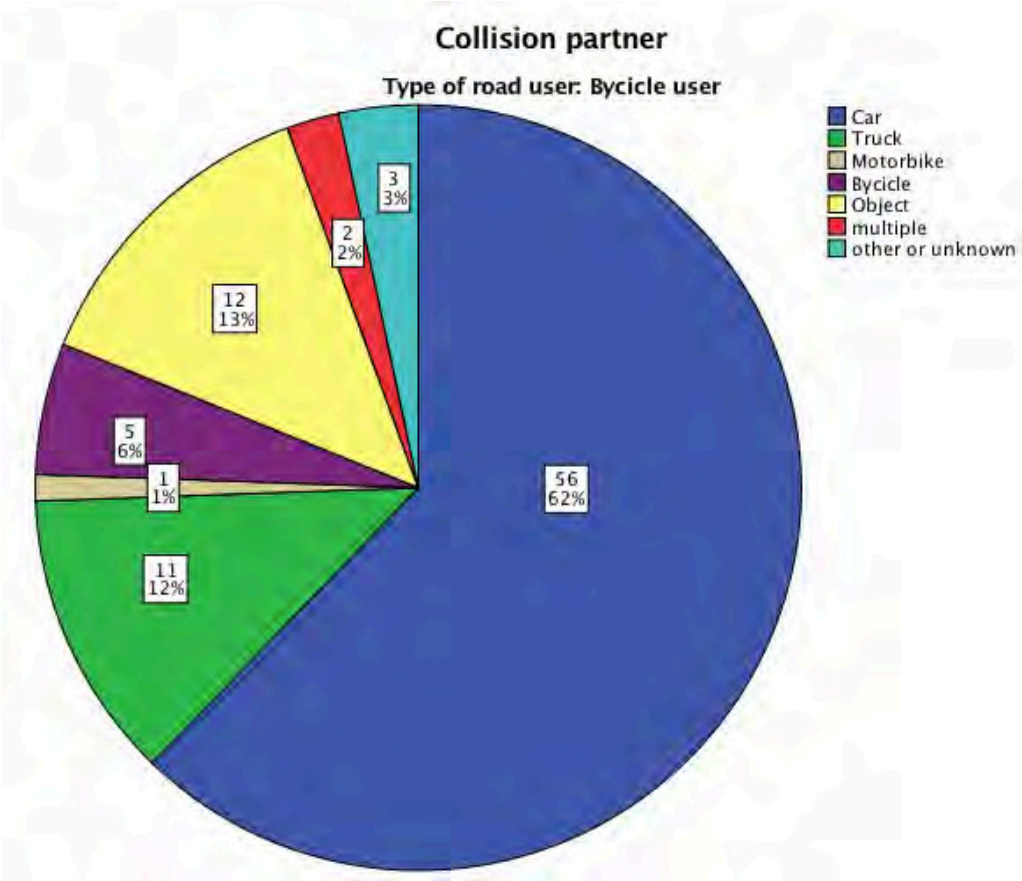

Figure 2

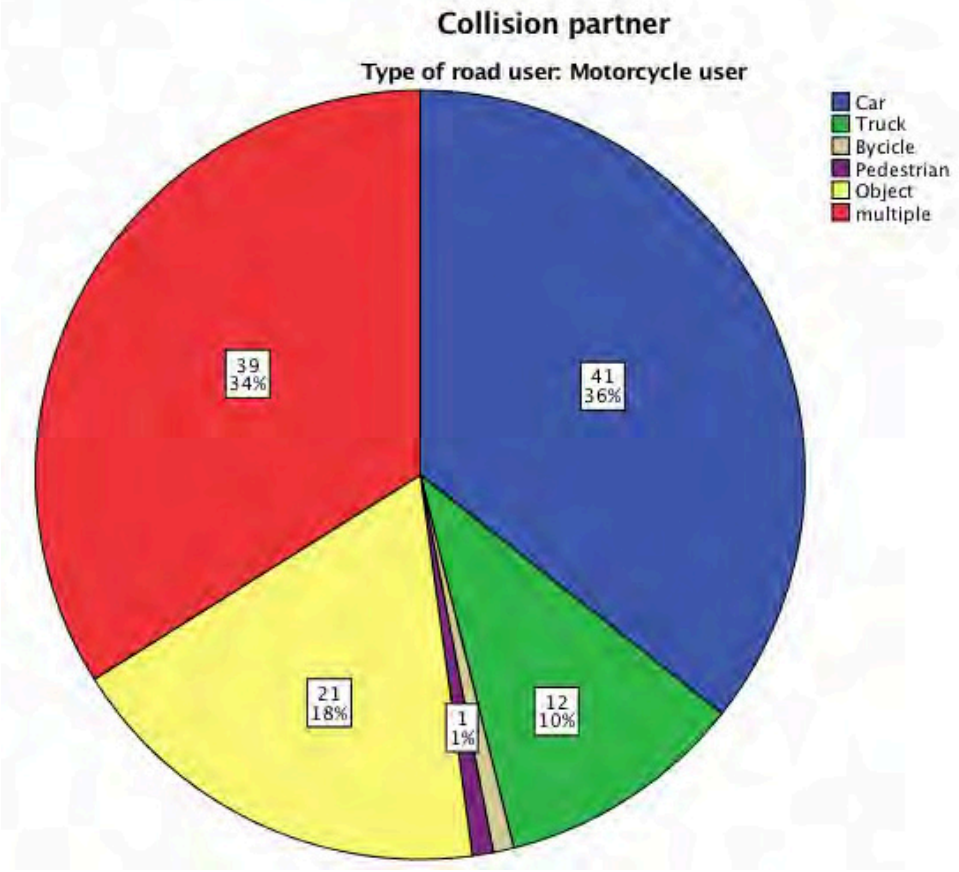

Figure 3

Types of fractures

Thoracic fractures were most frequent (46, 40 and 63 for P, B and M) ahead of lumbar fractures (29, 41, 35) und cervical fractures (33,21,40).

Concomitant injuries and injury severity

The main MAIS was 3.8, 2.8 and 3.2 for P, B and A with ISS 32, 16 and 23, respectively ($p<0.01$ or 0.001 for all comparisons). The distribution of injury severities is shown in figure 4 and 5. Kruskal-Wallis-Test showed that the distribution of injury severities was highly significantly different between groups ($p<0.001$).

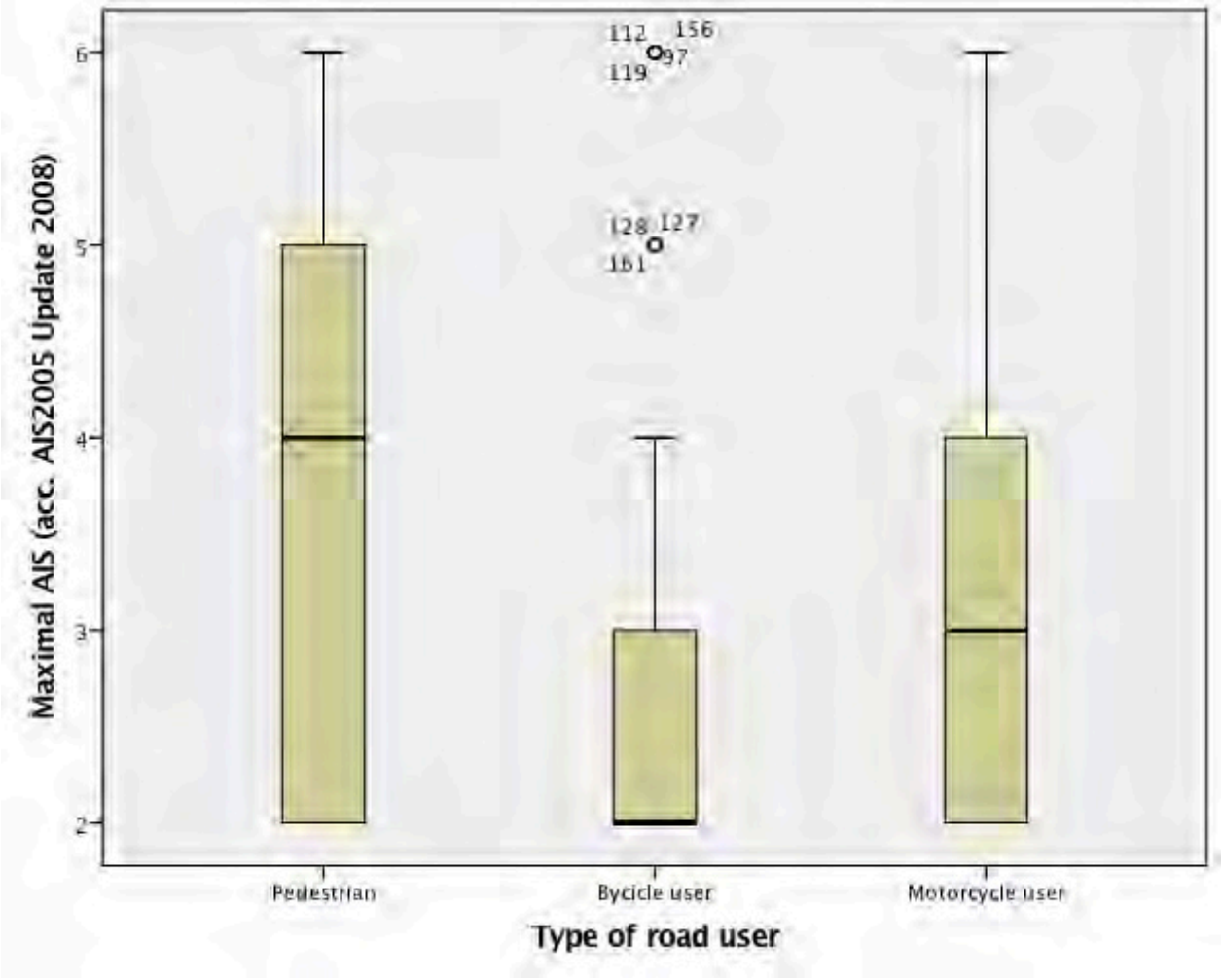

Figure 4

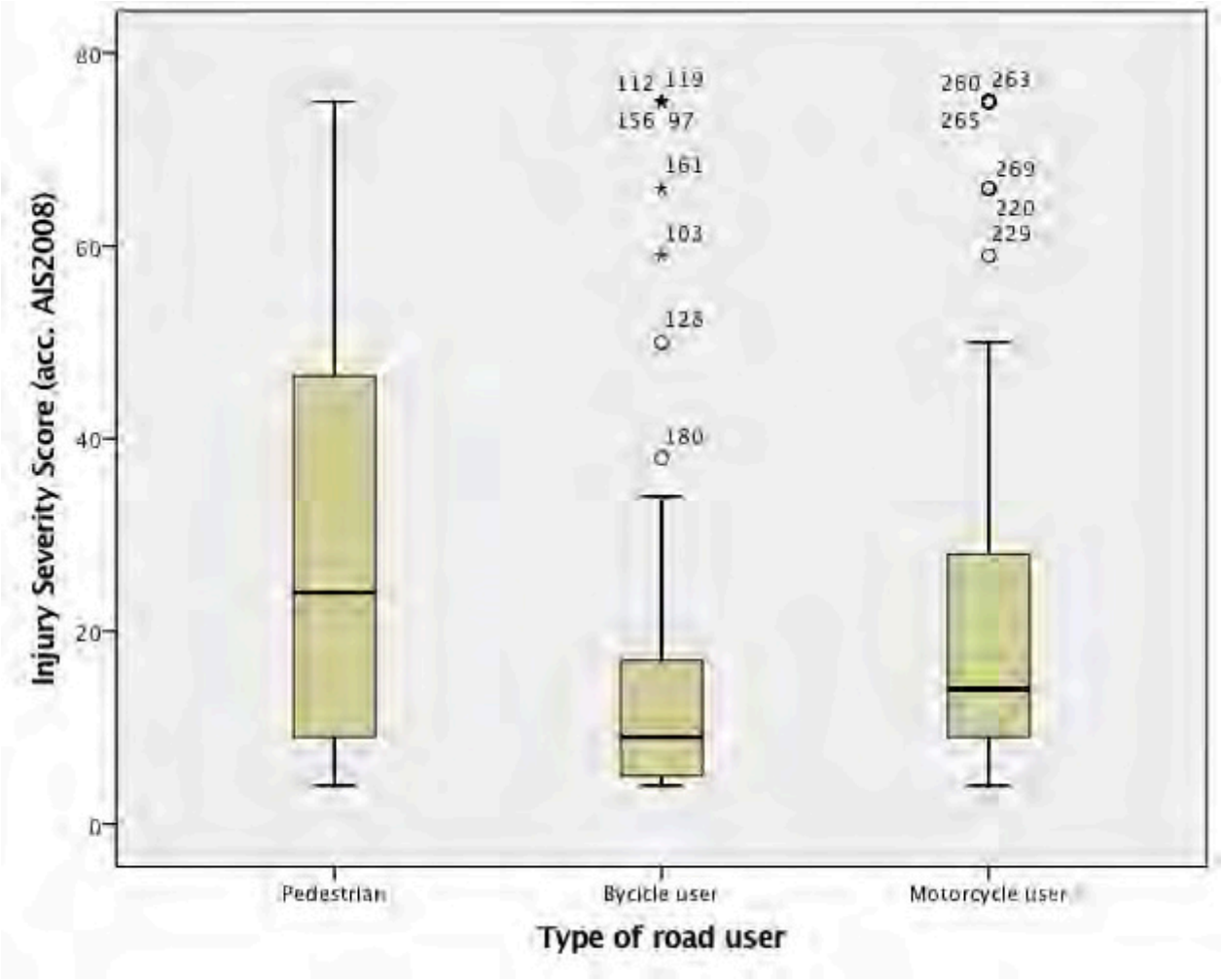

Figure 5

The mean AIS were calculated as shown in table 1.

Table 1: Mean AIS per group

	AIS head	AIS neck	AIS thorax	AIS abdomen	AIS pelvis	AIS arm	AIS leg
pedestrians	2,2	1,4	2,7	1,5	1,1	0,9	1,7
bycicle users	1,3	0,7	1,7	1,2	0,4	0,6	0,7
motorbike users	1,5	1,2	2,4	1,1	0,5	0,8	1,2

DISCUSSION

Our data show a significant risk for all investigated types of vulnerable road users to sustain spine fractures in traffic accidents. However, there are distinct differences between these three groups with pedestrians being at the highest risk for vertebral injuries.

Likewise, especially in pedestrians, spinal injuries are often associated with severe additional injuries, e.g. the head and a very high overall trauma severity (polytrauma).

Recently, we investigated the risk of front seat occupants of cars to sustain vertebral fractures in traffic accidents. Data was collected as described above. Accident data from 1988 to 2011 was used.

The overall vertebral fracture risk was 0,85% [1] . Thus, the findings from our studies on vertebral fractures support prior data showing higher injury severity of vulnerable road users compared to car occupants [2] .

In a study published in 1999, Peng and Bongard retrospectively investigated 5000 pedestrians injured by motor vehicles whose records were entered in a centralized county trauma database [5] . Spinal fractures were diagnosed in 1.8% of patients. In their study, 38% were under-aged patients, who had a lower mean injury severity. Taking this into account, the spinal fracture risk for adult pedestrians was very similar to our study. Consistently, Yanar et al. described age as an independent risk factor for pedestrians to sustain cervical spine fractures in traffic accidents [6] . In their study, the overall fracture risk for pedestrians to sustain cervical spine fractures in traffic accidents was 1.8%.

CONCLUSION

There is a significant risk of vulnerable road users to sustain spine fractures in traffic accidents. Especially in pedestrians, spinal injuries are often associated with severe additional injuries, e.g. the head and a very high overall trauma severity (polytrauma). Changes in vehicle design might be a potential focus for preventive measures.

ACKNOWLEDGEMENTS

For the present study accident data from GIDAS (German In- Depth Accident Study) was used. GIDAS is the largest in-depth accident study in Germany. The data collected in the GIDAS project is very extensive, and serves as a basis of knowledge for different groups of interest. Due to a well-defined sampling plan, representativeness with respect to the federal statistics is also guaranteed. GIDAS collects data from accidents of all kinds and, due to the on- scene investigation and the full reconstruction of each accident, gives a comprehensive view on the individual accident sequences and its causation. The project is funded by the Federal Highway Research Institute (BASt) and the German Research Association for Automotive Technology (FAT), a department of the VDA (German Association of the Automotive Industry).

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