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The Risk of Ankle/Foot Fractures Among Women Drivers

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THE RISK OF ANKLE/FOOT FRACTURES AMONG WOMEN DRIVERS

ABSTRACT

Motor vehicle crashes are a major cause of lower extremity trauma, especially foot/ankle fractures. Modification of motor vehicles to create a more crash worthy environment for the lower extremities would be one of the most effective ways to reduce the incidence and severity of these disabling and costly injuries. However, before such engineering or other interventions may be implemented, we need a better understanding of the epidemiology and biomechanics. Analysis of a linked police report/ hospital discharge database reveals a significantly higher incidence of ankle/foot fractures among drivers in frontal collisions, that seatbelts are not effective in preventing these injuries, and that women have a higher risk of ankle/foot fracture than men. Further analyses have revealed that this finding may be due to an inverse correlation between height and the risk of injury. That is, shorter drivers, most of whom are women, have a higher risk of ankle/foot fractures in frontal collisions.

INTRODUCTION

Lower extremity injuries resulting from motor vehicle crashes are a common cause of permanent disability and impairment (MacKenzie 1986; States 1986). In a 1988 study in Maryland it was noted that, due to the high prevalence of lower extremity injuries, they accounted for 40% of the one-year vehicular trauma treatment charges in the state. Furthermore, among patients admitted to trauma centers, it was noted that lower extremity injuries were the most costly of all injuries in this population. (Siegel J.H., Shafi S., Goodarzi S., and Dischinger P.C., 1994). In the past, the significance of these injuries was largely overlooked, due to the urgency of the more life-threatening injuries seen among trauma center patients. However, with increasing utilization of seatbelts and availability of air bags, it is anticipated that these injuries will become relatively more important, as survival rates for drivers in high energy collisions improve (Burgess A.R., Dischinger P.C., O'Quinn T.D., and Schmidhauser C.B., 1995).

In in-depth trauma center-based crash reconstruction studies of vehicular trauma patients, intrusion of the toepan of the vehicle was associated with distal tibia fractures and fractures to the talus, ankle joint dislocations, and foot bone fractures (Siegel, Mason-Gonzalez S., Dischinger P. et al., 1993; Siegel, Dischinger, Burgess, Cushing et al., 1994). Entrapment of the patient by the lower extremities often lead to the need for extrication by emergency medical services personnel, and further jeopardized the patients' outcomes due to the added elapsed time before administration of definitive care in the trauma center (Siegel J.H., Mason-Gonzalez S., Dischinger P.C. et al. 1993b).

More information is needed about the incidence of these injuries in different types of crashes, whether or not seatbelts and airbags are effective in their prevention, and whether or not there are variations in incidence due to driver characteristics such as gender. By integrating epidemiologic, clinical and experimental findings, it will be possible to better understand the exact mechanism of injury, thus allowing for targeted intervention measures to be implemented.

METHODS

Using police reports, all drivers injured in non-rollover crashes during the period 1991-1994 were identified. By linking police reports with hospital discharge and trauma registry databases, records were identified for all drivers (N=7188) admitted to Maryland hospitals during this period. There were 3835 men and 3353 women included in this sample.

From the police report, it is possible to determine characteristics of the crash, including the driver's age and gender, type of vehicle, use of safety equipment, and the primary point of impact. From the hospital discharge and trauma registry records, data on injury diagnoses are available. Thus, by combining these sources of information, it is possible to analyze the nature and severity of the injuries incurred by these drivers in terms of the characteristics of the crashes, such as the point of impact or seatbelt use, as well as the characteristics of the drivers, such as age and gender.

To address the question of height and the risk of ankle/foot fractures, data were obtained from the Clinical Trauma Registry of the R. Adams Cowley Shock Trauma Center (see Dunham et al., 1989) and linked with police crash reports. Comparisons between groups were made using Pearson's chi-square test of proportion. Tests for interaction were performed using the Breslau-Day test for homogeneity of the odds ratio.

RESULTS

Among the total group of 7188 patients admitted to hospitals during the study period, 16.1% had a lower extremity fracture. There was a significantly higher incidence of lower extremity fracture in frontal, as opposed to lateral and other, collisions (19.1% vs. 9.4%). Furthermore, as shown in Table 1, it may be noted that the incidence of lower extremity fracture was significantly higher in women; however, this male/female difference was only apparent for the drivers in frontal, not lateral, collisions.

Table 1
Incidence of Lower Extremity Fracture by Gender and Point of Impact (n=7188)

	Male	**Female**	**p**	**Total**
Frontal	16.1	22.7	<.001	19.1
Lateral	8.5	8.9	NS	8.7
Total	14.1	18.4	<.001	16.1

Subsequent tables are based on frontal collisions only, since the incidence of lower extremity fractures is highest in this type of crash. Table 2 shows the incidence of specific types of lower extremity injuries, with a comparison of male vs. female drivers. It may be noted that, while femur fractures are significantly higher among men, the incidence of ankle/foot fractures is significantly higher among women.

Table 2
Incidence of Specific Lower Extremity Fractures (Frontal Collisions, n=4961)

	Male (n=2690)	Female (n=2271)	p	Total (n=4961)
Femur	6.7	5.3	.04	6.1
Patella	2.9	3.0	NS	2.9
Tibia/Fibula	4.4	3.4	.07	3.9
Ankle	3.5	8.2	<.001	5.6
Tarsal/Metatarsal	2.3	5.9	<.001	3.9
Total Lower Extremity	16.1	22.7	<.001	

The next table (Table 3) shows a comparison of the incidence of lower extremity injuries among drivers in frontal collisions with and without seatbelts. Women are significantly more likely to be using seatbelts (67.8% vs 52.6%, p<.001). Moreover, with or without seatbelts, women in frontal collisions have a significantly higher incidence of lower extremity injury than men. Lower extremity fractures were uniformly higher among women than among men in both the belted and unbelted groups, as illustrated by a nonsignificant interaction p-value (p=.46).

Table 3
Incidence of Lower Extremity Fracture by Gender and Seatbelt Use (Frontal Crashes)

	Male	Female	p	Total
Belt	14.6	21.9	<.001	18.44
No Belt	17.4	23.6	<.001	19.70
Total	16.0	22.4	<.001	19.10

Table 4 compares the incidence of the specific lower extremity fractures for male and female drivers, with and without seatbelts. Regardless of belt use women drivers have a significantly higher incidence of ankle and metatarsal fractures.

Table 4
Incidence of Specific Lower Extremity Fractures by Gender and Belt Use

	Belt			No Belt			
	Male	Female	p	Male	Female		p
Total							
Femur	4.7	4.5	NS	8.5	6.6	NS	6.1
Patella	3.8	3.1	NS	2.2	2.6	NS	2.9
Tib/Fib	3.2	4.1	NS	3.4	4.9	NS	3.9
Ankle	3.2	8.3	<.001	3.9	8.0	<.001	5.6
Metatar	1.9	6.1	<.001	2.4	5.2	<.002	3.9
Total	14.6	21.9	<.001	17.4	23.6	<.001	19.1

Several reasons for the increased incidence of ankle/foot fractures in women were hypothesized:

differences in footwear, the fact that women drivers, as a group, are shorter than men drivers, and the possible role, if any, of osteoporosis. To directly address one of these hypotheses, data from the trauma registry of the R. Adams Cowley Shock Trauma Center were examined in order to see whether there was an association between the height of the driver and the risk of ankle/foot fracture. There were 1520 patients (959 men and 561 women) in this database, which spanned the period between July, 1987 and December, 1992.

Findings from this analysis (Dischinger P.C., Kerns T.J., and Kufera J.A., 1995) revealed that there is an inverse association between driver height and the incidence of ankle/foot fractures for both men and women (see Figures 1 and 2). Those drivers shorter than average (5'7" for this population) had a 64% increase in lower extremity fracture, mostly due to ankle/tarsal injuries. Thus, the incidence of these injuries appears to be a function of driver height, with an increase among shorter drivers, most of whom are women.

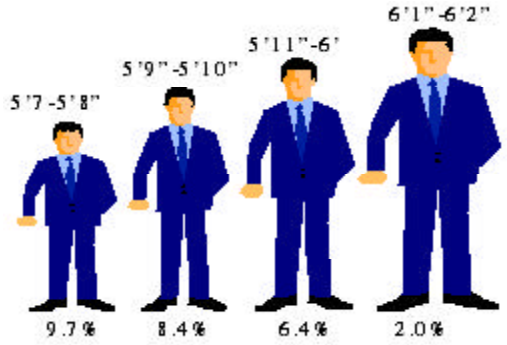

Figure 1
Incidence of Ankle/Tarsal Fractures in Men

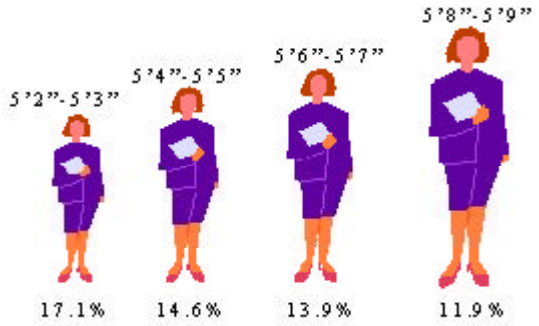

Figure 2
Incidence of Ankle/Tarsal Fractures in Women

DISCUSSION/CONCLUSIONS

It is apparent that the risk of ankle/foot fractures is a function of both crash and driver characteristics. In a previous analysis, we noted that lower extremity injuries were more frequent in frontal collisions, and that seat belts were, for the most part, not effective with regard to their prevention (Dischinger P.C., Cushing B.M., Kerns T.J., 1992). This analysis, based on a larger group of patients, confirms these findings, and focuses more on the comparisons between men and women drivers.

While we believe that the higher risk of ankle/foot injury noted for women is actually a reflection of height and not gender, the fact remains that the majority of shorter drivers are women. Further research needs to be conducted to better understand how height and gender may affect the risk of these injuries. The increased risk in women/shorter drivers may be a reflection of leg position (the angle of the femur or tibia relative to the ankle) as a function of seat placement, since women drivers are more likely than men to drive with the seat moved forward. Other factors might include drivers' foot size or the contribution of knee contacts. The possible influence of foot placement and vehicular intrusion on occupant lower limb injury has recently been described by Pilkey et al. (Pilkey W.D., Sieveka E.M., Crandall J.R., and Klopp G., 1994).

Before preventive measures such as changes in vehicle design can be implemented, further experi-

mental studies are required to explore the role of driver height, gender, and positioning of the seat and foot as related to the causation of these disabling injuries. Since, with the increasing availability of airbags, it is anticipated that there will be more survivors of serious frontal collisions with lower extremity injuries, there will probably be a relative increase of ankle/foot fractures. That is, before the advent of airbags, drivers in high energy collisions frequently suffered from multiple injuries to the head, thorax, abdomen and lower extremities; with airbags more drivers will survive due to a decreased incidence of head, chest, and abdomen injuries. Until changes in car design are implemented to prevent these injuries, the population of those disabled as a result of ankle/foot fractures should include a disproportionately high percentage of women drivers. Further research needs to be conducted to better understand how height and gender may affect the risk of these injuries. The increased risk in women/shorter drivers may be a reflection of leg position (the angle of the femur or tibia relative to the ankle) as a function of seat placement, since women drivers are more likely than men to drive with the seat moved forward. Other factors might include drivers' foot size or the contribution of knee contacts. The possible influence of foot placement and vehicular intrusion on occupant lower limb injury has recently been described by Pilkey et al. (Pilkey W.D., Sieveka E.M., Crandall J.R., and Klopp G., 1994).

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