Changing Patterns of Distal Lower Extremity Injury in Motor Vehicle Crashes

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Background

• What do we know about lower extremity injuries?
  – Common in frontal crashes
  – Frequently, but not always, associated with intrusion
  – Higher incidence in obese drivers
  – More ankle/foot fractures in women & shorter drivers
  – Often related to long-term disability, especially ankle/foot fractures involving articular surfaces
CIREN Report
Consequences and Costs of Lower-Extremity Injuries
Adverse Outcomes of Physical Functioning
1 Year Post-injury

BRIEF COMMUNICATIONS AND RESEARCH NOTES
LOWER EXTREMITY FRACTURES IN MOTOR VEHICLE COLLISIONS: THE ROLE OF DRIVER GENDER AND HEIGHT*

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Abstract—In a previous study it was noted that there was a higher incidence of lower-extremity fractures among women drivers. Analyses were based on a linkage between trauma registry and police crash report data. The present study addresses the issue of whether the differences noted are attributed to driver gender or are merely a reflection of differences in driver height.

An inverse association was noted between driver height and the incidence of lower-extremity fractures. Those shorter than average (5’7”) for this population had a 64% increase in lower-extremity fracture, which can be mainly attributed 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.

Keywords—Lower-extremity injuries, Gender, Height, Motor vehicle occupant
Incidence of Ankle/Tarsal Injury In Males

- 5'7"-5'8"
  - 9.7%

- 5'9"-5'10"
  - 8.4%

- 5'11"-6'
  - 6.4%

- 6'1"-6'2"
  - 2.0%

Charles "McC." Mathias, Jr., National Study Center for Trauma and Emergency Medical Systems
BMI, PDOF – not significant
Selection criteria: NASS 1998-2010, 10988 cases, drivers >= 16 yrs, belted, non-ejected, frontal PDOF ± 30°
Analysis of Foot & Ankle Injuries in CIREN
Comparison of Early vs. Late Model Year Vehicles

- All CIREN centers
- Model years 2001-2014
- Drivers
- Passenger vehicles
- Frontal collisions
- 1,411 cases
Definitions of Lower Extremity Injuries
Fractures and Dislocations

• Foot
  – Talus
  – Calcaneus
  – Tarsal/metatarsal bones

• Ankle
  – Malleolar
  – Distal tibia/fibula
# Foot Injuries Occurring in CIREN
## By Gender and Intrusion
### Model Years 2001-04 vs. 2005-14

<table>
<thead>
<tr>
<th>Category</th>
<th>Female 2001-04</th>
<th>Female 2005-14</th>
<th>Male 2001-04</th>
<th>Male 2005-14</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>16.8</td>
<td>18.4</td>
<td>5.7</td>
<td>10.2</td>
</tr>
<tr>
<td>3-7cm</td>
<td>28.4</td>
<td>26.9</td>
<td>9.8</td>
<td>17.9</td>
</tr>
<tr>
<td>8-29cm</td>
<td>33.3</td>
<td>33.3</td>
<td>16.3</td>
<td>18.1</td>
</tr>
<tr>
<td>30+cm</td>
<td>57.1</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: The chart compares the percentage of foot injuries by gender and intrusion level for Model Years 2001-04 vs. 2005-14.
Ankle Injuries Occurring in CIREN
By Gender and Intrusion
Model Years 2001-04 vs. 2005-14

[Bar chart showing the distribution of ankle injuries by gender and intrusion for model years 2001-04 and 2005-14.]
Foot and Ankle Injuries in CIREN at High Delta V (46+ kph)

- Foot Injuries: 52.6% (MY 2001-04) vs. 59.9% (MY 2005-14)
- Ankle Injuries: 51.5% (MY 2001-04) vs. 59.3% (MY 2005-14)
Aim of Current Analyses
Weighted NASS Data

• To assess trends over past 14 years in ankle/foot injuries occurring among drivers in passenger vehicles involved in frontal collisions
• To determine whether gender differences still exist for these injuries
• To identify risk factors for foot and ankle injuries
  – Crash and host related factors
  – Separately for men and women
Analysis of Foot & Ankle Injuries in NASS
Comparison of Early vs. Late Model Year Vehicles

- Weighted data
- Model years 2001-2014
- Drivers
- Passenger vehicles
- Frontal collisions
- 19,174 cases (unweighted)
  - 10,268 men, 8,906 women
  - 488 foot injuries, 386 ankle injuries
Incidence of Foot Injuries in Weighted NASS Data
Passenger Vehicle Drivers in Frontal Crashes
Model Years 2001-04 vs. 2005-14

<table>
<thead>
<tr>
<th></th>
<th>MY 2001-04 (%)</th>
<th>MY 2005-14 (%)</th>
<th>p</th>
<th>OR</th>
<th>95% CI for OR</th>
</tr>
</thead>
<tbody>
<tr>
<td>All drivers</td>
<td>2.03</td>
<td>0.49</td>
<td>&lt; 0.001</td>
<td>4.20</td>
<td>1.70-10.38</td>
</tr>
<tr>
<td>Females</td>
<td>3.44</td>
<td>0.59</td>
<td>&lt; 0.001</td>
<td>6.00</td>
<td>1.99-18.08</td>
</tr>
<tr>
<td>Males</td>
<td>0.68</td>
<td>0.39</td>
<td>0.09</td>
<td>1.73</td>
<td>0.86-3.46</td>
</tr>
</tbody>
</table>
# Incidence of Ankle Injuries in Weighted NASS Data

Passenger Vehicle Drivers in Frontal Crashes

Model Years 2001-04 vs. 2005-14

<table>
<thead>
<tr>
<th></th>
<th>MY 2001-04 (%)</th>
<th>MY 2005-14 (%)</th>
<th>p</th>
<th>OR</th>
<th>95% CI for OR</th>
</tr>
</thead>
<tbody>
<tr>
<td>All drivers</td>
<td>0.83</td>
<td>0.28</td>
<td>&lt; 0.001</td>
<td>2.95</td>
<td>1.92-4.52</td>
</tr>
<tr>
<td>Females</td>
<td>1.25</td>
<td>0.35</td>
<td>&lt;0.001</td>
<td>3.62</td>
<td>1.35-9.70</td>
</tr>
<tr>
<td>Males</td>
<td>0.43</td>
<td>0.23</td>
<td>0.22</td>
<td>1.95</td>
<td>0.59-6.46</td>
</tr>
</tbody>
</table>
Incidence of Foot & Ankle Injuries for Females & Males
Passenger Vehicle Drivers in Frontal Crashes
Model Years 2001-04 vs. 2005-09 vs. 2010-14

Foot Injuries

Females

Males

Ankle Injuries

Females

Males

Percent

0.0

0.4

0.8

1.2

1.6

2.0

2.4

2.8

3.2

3.6

4.0

MY 2001-04

MY 2005-09

MY 2010-14
Covariates for Logistic Regression
Incidence of Foot & Ankle Injury by Gender

• Model years
  – 2001-04 vs. 2005-14
  – 2005-09 vs. 2010-14
• Age 55+ vs. < 55
• Belted vs. Unbelted
• Toepan/panel intrusion vs. no intrusion
  – Highly associated with Delta V
• Height & Weight categories (vs. Tall & Lean)
  – Short & Lean
  – Short & Overweight
  – Tall & Overweight
Cut Points for Height and Weight
CDC 2012 Data

• Men
  – Mean height: 5 feet 9 inches
  – Mean weight: 195 pounds

• Women
  – Mean height: 5 feet 4 inches
  – Mean weight: 166 pounds

• Definitions
  – Short /Tall: below /above mean height
  – Lean/Overweight: below/above mean mean weight
# Multivariable Regression of Weighted NASS Model Years 2001-14
Outcome = Incidence of Foot Injury

<table>
<thead>
<tr>
<th>Parameter</th>
<th>FEMALES</th>
<th>MALES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>p</td>
<td>OR</td>
</tr>
<tr>
<td>MY 2001-04</td>
<td>&lt;0.001</td>
<td>9.49</td>
</tr>
<tr>
<td>Age 55+</td>
<td>0.007</td>
<td>6.65</td>
</tr>
<tr>
<td>Belted</td>
<td>0.30</td>
<td>0.67</td>
</tr>
<tr>
<td>Intrusion</td>
<td>&lt;0.001</td>
<td>16.93</td>
</tr>
<tr>
<td>Short/Lean</td>
<td>0.08</td>
<td>0.68</td>
</tr>
<tr>
<td>Short/Overweight</td>
<td>0.05</td>
<td>5.24</td>
</tr>
<tr>
<td>Tall/Overweight</td>
<td>&lt;0.001</td>
<td>18.43</td>
</tr>
</tbody>
</table>
Incidence of Foot Injuries
Distributed by Gender and Intrusion Magnitude
Weighted NASS MY 2001-04 vs. MY 2005-14
Multivariable Regression of Weighted NASS Model Years 2001-14
Outcome = Incidence of Ankle Injury

<table>
<thead>
<tr>
<th>Parameter</th>
<th>FEMALES</th>
<th>MALES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>p</td>
<td>OR</td>
</tr>
<tr>
<td>MY 2001-04</td>
<td>0.002</td>
<td>5.51</td>
</tr>
<tr>
<td>Age 55+</td>
<td>0.64</td>
<td>1.52</td>
</tr>
<tr>
<td>Belted</td>
<td>0.06</td>
<td>0.49</td>
</tr>
<tr>
<td>Intrusion</td>
<td>&lt;0.001</td>
<td>46.66</td>
</tr>
<tr>
<td>Short/Lean</td>
<td>0.86</td>
<td>1.10</td>
</tr>
<tr>
<td>Short/Overweight</td>
<td>0.07</td>
<td>1.59</td>
</tr>
<tr>
<td>Tall/Overweight</td>
<td>0.04</td>
<td>6.66</td>
</tr>
</tbody>
</table>
Incidence of Ankle Injuries Distributed by Gender and Intrusion Magnitude Weighted NASS MY 2001-04 vs. MY 2005-14
Incidence of LEI in Weighted NASS
Odds Ratios of Females Relative to Males

- Foot Injuries:
  - MY 2001-04: 5.23
  - MY 2005-09: 1.58
  - MY 2010-14: 1.20

- Ankle Injuries:
  - MY 2001-04: 2.93
  - MY 2005-09: 1.70
  - MY 2010-14: 0.98
Summary

• During the past 10 years there has been a marked decline in ankle/foot injuries in frontal collisions, especially for women

• Foot injuries
  – The ratio of female to male injuries in the newest model years is now 1.20
  – Intrusion remains a major risk factor for both men and women
  – For women, however, age 55+ and being overweight (regardless of height) remain significant risk factors
Summary (cont’d)

• Ankle injuries
  – The ratio of female to male injuries in the newest model years has now declined to 0.98
  – Intrusion is the strongest risk factor for both men and women
  – Being tall and overweight increases risk for women, while being short and overweight is a risk for men
Future Steps

• To examine specific foot and ankle bones to determine possible interactions with gender differences

• To determine whether there are differences observed in CIREN data regarding contact points between earlier and later model year vehicles involved in frontal crashes