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EFFECTS OF FRONT SEAT PERFORMANCE FAILURE ON REAR SEAT OCCUPANT INJURIES IN REAR IMPACTS

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ABSTRACT

An analysis of rear end accidents involving rear seat occupants seated behind a front seat occupant was conducted examining the probability of serious injury as a function of both crash severity and front seat performance failure. Seat performance failure is when some element of the seat fails to do what it is designed to do, e.g. a seat back lock allows the seat back to move during the collision. The results suggest that the risk of serious injury is greater in the 6.7-11.2 m/s Delta-V crash severity range when the seat in front of the occupant suffers a performance failure.

INTRODUCTION

Front seat failures have been the subject of much controversy over the years in the context of front seat occupant injuries[1]. At the same time, the literature appears to be absent of analyses asking the question of what are the effects of front seat failures on rear seat occupants.

METHODS

The 1988-1997 National Accident Sampling System Crashworthiness Data System (NASS-CDS) was used. This data is a stratified sample data set collected by the National Highway Traffic Safety Administration (NHTSA) of accidents that had at least one vehicle towed from the scene. All occupants seated rearward of the front seats in light body vehicle styles and for which there was an occupant in the seat forward of the case occupant were selected for use. Only occupants of vehicles that had a primary impact to the rear and for which no rollover had occurred were considered.

Ranges of crash severity were created and cases with known Delta-V (an index of vehicle crash severity) and known maximum AIS (Abbreviated Injury Scale) or fatal injury outcome were analyzed. Injury outcomes were separated into none, minor, and moderate (AIS 0-2) and compared with those with serious, severe, critical and fatal (AIS 3-6, death). The effects of age, intrusion, vehicle type, performance of the seat forward of the rear seat occupant, rear seat performance and restraint usage were considered in the study. The SAS[2] and SUDAAN[3] analysis programs were used to analyze the data and determine statistical significance and evaluate 95% confidence intervals.

RESULTS

The analysis resulted in 404 occupant records, representing 249,714 people that applied to the conditions of the study, see Table 1. (One record was above the 20.1 m/s Delta-V of interest.)

Delta-V (m/s)		All	w/o Seat Back Failure	w/ Seat Back Failure
All	Sample	404	265	139
	Weighted	249714	212979	36735
.01-6.7	Sample	210	166	44
	Weighted	200659	181040	19619
6.7-11.2	Sample	150	78	72
	Weighted	44599	30119	14478
11.2-20.1	Sample	43	21	22
	Weighted	4449	1820	2629

Table 1: Sample size and weighted size as a function of Delta-V and front seat back performance.

The probability of serious injury as a function of crash severity range is detailed in Table 2 and shown in Figure 1 below. Most of the cases selected represented rear seat occupants sitting behind front seats, as opposed to a third row seated occupant sitting behind a second row occupant.

Delta-V (m/s)	All Cases (%)	w/o Seat Back Failure (%)	w/ Seat Back Failure (%)
All Cases	0.61	0.14	3.30
.01 – 6.7	0.00	0.00	0.00
6.7-11.2	2.90	0.32	8.27
11.2-20.1	4.98	11.39	0.55

Table 2: Probability of serious injury to rear seat occupants as a function on Delta-V and front seat back performance.

As can be seen in Figure 1, the effect of front seat performance failure on an occupant seated behind a front seat occupant in the 6.7-11.2 m/s was found to be significant. The likelihood of serious to fatal injury, when seat performance failure occurred in a seat directly in front of a rear seat occupant, was found to be increased about 25 times (.32% v 8.27%) in this crash severity range.

The role of age was not found to be significant in the analysis considering 0-12 and persons over 12. However, it was observed that the older group had a substantially higher injury rate for the same conditions.

Of the other variables examined; intrusion, rear seat performance failure, rear restraint type and general vehicle type, seemed to be of lesser importance and did not prevent front seat performance from being significantly associated with injury outcome.

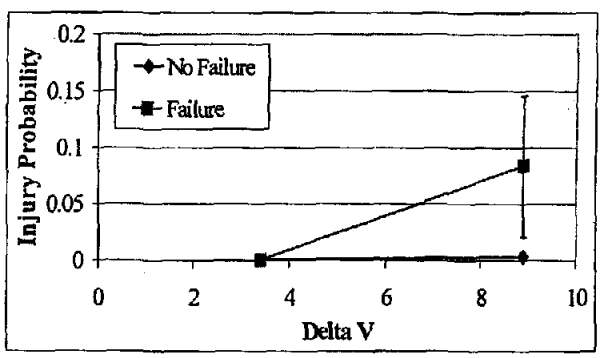

Figure 1: Graphic of injury probability as a function of crash severity (in m/s) with and without forward seat performance failure.

Examination of the results shows that the injury contacts are dominated for those cases as "seat, back structure" at 45% with the next closest being "unknown source" at 29%.

CONCLUSIONS

In primarily rear impacts of 6.7-11.2 m/s crash severity, seat performance failure of an occupied seat in front of a rear area seated occupant significantly increased serious injury outcome for that rear area seated occupant.

The effect of using the seat performance failure variable alone in the more severe crash severity range of 11.2-20.1 m/s Delta-V was observed to have an opposite effect compared to the 11.2-20.1 m/s Delta-V results. However, when intrusion in the rear seat area was included the results were not significantly different at the 95% confidence level.

The results at the 11.2-20.1 m/s Delta-V crash severity suggest that additional factors are involved in this regime where major intrusion effects are observed. Consideration of additional factors, such as the effect of front seat type (e.g. bucket, bucket with folding back, bench), rear seat occupant restraint (unrestrained, 2pt, 3pt), intrusion, and the potential for not being able to detect the front seat performance failure in the face of the large amounts of intrusion observed in this range, was not possible due to the lack of data in this crash severity range. However, case by case analysis of the hardcopy records should be carried out to assist in identifying what factors are at work at this crash severity (as should also be done in the lower crash severity range).

In addition, it appears that all primary crash severity modes should be considered in the analysis based on hypotheses arising from this work and field observations as to the mechanisms that are increasing the rear seat occupant injury outcome in the face of front seat performance failure.

REFERENCES

[1] Friedman, K., Gaston, F., Bish, J. and Sances, T., "Seat Failure in Rear Impacts", 1999 ASME International Mechanical Engineering Congress and Exposition, November 14th – 19th.

[2] SAS Institute Inc., SAS Campus Drive, Cary, NC 27513

[3] Software for the Statistical Analysis of Correlated Data, Research Triangle Institute, P.O. Box 12194, Research Triangle Park, NC 27709

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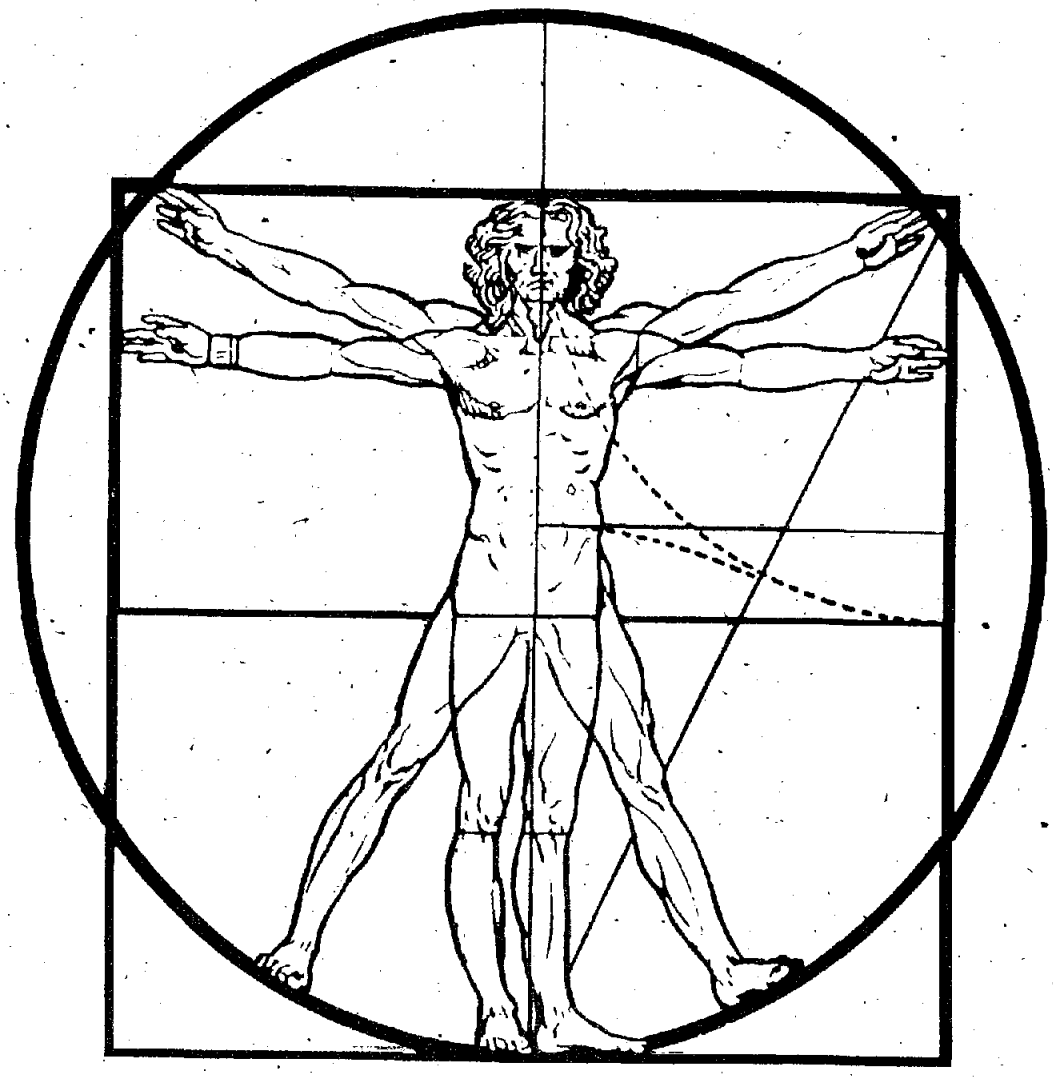

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