5^{th} vs 50^{th}

Results of 56 KMPH Crash Tests

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Outline

- Motivation
- Test Set Up
- Injury Test Results
  - Driver Dummy
- Discussion
- Conclusion

Motivation

- Performance data on the 5th percentile in a 56 KMPH (35 MPH) full frontal barrier crash was lacking.
- Previous testing at speed of 48 KMPH (30 MPH) with the 5th percentile showed that the 5th incurred greater injury than the 50th.

Previous Testing with 5th Percentile Dummy

- 1998 – NHTSA and Transport Canada tested the 5th percentile dummy and the 50th percentile dummy in paired 48 KMPH (30 MPH) belted full-frontal crash tests.
  - 5th percentile dummy experienced increased injury measures to the neck and tibia compared to the 50th percentile dummy.

Dalmotas, D, et al., "Assessments of Air Bag Performance Based on the 5th Percentile Female Hybrid III Crash Test Dummy," 16th ESV, 1998.

Test Set Up

- Selection of 10 MY 2001 vehicles
  - Vehicles tested were from the light, compact, medium, SUV and minivans class
  - Vehicles had new and emerging air bag and belt technologies
  - Same model tested by NCAP using the 50th

Vehicle Matrix

Vehicle Size	Model	Driver and Passenger		
		Air Bag Inflator Type	Load Limiter	Pretensioner
Light	Civic 4 dr	Dual Stage	✓	✓
	Sentra	Single Stage	✓	✓
Compact	Echo	Single Stage	✓	✓
Medium	Maxima	Dual Stage	✓	✓
	Accord	Dual Stage	✓	✓
	Impala	Dual Stage	✓	
SUV	Escape	Single Stage	✓	✓
	Durango	Single Stage	✓	✓
Minivan	Grand Caravan	Multi-Stage	✓	✓
	Windstar	Dual Stage	✓	✓

Test Procedure

- Frontal NCAP laboratory procedure was used:
  - One dummy seated in the driver position and other seated in the right front passenger seating position
  - Test speed of 56 KMPH (35 MPH)
- Vehicles ballasted so that those tested with 5th percentile dummy had nearly identical test weights to those tested with the 50th percentile dummy – allows for direct comparison between the two dummies.

Test Procedure Cont…

- Seating procedure
  - 5th percentile positioned at forward-most position on seat track
  - 50th percentile positioned at mid-track

Test Procedures Cont…

- Paint Locations to monitor dummy-to-vehicle interaction
  - Head, chin, nose, and knees (each with a different color)
  - Ho[illegible] pe[illegible] air bag, up[illegible] the 5th pe[illegible]
  - Ste[illegible] pe[illegible] e steering wheel before the air bag was fully inflated – indicating that the air bag deployed to late to adequately protect the occupant

Test Results – HIC 15

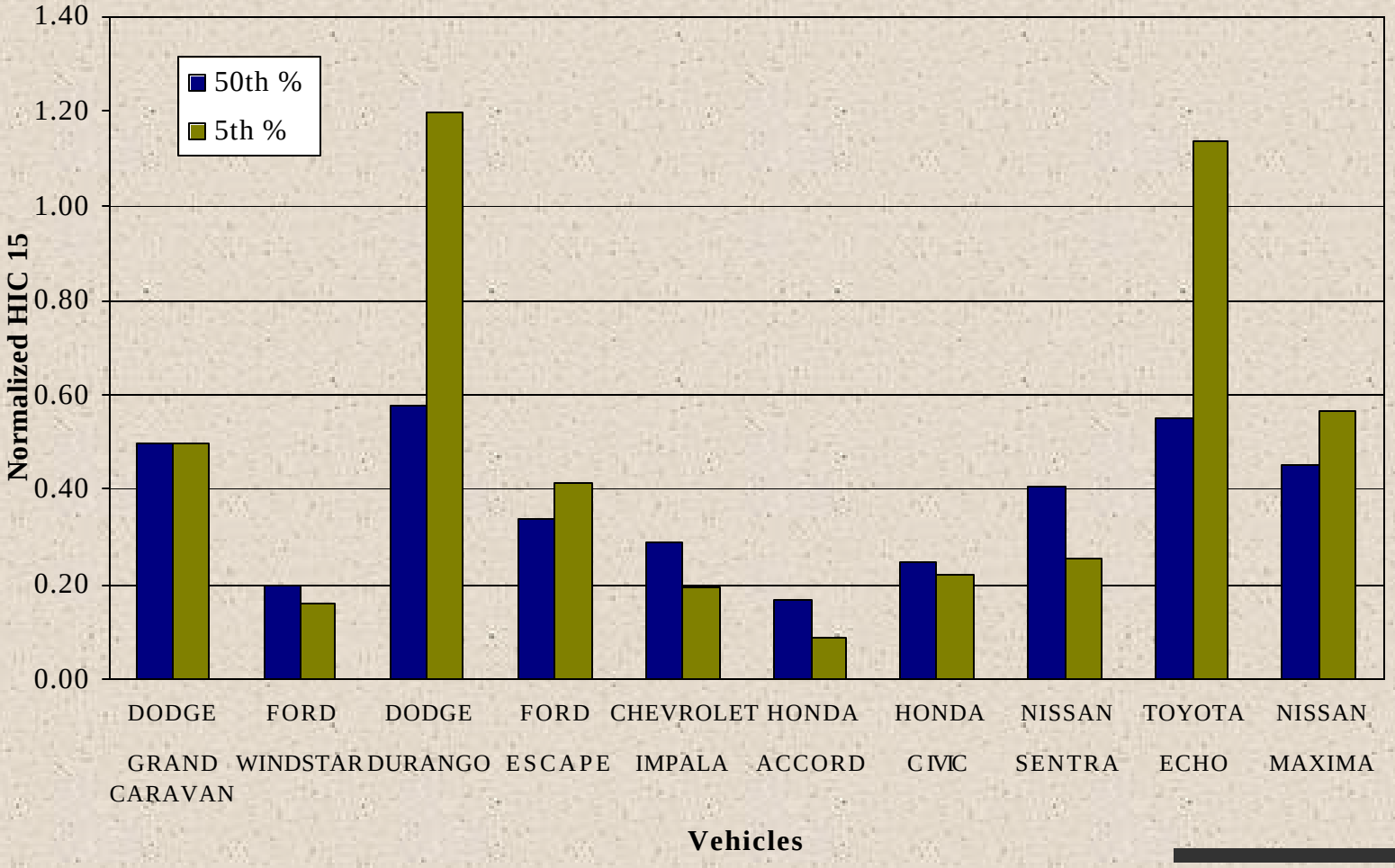
- In 80% of the vehicles tested, the 5th % driver dummy incurred similar HIC 15 results to the 50th % driver dummy and they were below the IARV by 20% or more.
- One passenger car (Toyota Echo) and one LTV (Dodge Durango) exceeded the HIC 15 limit of 700.

HIC 15 Injury Cont….

- The 2 vehicles which exceeded the HIC 15 injury criteria:
  - were equipped with single stage air bags
  - had the highest HIC values for the 50th % driver dummy as well
- No 5th % nor 50th % passenger dummy exceeded the IARV for HIC 15.

HIC 15 Injury Cont….

Figure 1: 50th % Driver Vs. 5th % Driver Normalized HIC 15 Injury



Test Results-Nij

- Two 5th percentile driver dummies exceeded the IARV of 1.0.
  - The Dodge Durango had a Nij of 1.20 and the Dodge Grand Caravan had a Nij of 1.71.
- Of the remaining vehicles tested with the 5th percentile driver dummy, 3 had Nij's which were marginal and the remaining 5 were below the IARV by more than 20%.

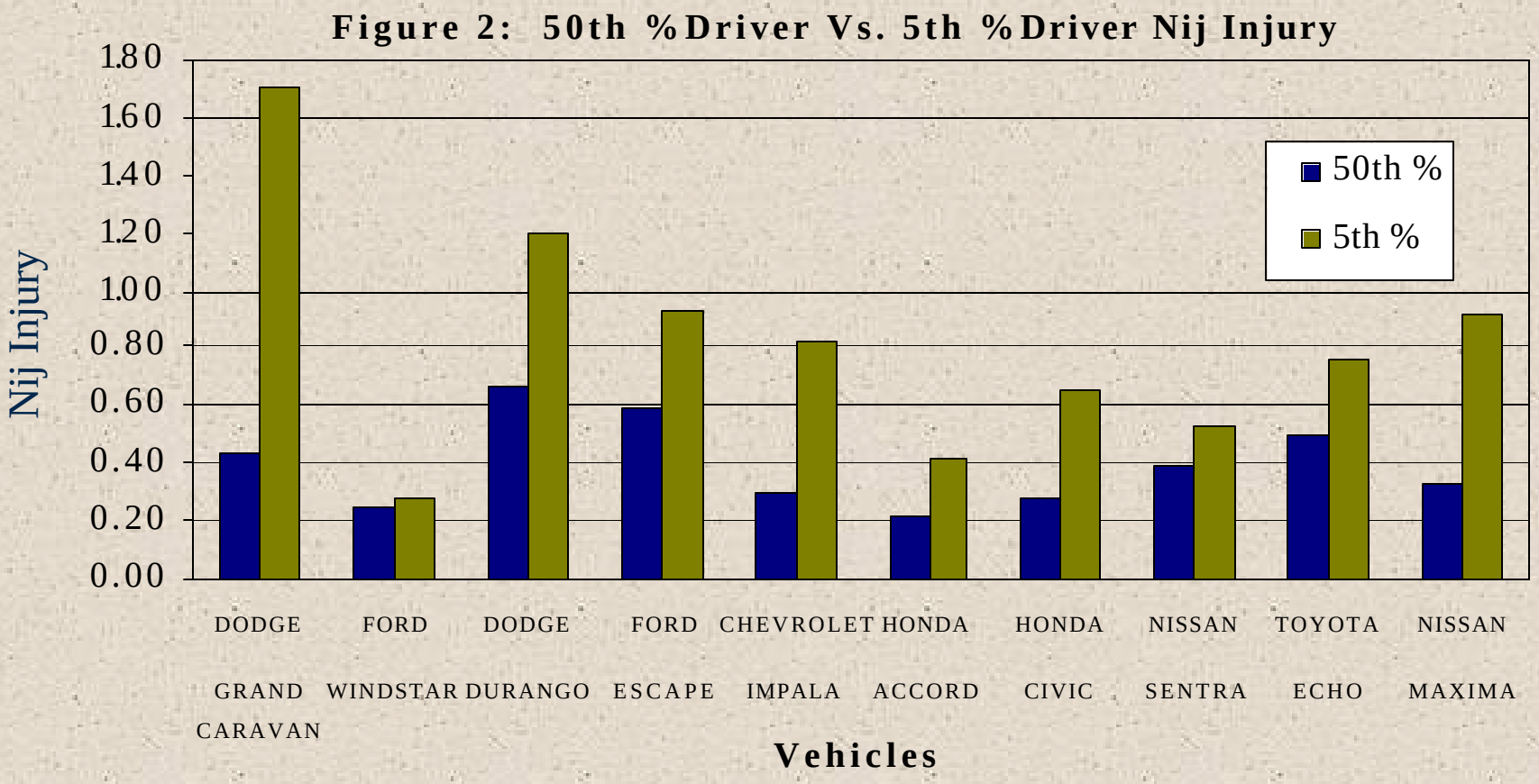
Nij Injury Cont….

- All 50th percentile driver dummies easily passed the IARV for Nij as all had Nij values below the IARV by more than 20%.
- For each vehicle tested, the 5th percentile driver dummy had greater Nij readings than the 50th percentile driver dummy.

Nij Injury Cont….

- One vehicle exceeded the IARV for the 5th percentile passenger dummy – Dodge Durango
- 2 vehicles had marginal Nij readings for the 5th percentile passenger dummy and the remaining 7 vehicles were below the IARV by more than 20%.
- All 50th percentile passenger dummies were below the IARV by more than 20%.
- 7 out of 10 vehicles tested recorded higher injury values for the 5th percentile passenger dummy than for the 50th percentile passenger dummy.

Nij Injury Cont….



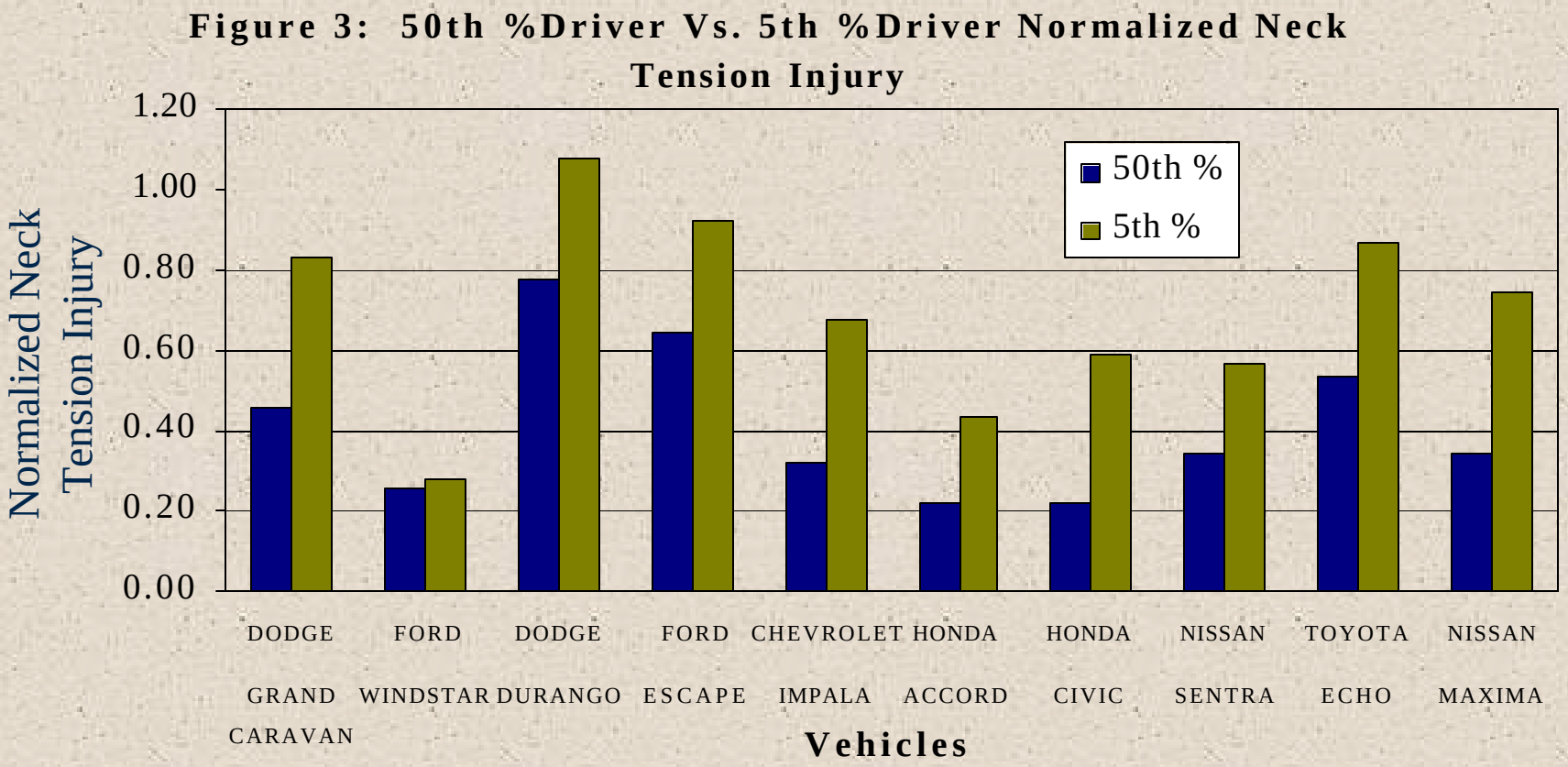
Test Results – Neck Tension

- Normalized neck tension injury values recorded for the 5th percentile driver dummy were consistently higher than those recorded for the 50th driver dummy.
- However, 9 out of 10 5th percentile driver dummies passed the neck tension criteria of 4,287 N.
  - Only vehicle to exceed the neck tension criteria – Dodge Durango – also exceeded the respective IARVs for both Nij and HIC
- Three 5th percentile driver dummies marginally passed the IARV for neck tension and the remaining 6 vehicles were below the IARV by more than 20%.

Neck Tension Injury Cont….

- All 50th percentile driver dummies were below the IARV of 6,806 by more than 20%.
- The 5th percentile passenger dummy had greater normalized neck tension readings than the 50th percentile passenger dummy in the majority of the vehicles tested.

Neck Tension Injury Cont….



Test Results – Neck Compression

- Neither 50th nor 5th percentile driver and passenger dummies exceeded the peak neck compression values for each respective dummy. All were well below the IARV by more than 20%.
- On average, the 5th percentile driver and passenger dummies recorded greater neck compression injury values than the 50th percentile driver and passenger dummies, respectively.

Test Results – Chest Acceleration

- In 6 of 10 vehicles, the 5th percentile driver dummy recorded higher chest acceleration injury values than the 50th percentile dummy.
- However, on average, both dummies achieved similar readir
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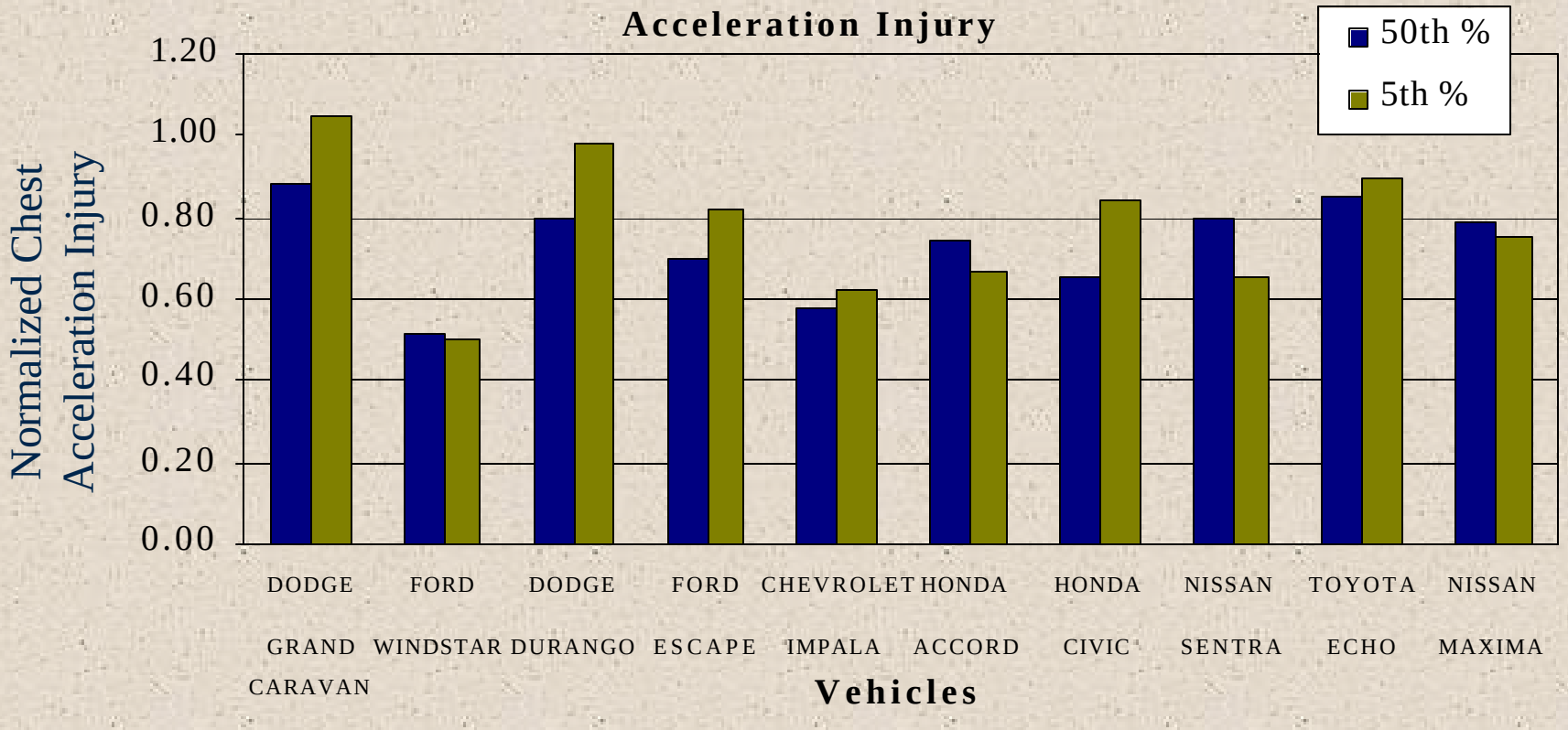
- The 5th percentile driver dummy exceeded the IARV in one vehicle – Dodge Grand Caravan

Chest Acceleration Injury Cont….

- All 5th and 50th percentile passenger dummies recorded chest acceleration injury values that were below the IARV of 60 G.
  - 3 of these 10 vehicles were marginal for each dummy type
  - 2 of those vehicles that were marginal for the 5th percentile passenger dummy were also marginal for the 50th percentile passenger dummy in the comparable crash test
- Although average readings were similar, the 5th percentile passenger dummy had higher chest acceleration than the 50th percentile passenger dummy in 9 of the 10 tests.

Chest Acceleration Injury Cont….

Figure 4: 50th %Driver Vs. 5th %Driver Normalized Chest Acceleration Injury

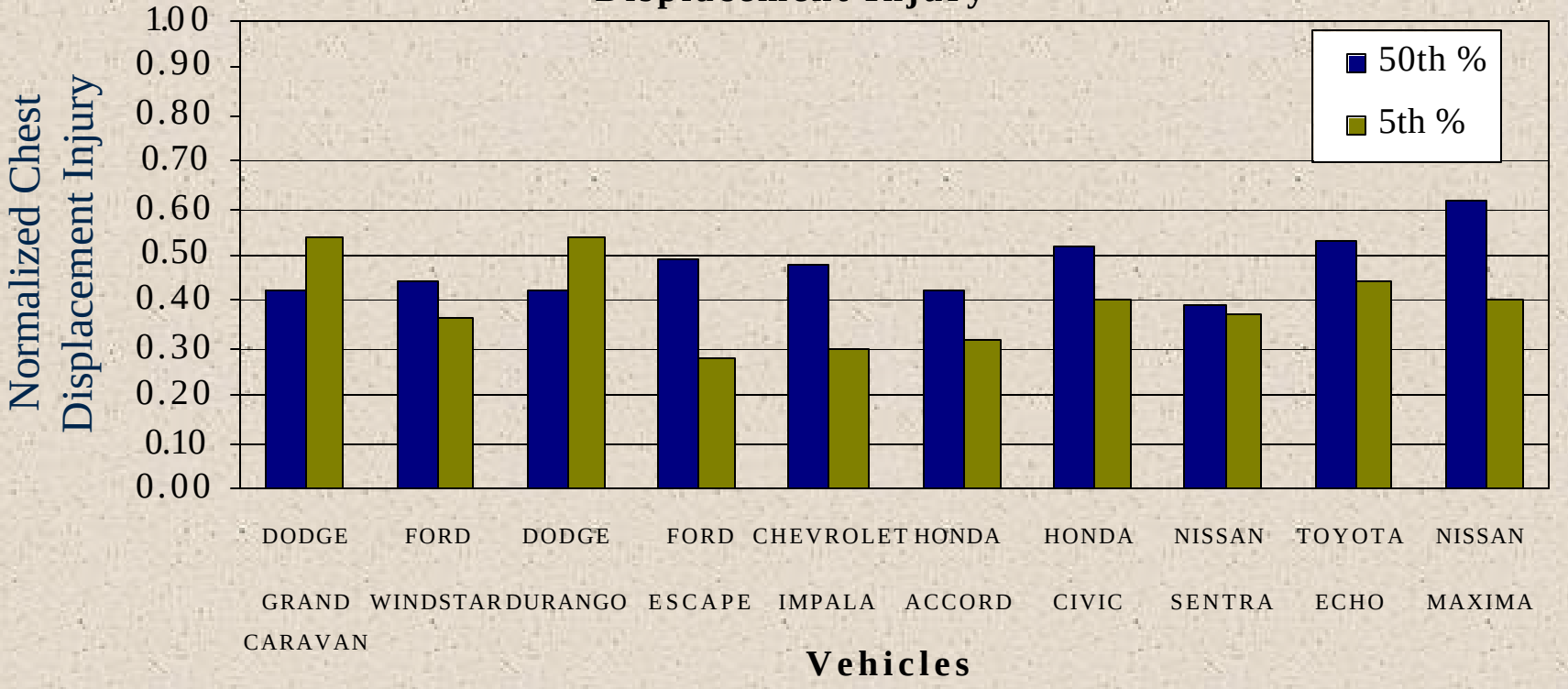


Test Results – Chest Deflection

- Neither 5th nor 50th percentile driver dummies experienced excessive chest deflections.
- Both 5th and 50th percentile driver dummies were well below the respective IARVs for each dummy type by more than 20%.
- Normalized chest deflection readings for the 50th percentile driver dummy were slightly greater than for the 5th percentile driver dummy, but on average, both dummies achieved similar results.
  - Normalized chest deflection for 5th driver – 0.40
  - Normalized chest deflection for 50th driver – 0.47

Chest Deflection Injury Cont….

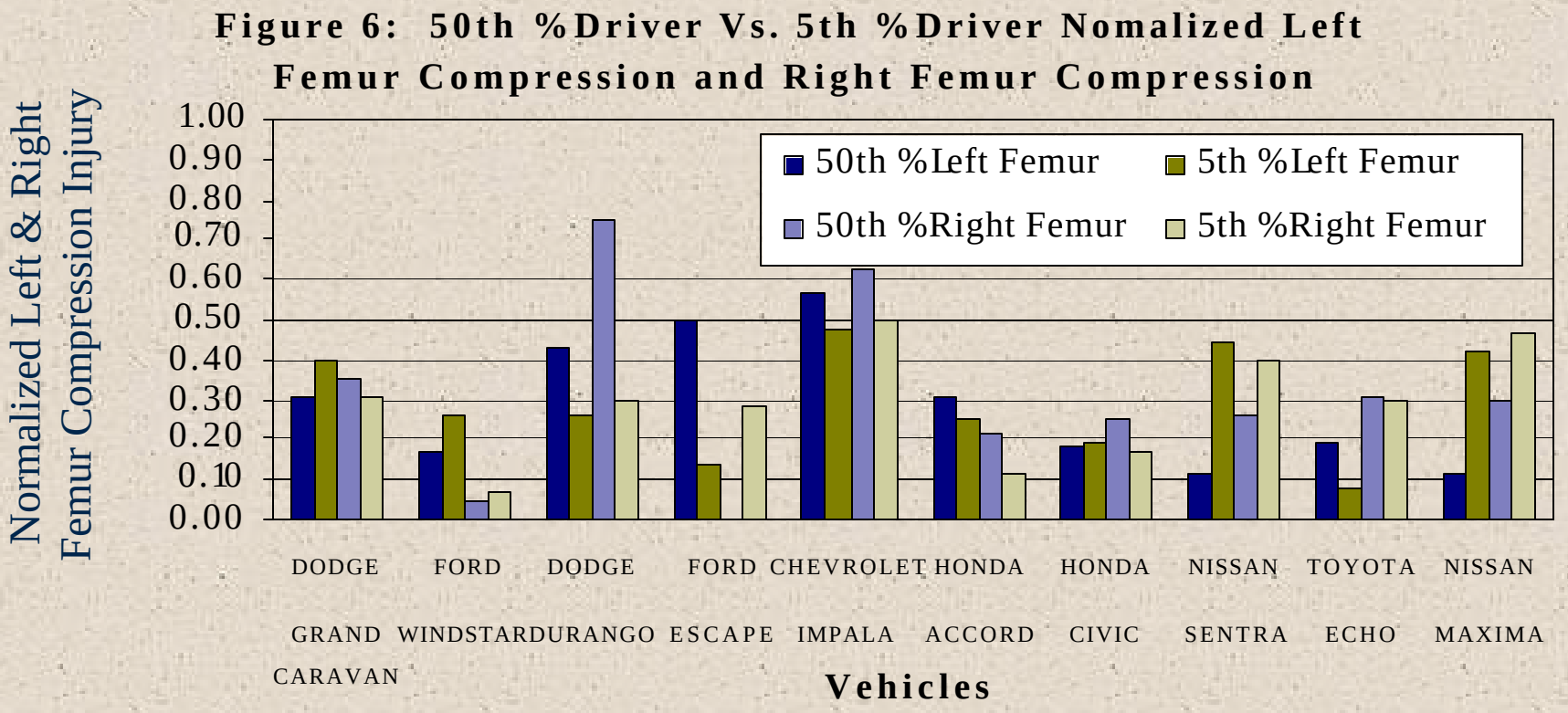
Figure 5: 50th %Driver Vs. 5th %Driver Normalized Chest Displacement Injury



Test Results - Femur

- 5th percentile driver and passenger dummy readings were well below 20% of the IARV of 6.8 KN for femur compression.
- For each vehicle, the values for the left and right leg were similar.
- 50th percentile driver and passenger dummies also recorded femur compression loads well below the respective IARV of 10 KN.

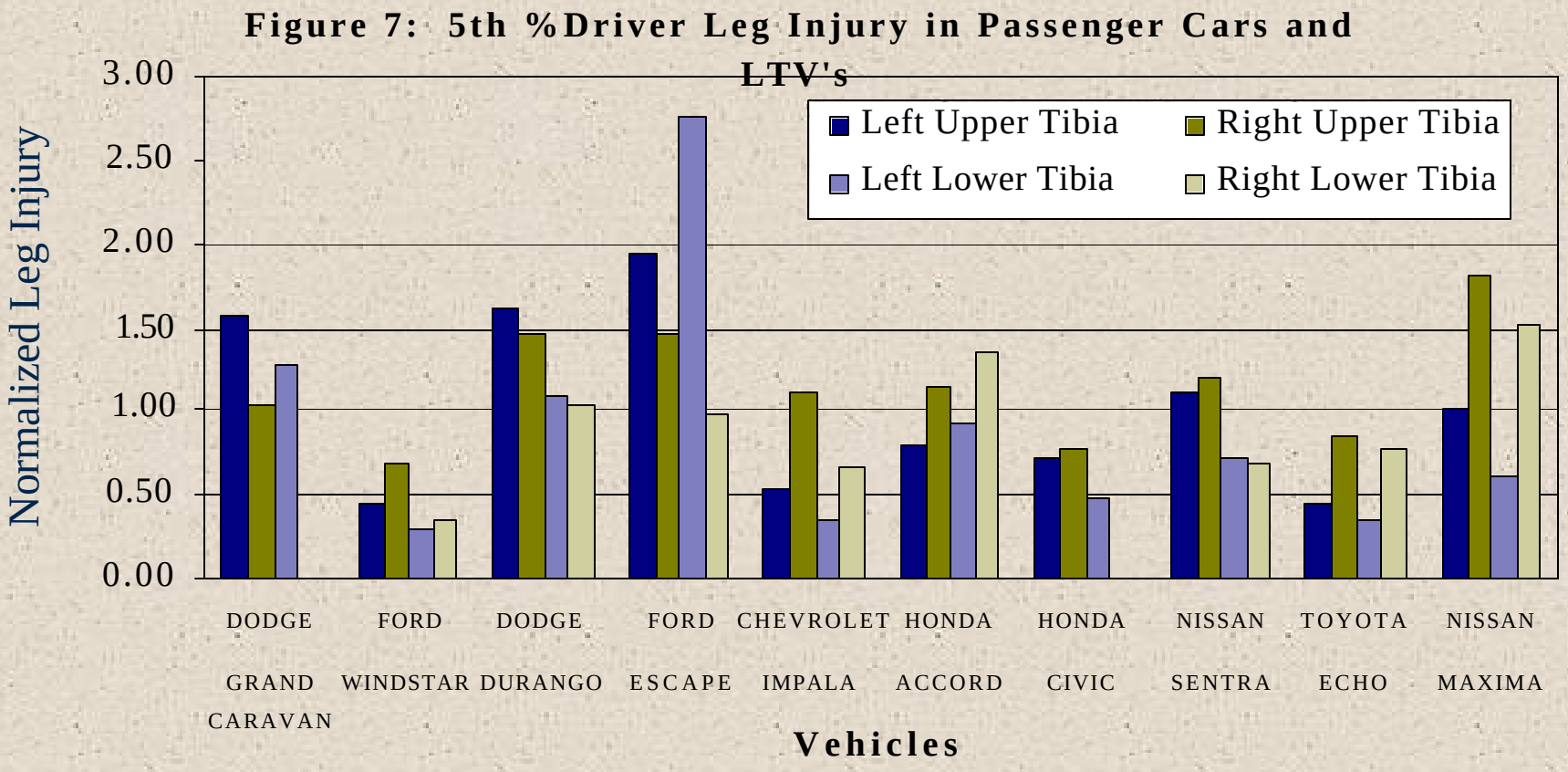
Femur Injury Cont….



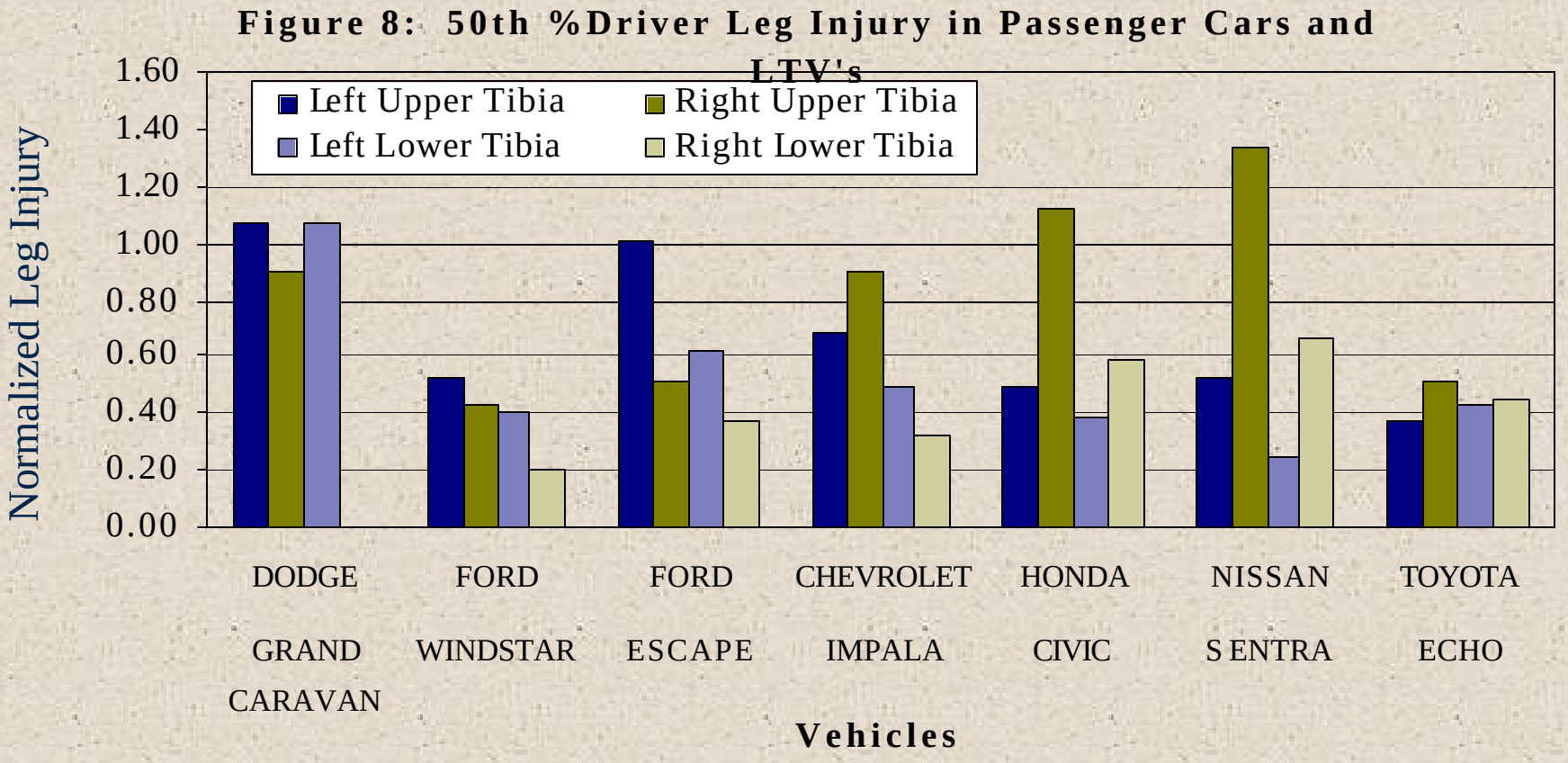
Test Results – Tibia Index

- 5th percentile driver dummy - all but 3 vehicles exceeded one of the four indices for the tibia
- 50th percentile driver dummy - only 4 vehicles exceeded one of these indices
- 5th percentile passenger dummy - all but 2 vehicles exceeded one of the four indices for the tibia
- 50th percentile passenger dummy - only 3 vehicles exceeded one of the tibia indices.

Tibia Index Injury Cont….



Tibia Index Injury Cont….



The Need For Different Stature Dummies

- It appears that most vehicles would achieve dummy injury values below the IARV for HIC, chest acceleration, Nij, neck tension, neck compression, and the lower extremities.
- However, several vehicles tested either exceeded the IARV for the 5th percentile dummy or were marginal for one or more of the injury criteria.

Discussion - The Need For Different Stature Dummies

- In some instances, vehicles exceeded injury criteria for the 5th percentile dummy, but did not exceed injury criteria for the 50th percentile dummy. Analysis showed that this is due to:
  - Vehicle structure
  - Occupant restraint systems (seat belt load limiters, pretensioners, and air bags)
- The restraint system and the vehicle structure work together to protect the occupant.

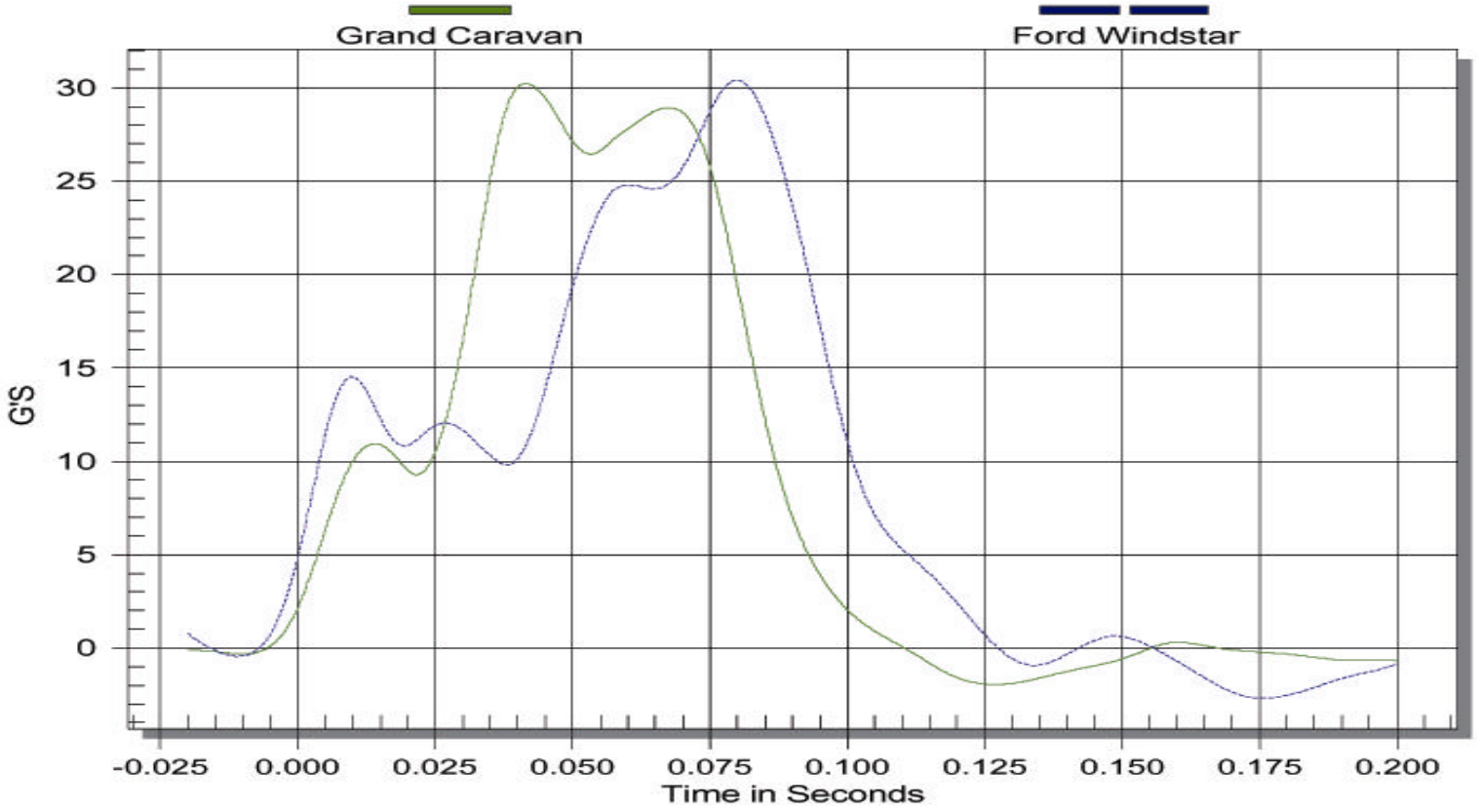
Discussion Cont….

- Grand Caravan and Ford Windstar illustrate the effect that restraint systems and vehicle structure have on dummy performance.
- Both vehicles:
  - Used identical seating procedures
  - Had almost identical chest-to-steering wheel distances (228 mm for Windstar, and 224 mm for Grand Caravan)
  - Similar weights and are minivans in the same weight class
- The Windstar was one of the better performers across all injury values. The Grand Caravan exceeded two IARVs.

Discussion – Vehicle Structure

- Vehicle pulses were analyzed
- 3 factors associated with crash management:
  - Dynamic crush
  - Maximum acceleration of the occupant compartment
  - Time period of the acceleration pulse
- Vehicle pulses for both vehicles show:
  - The Grand Caravan and the Windstar have roughly the same peak G
  - The Windstar peaks later in time than the Grand Caravan

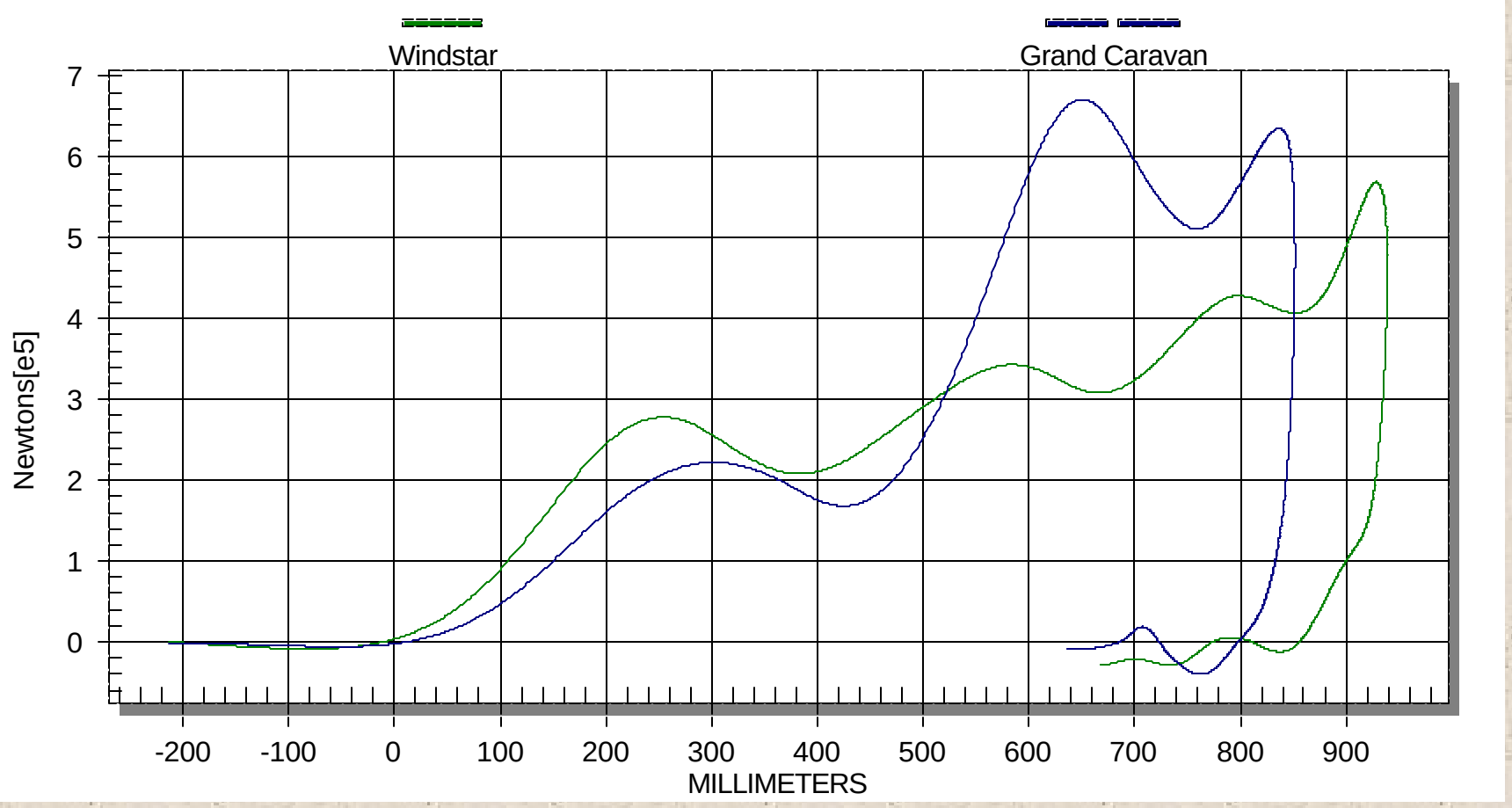
Discussion Cont….



Discussion Cont….

- Plotting the force that the vehicle is applying to the load cell wall versus the amount the vehicle crushes shows:
  - Fo nitially sti
  - Af uch mc
  - At 450 mm, the Grand Caravan becomes very stiff.

Discussion Cont….



Discussion Cont….

- Bumper to firewall distance:
  - Windstar – 1201 mm
  - Grand Caravan – 725 mm
- Overall lengths of the 2 vehicles are almost the same. (Windstar is 170 mm longer.)
- So, for about the same mass and overall length of vehicle, the Windstar has more bumper to firewall distance to absorb the crash energy than does the Grand Caravan. Then, less force is transmitted to the occupant, reducing the chance for injury.

Discussion – Restraint Systems

- Head resultant curves were overlaid for the Grand Caravan and the Windstar.
  - Both vehicles peak at approximately the same time, but the e
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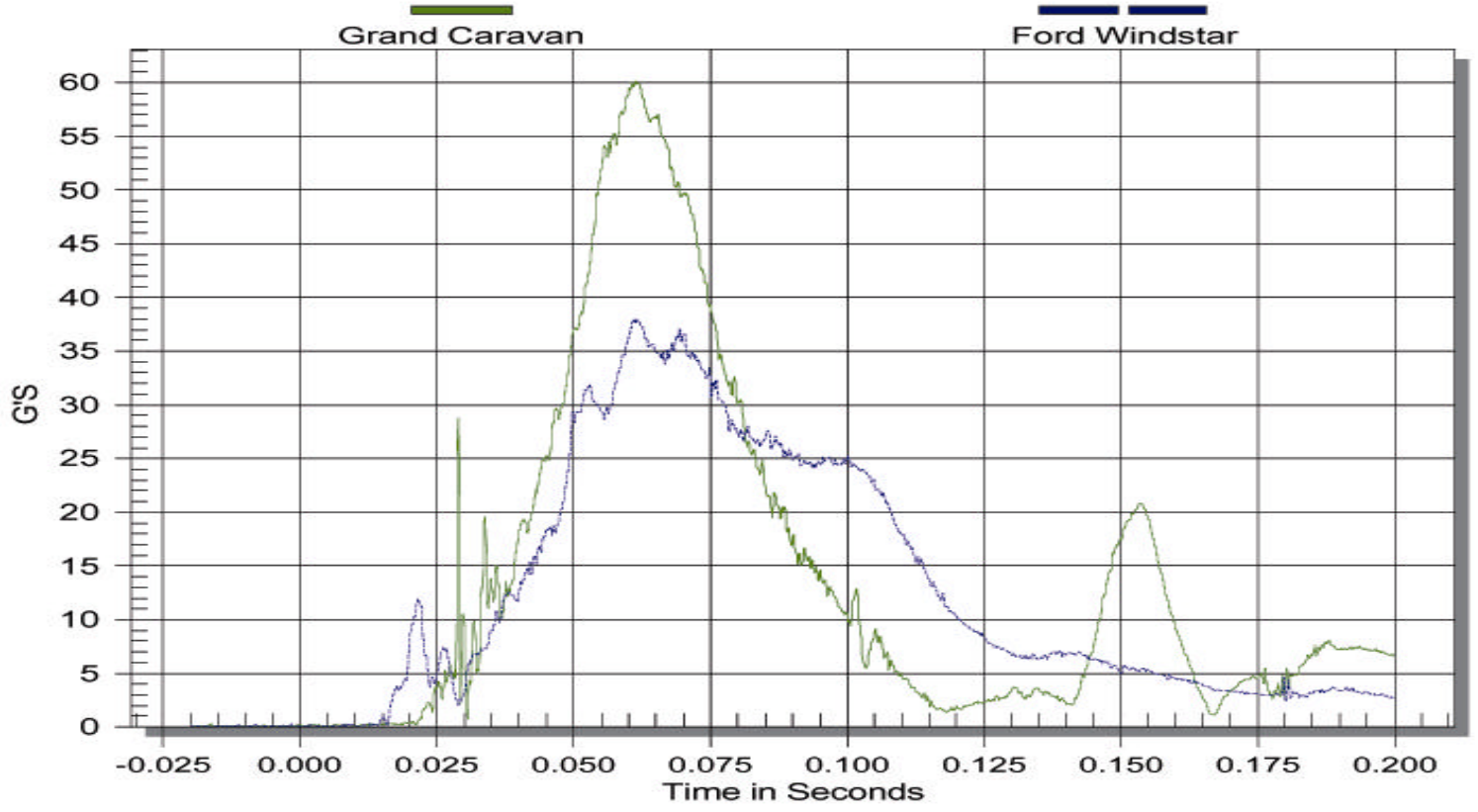
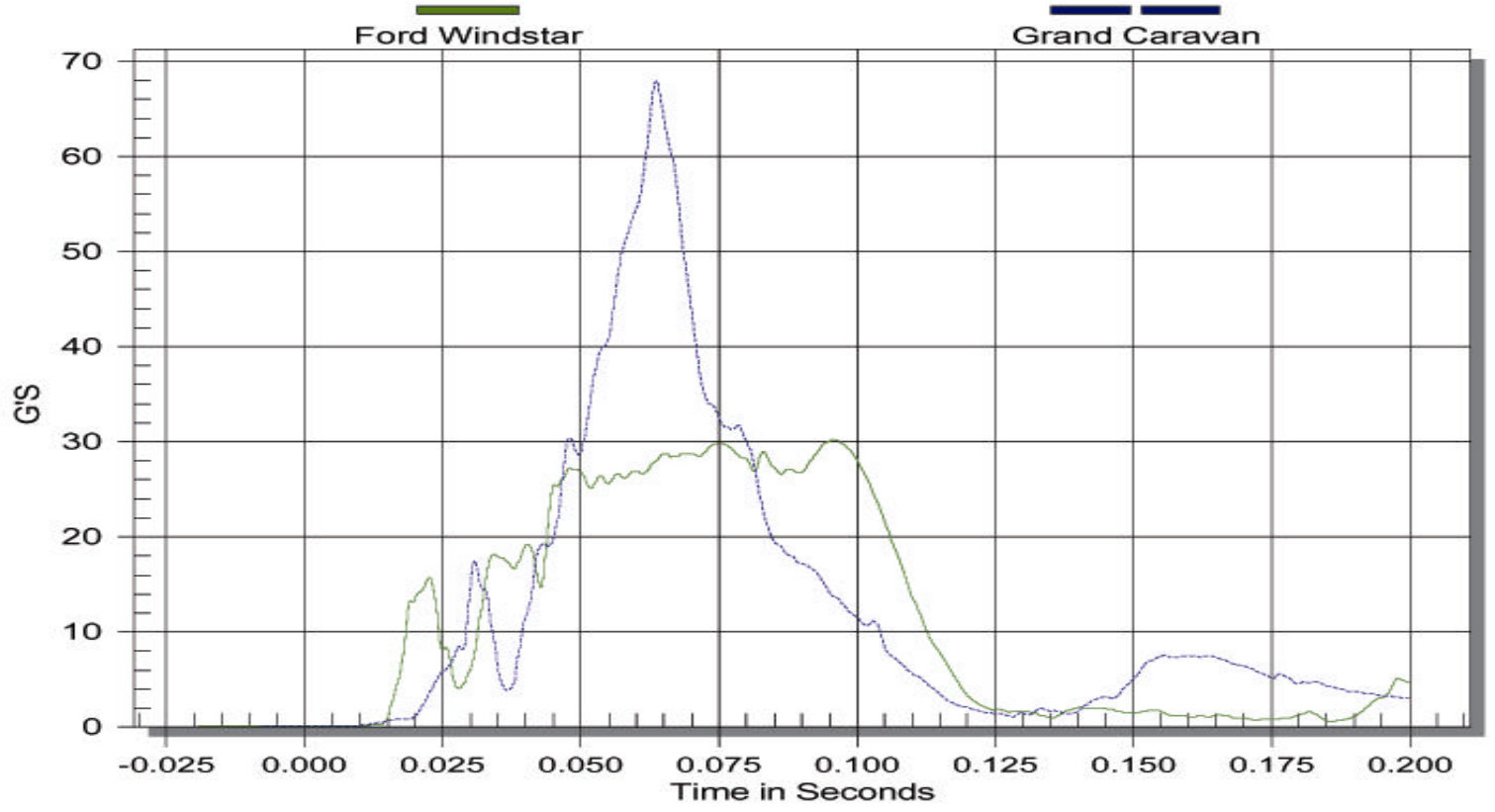
Discussion Cont….



Discussion Cont….

- Chest resultant curves were overlaid for the Grand Caravan and the Ford Windstar.
  - The he peak G f
  - The ntrated spil ver 50 ms.

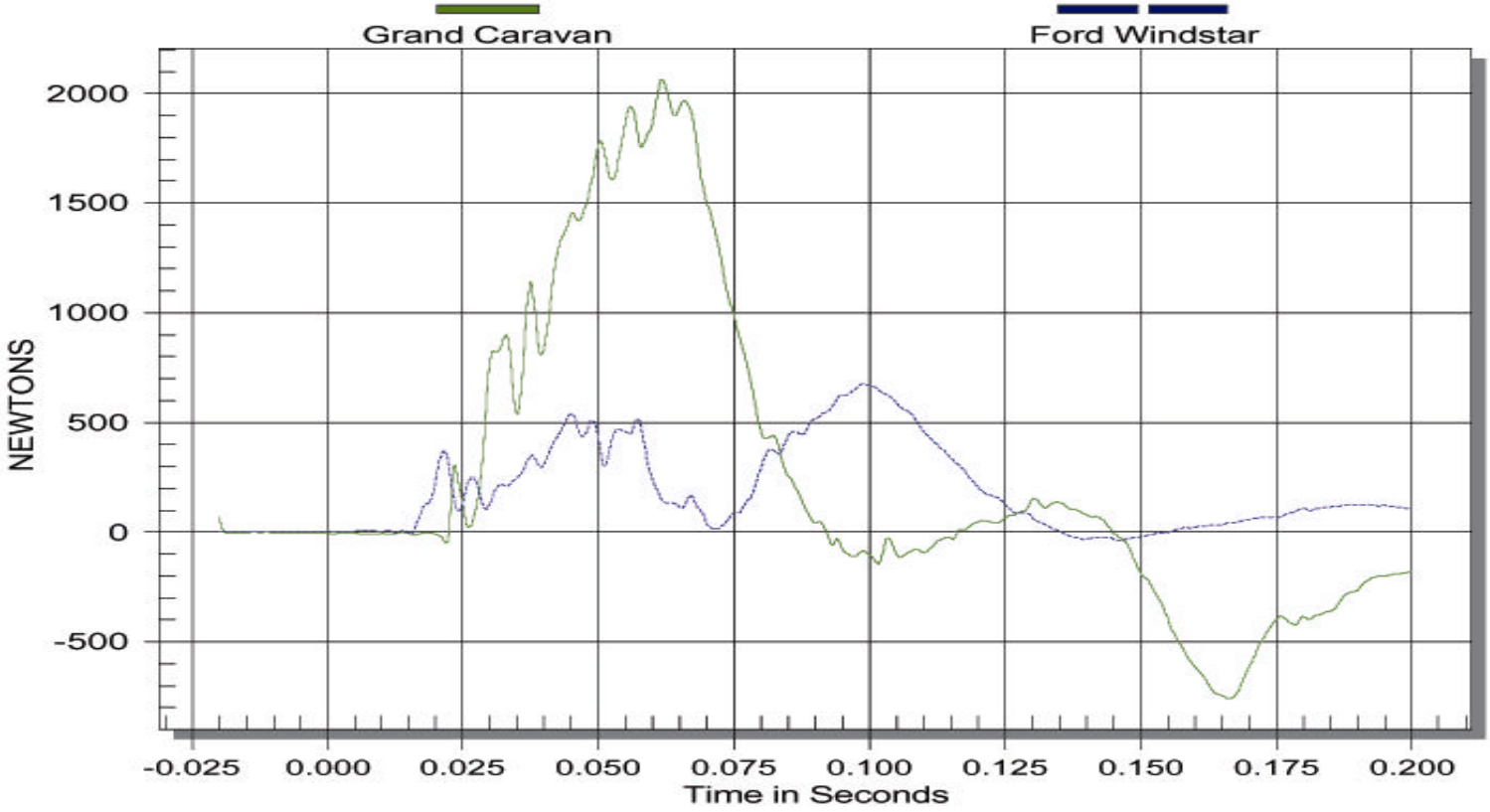
Discussion Cont….



Discussion Cont….

- Curves showing neck force in the z-direction were overlaid for the Grand Caravan and the Ford Windstar.
  - Driver in the Windstar had a max peak of 735 N, whereas the driver in the Grand Caravan had a max peak neck force of 2,172 N.
  - Air bag is the major contributor to performance
- Need different stature dummies to ensure that equal protection is provided to all occupants.

Discussion Cont….



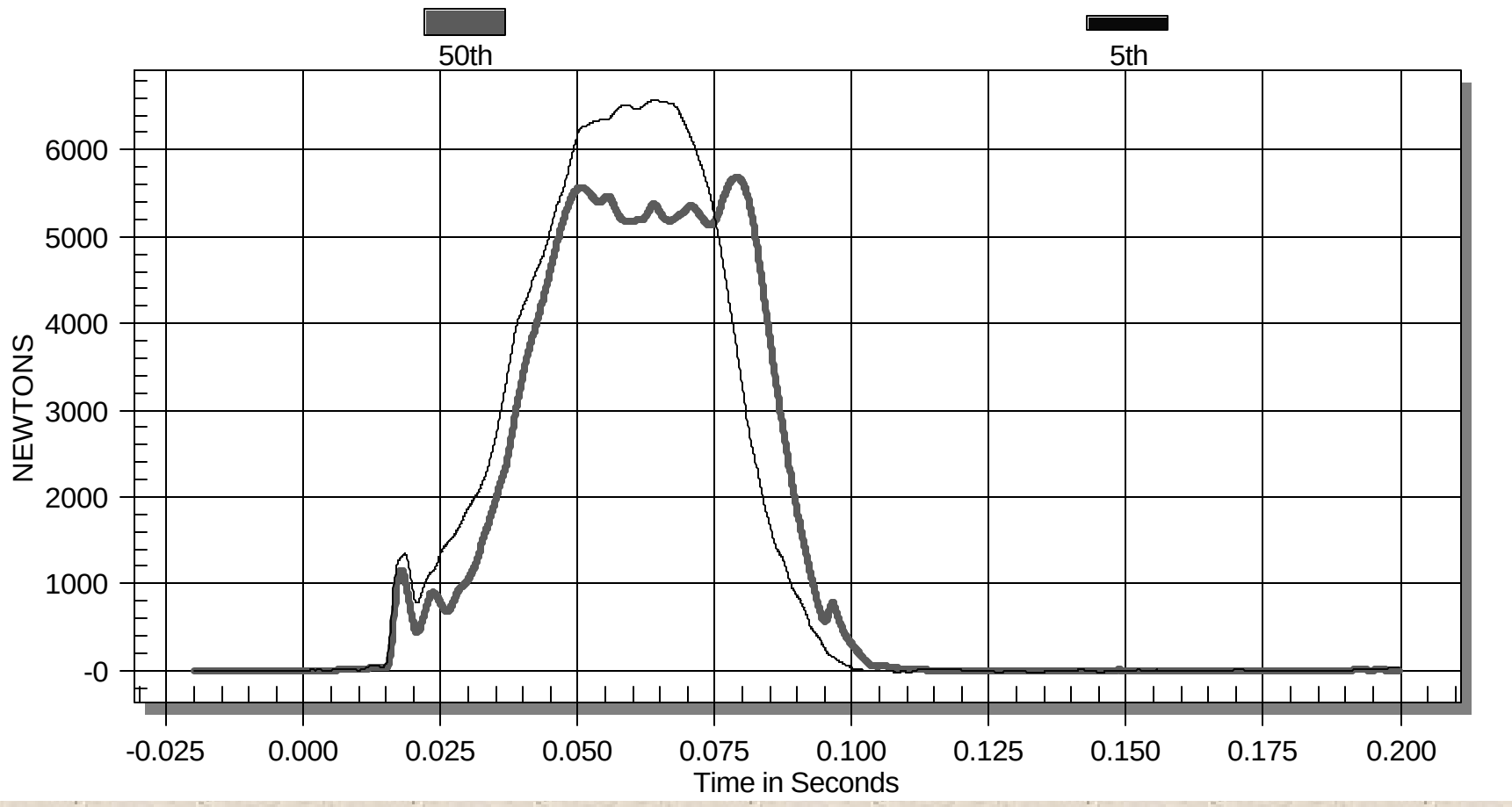
Discussion Cont….

- Driver shoulder belt load data for the Toyota Echo and Nissan Sentra (for both the 5th and 50th percentile dummies) was analyzed to see the effect pretensioners and load limiting seat belts had on occupant performance.

Discussion Cont….

- Toyota Echo – Data traces show:
  - Pretensioners activated for both the 5th percentile and 50th percentile dummies
  - 5th percentile peak belt load force was higher than that of the 50th by 1,000 N, indicating a very stiff belt. – resulting in restricted translation and higher forces for the occupant.
- 5th percentile dummy had higher values of HIC and resultant chest acceleration than did the 50th
  - Likely that the load limiter may not have worked as effectively for the 5th as for the 50th

Discussion Cont….



Discussion Cont….

- Nissan Sentra – Data traces show:
  - Pretensioners for both the 5th and 50th dummies act
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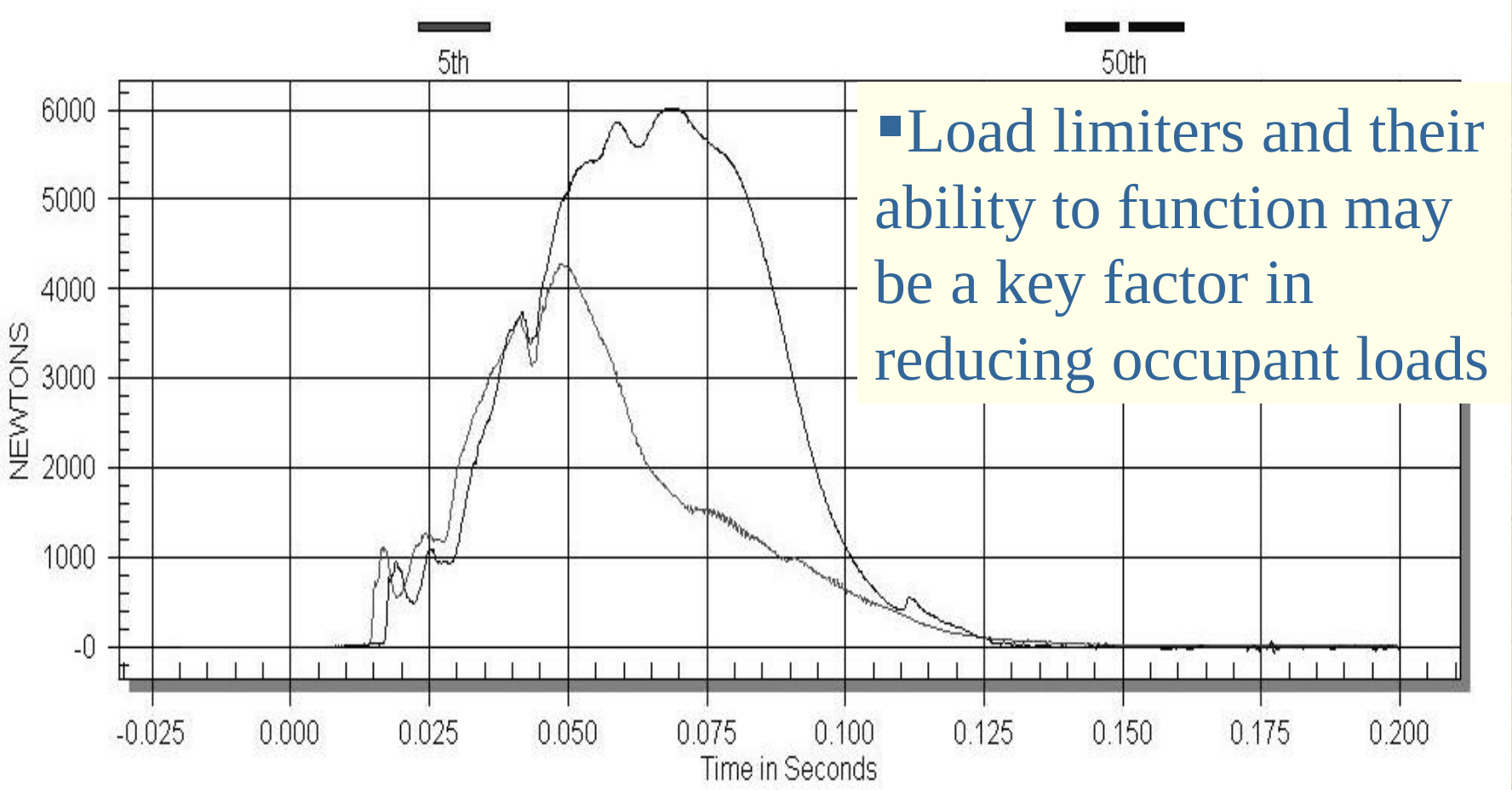
  - 5tl chest acceleration than the 50th

Discussion Cont….



- Load limiters and their ability to function may be a key factor in reducing occupant loads

Conclusion

- 2001 – NHTSA conducted 10 belted 56 KMPH (35 MPH) frontal vehicle crash tests using the 5th percentile dummy.
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  - 5th an the 50 x and lov
  - Ne equal protection for all occupants