

AN NCAP STAR RATING SYSTEM FOR OLDER OCCUPANTS

Kennerly Digges

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Significant Changes to NCAP in 2011

- **5th Female Dummy** seated full-forward as the Right Front Passenger
- Applied injury risk functions that shifted the emphasis from AIS 4+ injury risk to **AIS 3+** injury risk for the **head, neck and chest**
- Added **AIS 2+** injury risk for the **knee-thigh-hip (KTH)** complex
- Created and applied a **combined injury risk (CPI)** metric to calculate overall injury risk to the above-mentioned four body regions
- **CPI = $1 - (1 - P_{\text{head}})(1 - P_{\text{neck}})(1 - P_{\text{chest}})(1 - P_{\text{kth}})$**
 - Where P_n = Probability of Injury to the n^{th} body region of a 35 year old male

Research Questions

- Do the risk functions prioritize the body regions so as to **optimize the restraint systems for older individuals?**
- Are the risk functions used for each body region representative of the **injury tolerance of older occupants?**
- How would NCAP star ratings change if risk functions for older occupants were applied?

Approach to NCAP for Older Occupants

Laboratory Crash Data (NCAP)

1988 – 2006 Tests (n =306)

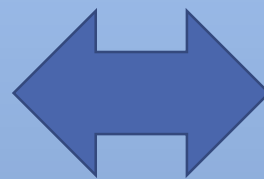


On-road Crash Data (NASS)

1988-2008 NASS Years (n=20,000 Raw)
(6,000,000 Weighted)



Injury risks measured by
NCAP Crash Dummies



Injury risks observed in
similar vehicles on-the-road

CORRELATION

Approach to NCAP for Older Occupants



Laboratory Crash Data (NCAP)

1988 – 2006 Tests (n =306)

- 306 NCAP Vehicles Tested
- Belted Front Dummies
- Frontal Crash –
 - Single Direction
 - Single Speed
- Dummy Injury Measurements
 - Injury Risk for Young
 - Age Appropriate Risk Functions



On-road Crash Data (NASS)

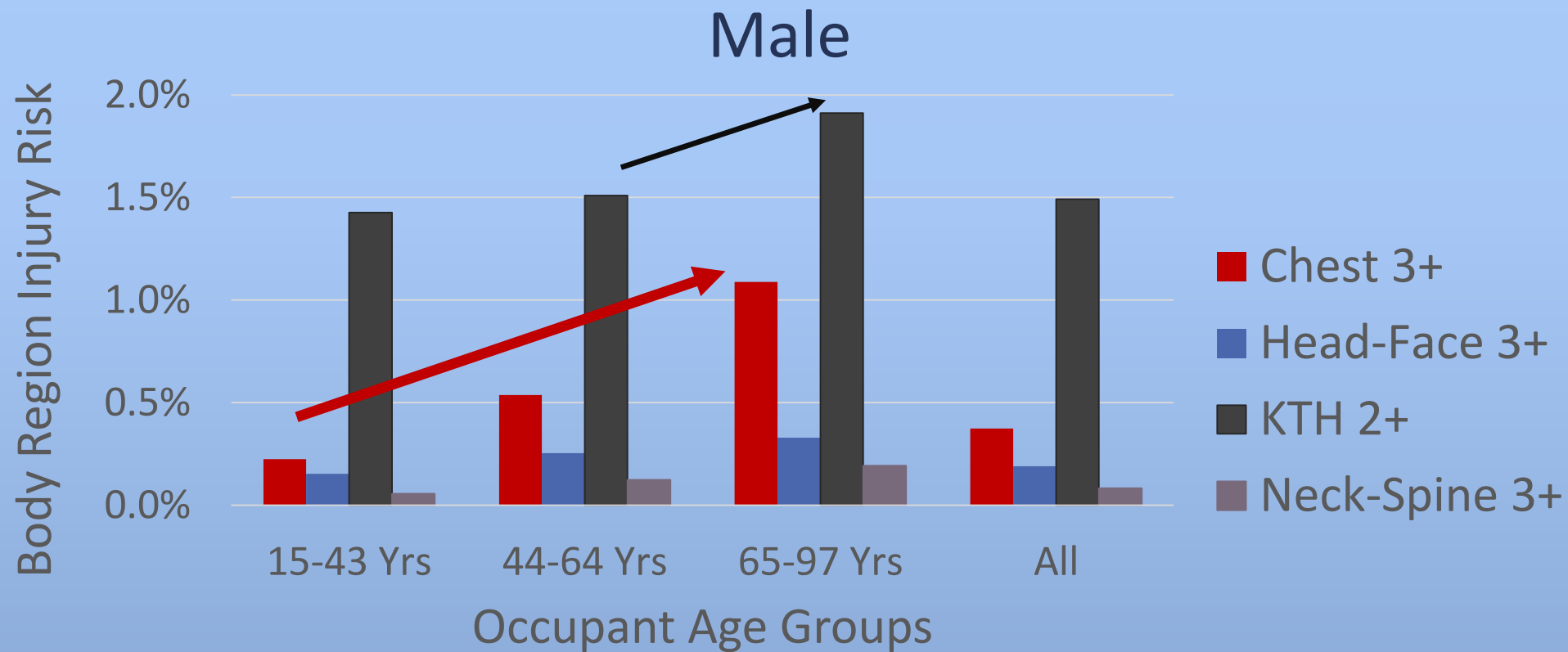
1988-2008 NASS Years (n=20,000 raw)

- Crash Exposed NCAP-like Vehicles
- Belted Front Occupants
- Frontal Crash –
 - NCAP-like Crashes
 - NCAP Severity Range
- Occupant Injuries
 - Injury Risks for all Ages
 - Can be Separated by Age Group

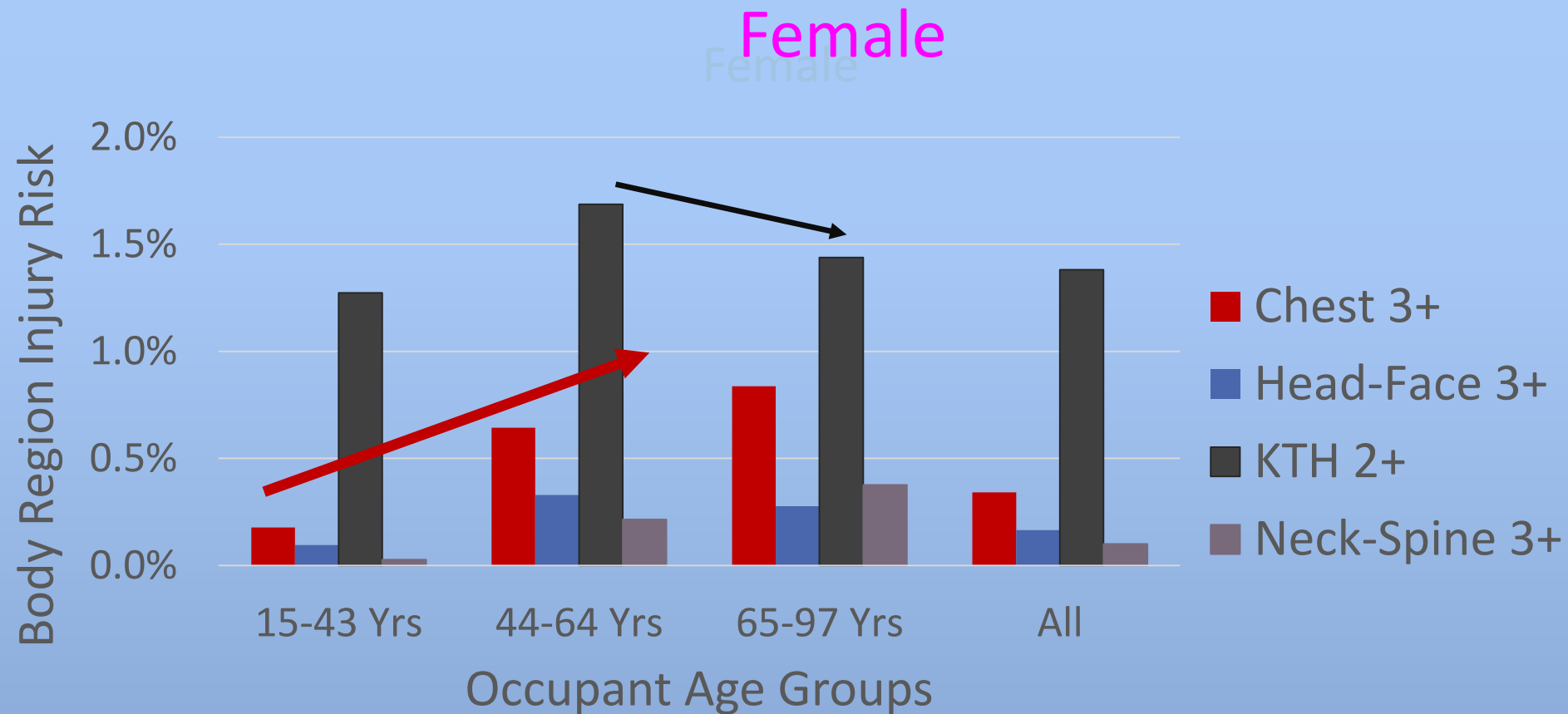


CORRELATION

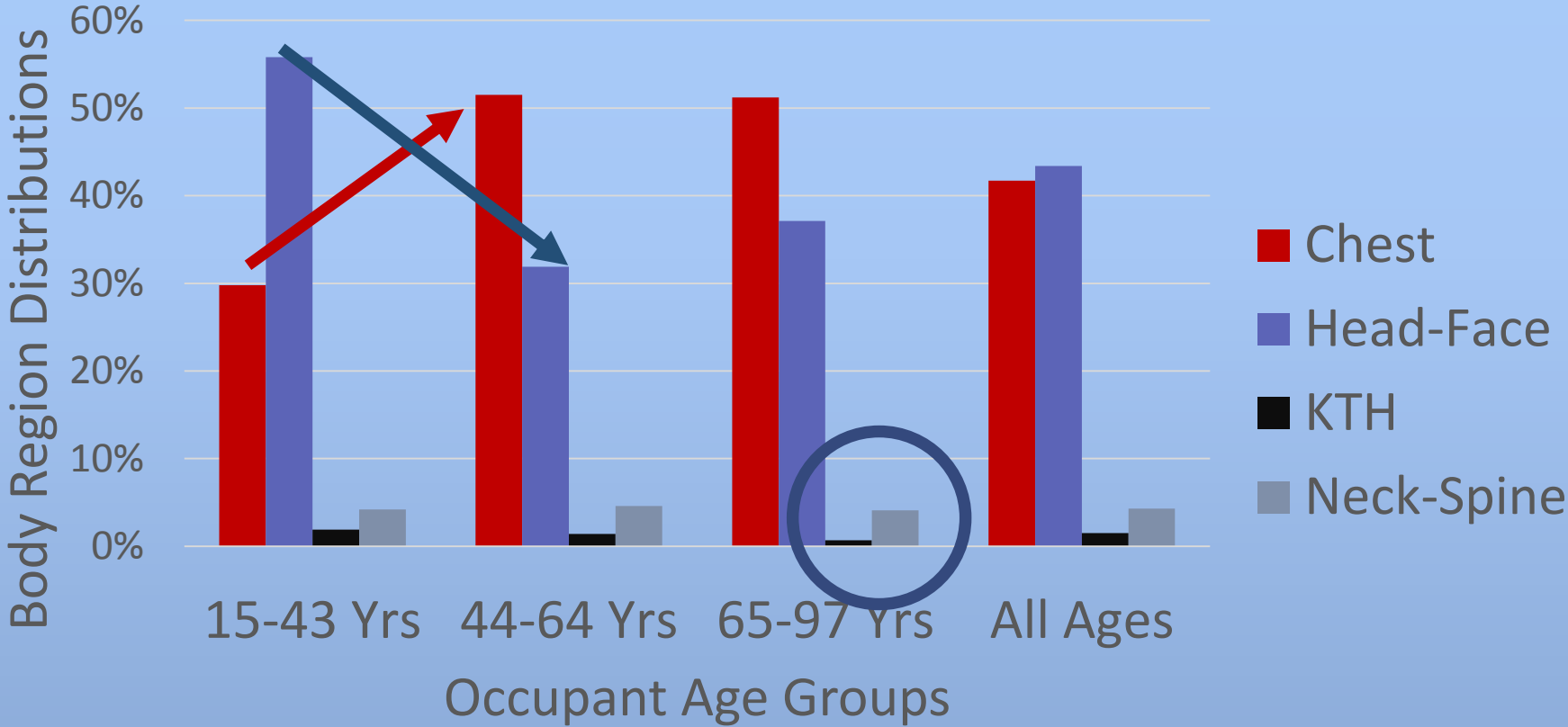
NASS Male Injury Risks – NCAP Like Crashes



NASS Female Injury Risks – NCAP Like Crashes



Distribution of AIS 4+ Injuries by Age Groups



Belted Front Seat Occupants in Frontal NCAP Like Crashes

Observations – NASS Elderly Injury Priority by Body Region

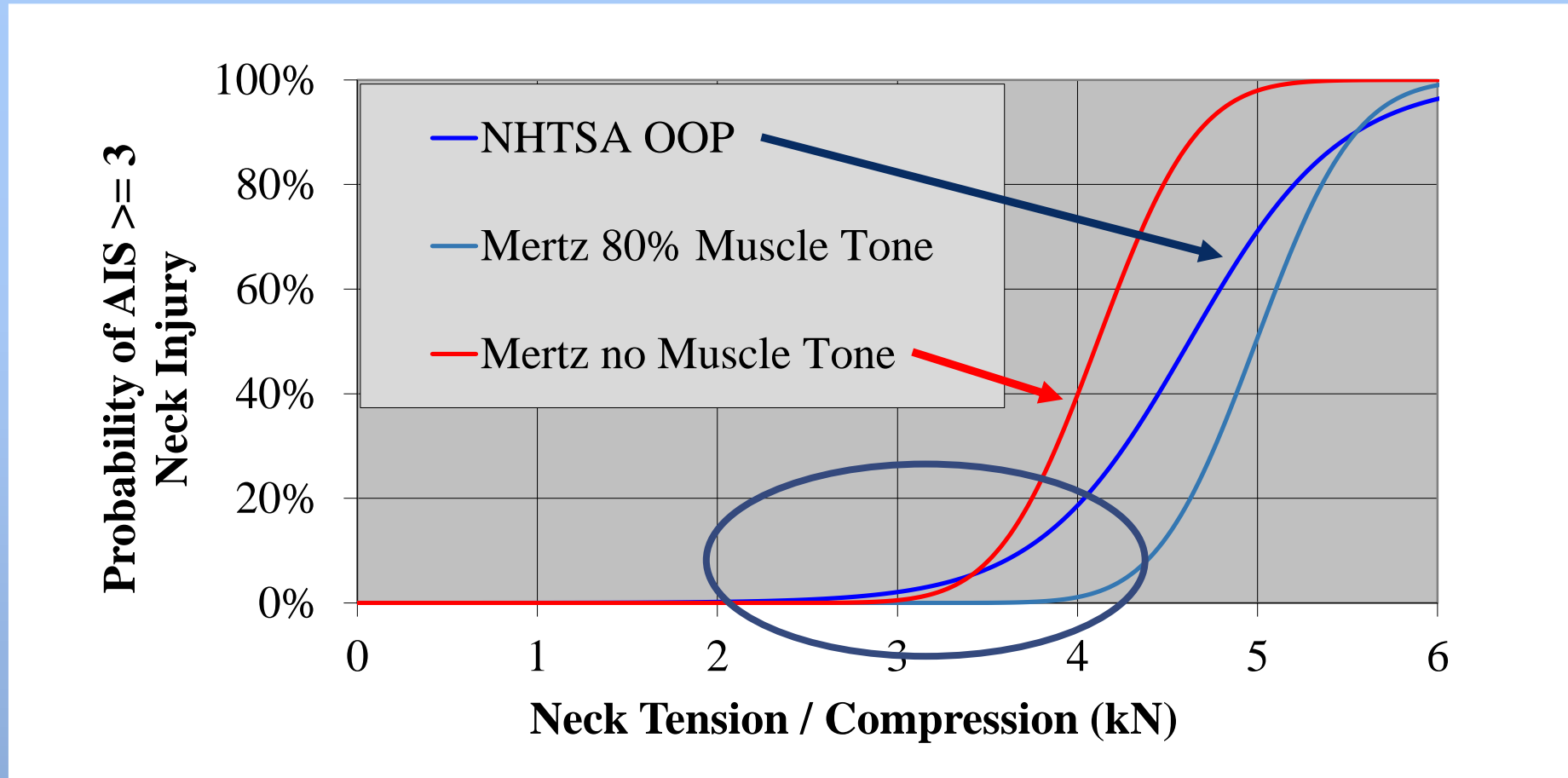
- ***Chest injury*** dominates ***AIS 3+ and 4+ Injuries*** for 65+ occupants
- ***Chest injury*** dominates ***AIS 4+ Injuries*** for occupants over 44 years old
- ***Neck/Spine*** and ***Head/Face AIS 3+ Injury*** risks for 65+ males are less than ***30%*** of the ***Chest Injury Risks***
- ***Neck/Spine*** and ***Head/Face AIS 3+ Injury*** risks for 65+ females are less than ***50%*** of the ***Chest Injury*** Risks
- ELDERLY NCAP RATINGS SHOULD PRIORITIZE REDUCTIONS IN CHEST INJURY
- IN OPTIMIZING FOR NCAP, THE BODY REGION WITH THE HIGHEST RISK RECEIVES PRIORITY

Body Regions with Highest Injury Risk – 2011 NCAP (64 tests)

Body Region	Driver	RF Passenger
	2011 NCAP	2011 NCAP
Head	0	0
Neck	60	64
Chest	3	0
KTH	1	0
All	64	64

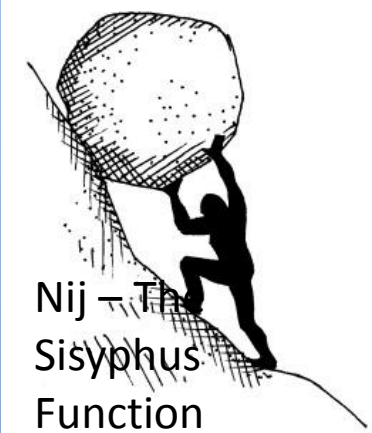
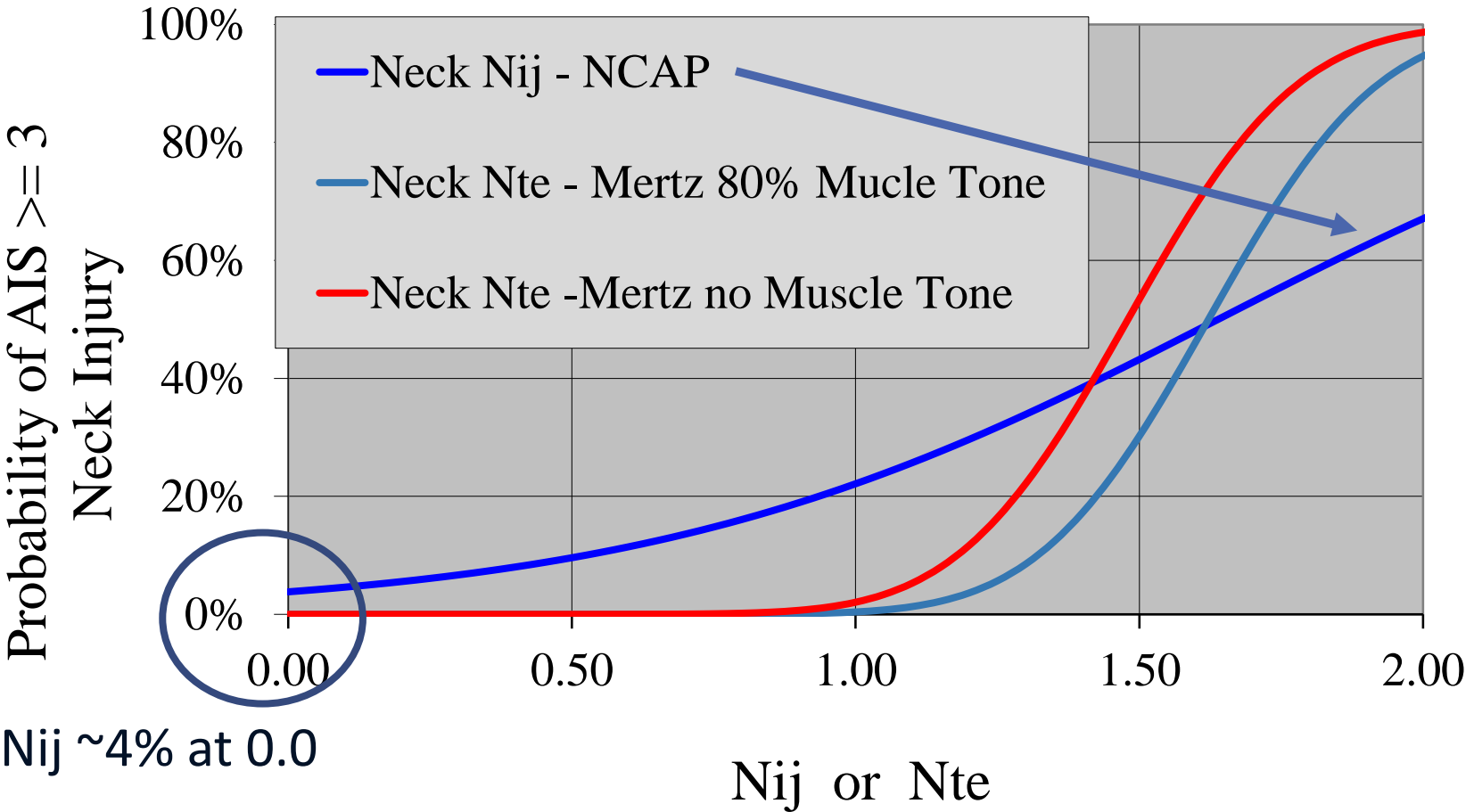
AIS 3+ Neck Injury Risk is the highest CPI Factor in 2011 NCAP
Suggests a need to modify the Chest and Neck Injury Risk Functions

FMVSS 208 OOP vs. Mertz Muscle Tone Neck Injury Risk Functions

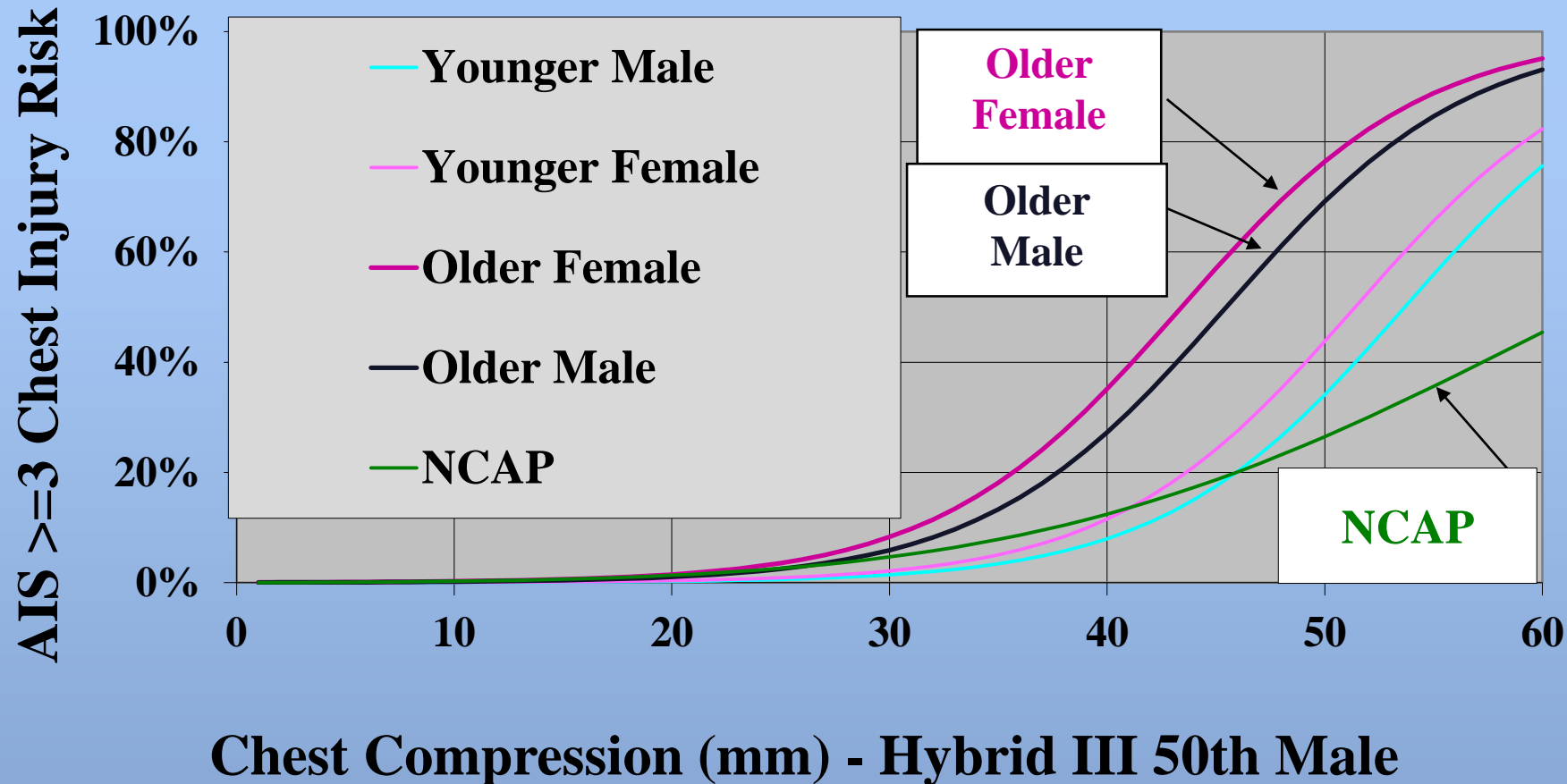


Mertz no-muscle Tone Function generally similar to NHTSA OOP at low Tension/Compression

NCAP 2011 Nij vs. Mertz Nte Muscle Tone Neck Injury Risk Functions – Replace Nij with Nte



NCAP 2011 vs. Prasad Age Related Chest Injury Risk Functions – Replace NCAP with Older Male and Female



NASS Injury Risk by Body Region and NCAP Crash Severity Ranges

	Injury Risk Field Data (NASS)		
Crash Severity	49-64 km/h	56-71 km/h	Mid-point
Body Region	Lower Bound	Upper Bound	Mid-Bound
Neck-Spine 3+	0.7%	0.7%	0.7%
Head-Face 3+	2.4%	4.0%	3.2%
Chest 3+	7.7%	13.6%	10.6%
KTH 2+	11.3%	16.7%	14.0%
NCAP (Any)	16.7%	25.1%	20.9%

NASS vs. NCAP (Applying 2011 NCAP and Alternative Elderly Risk Functions)

Body Region	1988-2008 NASS Data
	NASS Mid-Bound
Neck-Spine 3+	0.70%
Head-Face 3+	3.2%
Chest 3+	10.6%
KTH 2+	14.0%
NCAP (Any)	20.9%

NASS vs. NCAP (Applying 2011 NCAP and Alternative Elderly Risk Functions)

Body Region	1988-2008 NASS Data	1988-2006 NCAP Data	
	NASS Mid-Bound	2011 NCAP Risk Functions	
Neck-Spine 3+	0.70%	7.90%	
Head-Face 3+	3.2%	2.3%	
Chest 3+	10.6%	6.8%	
KTH 2+	14.0%	4.9%	
NCAP (Any)	20.9%	20.1%	

NASS vs. NCAP (Applying 2011 NCAP and Alternative Elderly Risk Functions)

Body Region	1988-2008 NASS Data	1988-2006 NCAP Data	
	NASS Mid-Bound	2011 NCAP Risk Functions	Alternative Elderly Risk Functions
Neck-Spine 3+	0.70%	7.90%	0.55%
Head-Face 3+	3.2%	2.3%	2.3%
Chest 3+	10.6%	6.8%	12.5%
KTH 2+	14.0%	4.9%	4.9%
NCAP (Any)	20.9%	20.1%	20.2%

Body Regions with Highest Injury Risk – 2011 NCAP vs. Older Occupant Risk Functions

Body Region	Driver		RF Passenger	
	2011 NCAP	Older Male	2011 NCAP	Older Female
Head	0	2	0	8
Neck	60	0	64	0
Chest	3	40	0	27
KTH	1	22	0	29
All	64	64	64	64

NCAP vs. Older Occupants Star Rating – Driver

DRIVER STARS	OLD MALE_50M					
NCAP 2011	1	2	3	4	5	Total
1						
2			Increased Stars			
3	1	6				7
4		7	5	5	2	19
5	Decreased Stars			8	15	23
Total	1	13	5	13	17	49

NCAP vs. Older Occupants Star Rating – RF Passenger

PASS. STARS	OLD FEMALE_5F					
	1	2	3	4	5	Total
1			Increased Stars			
2	5	3	2			10
3		1	3	4		8
4		2	7	10	7	26
5	Decreased Stars				5	5
Total	5	6	12	14	12	49

Conclusions

- **Chest** Injuries *predominate* the AIS 3+ and AIS 4+ for the 65+ occupants
- **AIS 3+ Head** Injury Risks remain relatively *constant* for the 45+ occupants
- For Age 65+, **AIS 2+ KTH** Injury Risks *increase* for males but *decrease* for females
- For Age 65+, **AIS 3+ Neck** Injury Risks are *50% higher* for females than for males; The male **AIS 3+ Neck** Injury Risk was *20% of the Chest* Injury Risk
- For Age 65+, **AIS 4+ Neck** Injuries comprise *less than 5%* of the AIS 4+ Injuries
- An Elderly Occupant rating should *increase* the priority of the **Chest**

Conclusions – Applying Alternative Injury Functions

- When applied to the 2011 NCAP tests there was a general downward shift in the star ratings awarded to the driver.
- For both drivers and passengers there were vehicles that advanced from 4 stars to 5 stars.
- The number of passengers with 5 star ratings more than doubled.
- The proposed rating system for older occupants would provide safety recommendations that differ from the NHTSA NCAP ratings.
- The application of this alternative rating system would produce added incentives for safety designs that more correctly prioritize the reduction of the injuries most harmful to older (45+) occupants.

Limitations

- 5th Female Dummy seated full-forward in right front passenger position may not encourage optimum protection for the exposed population.
- Lack of control of the shoulder belt positioning on the dummy may provide misleading and inconsistent chest injury measurements.
- The NCAP crash severity may not induce safety systems that function equally well at the lower speeds that are more likely to cause injuries to elderly occupants.

Thank You for your attention!

Questions?