Questions/Discussions with respect to Japan’s Proposal at the last informal GTR7 meeting in Munich on July 17, 2015

WebEx GTR No. 7 Group of Experts
Whiplash Injury Criteria Meeting

August 27, 2015

Question/Discussion Specifics:

1) Review of the main issues from the last IF GTR7 meeting
2) Which dummy (BioRID-II & HY-III) is a better tool for measurement of the neck injury risk for the GTR7
3) Status and statistical significance of the injury criteria proposed by Japan
4) Relationship between the Backset and the JNCAP scores
5) Discussion of the safety benefits (Effectiveness of ENCAP/JNCAP/IIHS adaption in the market)
6) Additional Discussion on the BioRID-II dummy maintenance conditions

Appendices

a. Relationship between the injury values and the backset under the JNACP
b. Comparison between 17.6 km/h and 20 km/h with respect to the test results on under the JNACP

1) Review of main issues from the last IF GTR7 meeting

1) Review of main issues at the last GTR7 meeting

Japan Proposal
Injury Evaluation Parameters and Injury Criteria for GTR7

Injury Criteria		WAD2+ 82.9% Value (IV-NIC=1.1)
NIC Max		23
Upper Neck	FX (Backward)	640
	MY(Flx/Ext)	34
Lower Neck	FX (Backward)	640
	MY(Flx/Ext)	34

Units:
Force (N)
Moment (Nm)

Time Schedule	Meeting	Main Items for Discussion
August 27, 2015: Web meetings	TEG	1) Injury Criteria 2) Safety Benefits (Effectiveness on the risk of neck injuries : ENCAP/JNCAP/IIHS)
September 7 & 8, 2015 (London)	IF GTR7	1) Injury Criteria (9/7) 2) MR 3) Draft documents of GTR7 4) Revision of R17
October 7 & 8, 2015 (BAS't)	IF GTR7	Refinement of draft documents for GRSP
December 2015	GRSP	Initial (Informal) Proposal Documents
January 2016	IF GTR7	Confirmation of Formal Documents
May 16, 2016	GRSP	Formal Proposal Documents
June 17, 2016	WP29	Formal Proposal Documents for Legal Check etc.
November 16, 2016	WP29	Adoption of Documents

2) Which dummy (BioRID-II & HY-III) is a better tool for the measurement of the neck injury risk for the GTR7

＜Comparison of BioRID-II & HY-III as a better tool for injury risk measurements＞

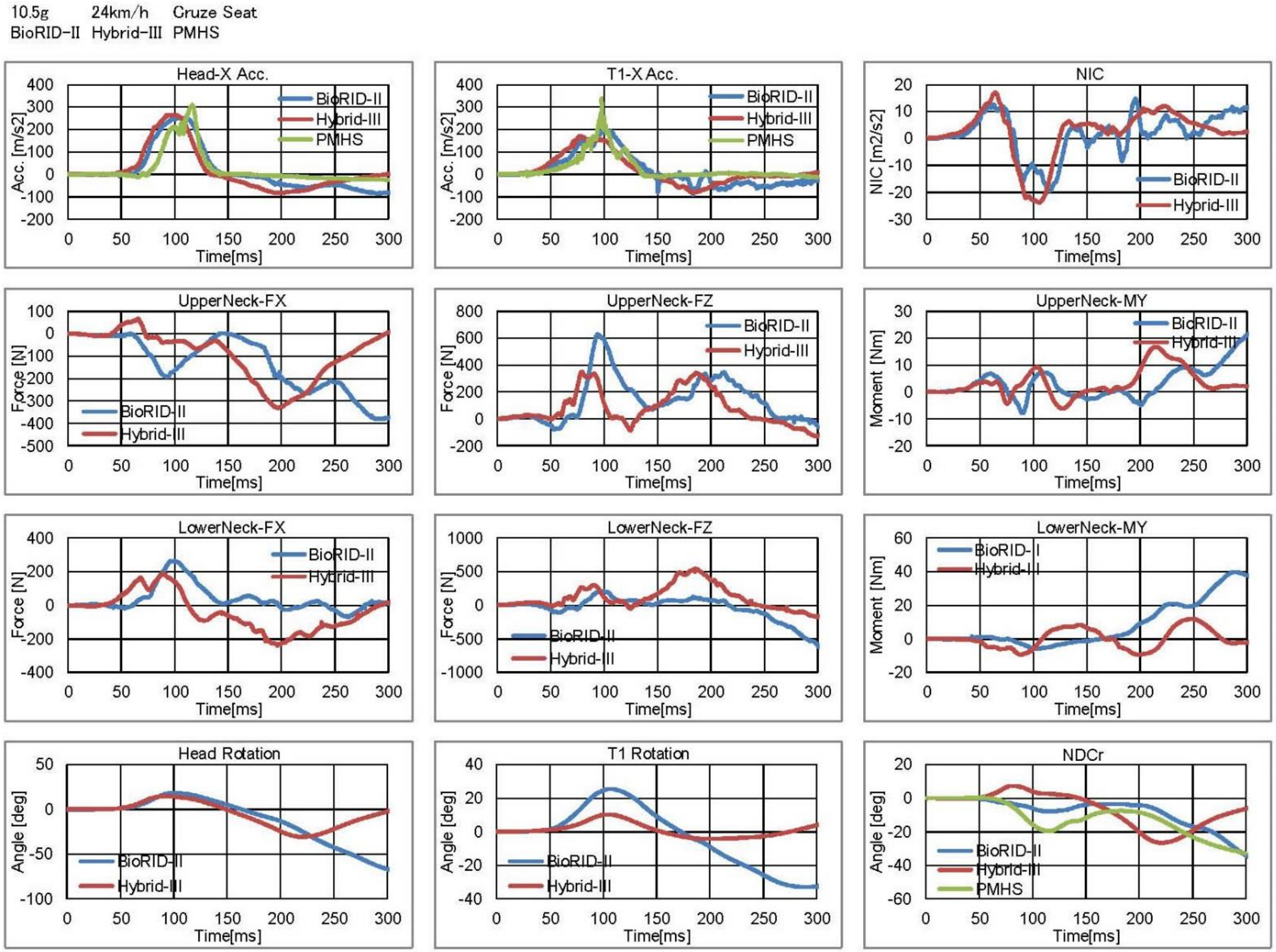
Sled Test Matrix at NHTSA (VRTC)

BioRID-II and HY-III were used on the same test series

Test Date	141211	141215	141216	141217	141217
Test Condition	24km/h	24km/h	202a	JNCAP	JNCAP
Test Seat	Cruze	Camry	Cruze	Cruze	Camry

- Comparison of time-histories of the dummy under same test condition
- Comparison of individual responses (peak values) for the dummies

<Comparison of BioRID-II & HY-III>



- The patterns of the time-histories and the peak values on the BioRID-II and the HY-III were different.
- The flexion motion of the head/neck on the BioRID-II is smaller than that of the PMHS.
- The flexion motion of the HY-III is completely inversed, and it is impossible to reproduce the flexion motion of the PMHS.

<Comparison of BioRID-II & HY-III>

HY-III response values related to BioRID-II [%] : [HY-III]/[BioRID-II]*100

	24km/h				202a		JNCAP			
	Cruze		Camry		Cruze		Cruze		Camry	
	Hybrid-III		Hybrid-III		Hybrid-III		Hybrid-III		Hybrid-III	
NIC	134		147		113		114		133	
UNFX	5633		194		6581		845887		507	
UNFZ	56		93		67		87		134	
UNMY-F	125		140		210		172		212	
UNMY-E	79	762	6	170	2	829	81	94126	1198369	133363
LNFX	70	(153)	136	(118)	69	(109)	89	(156)	177	(156)
LNFZ	145		201		295		268		461	
LNMY-F	454		589		51		224		234	
LNMY-E	164		23		68		213		44	
	() without UNFX		() without LNMY(Flx)		() without UNFX		() without UNFX		() without UNFX, UNMY-E,LNFZ	

- NIC, UNMY-F, and LNFZ of the HY-III are bigger than that of BioRID.
- UNFZ, UNMY, LNFX, and LNMY of the BioRID are bigger than that of the HY-III.
- The evaluation results for the seat characteristics will be changed by the dummies.
- The related angle motions of the head and the T1 between the HY-III and the BioRID are completely inversed.

←The biofidelity of the BioRID is quite higher than that of the HY-III. The head/neck motion in the flexion of the HY-III is also not reproduced.

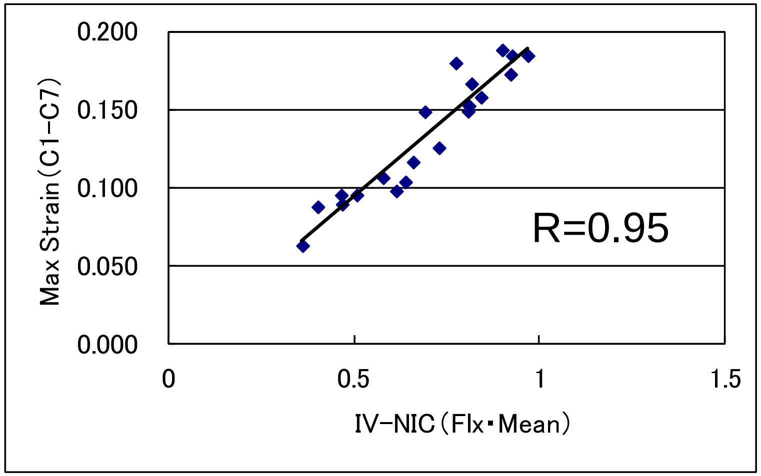
3) Status and statistical significance of the injury criteria proposed by Japan

◆ 20 accident cases for FE Simulation

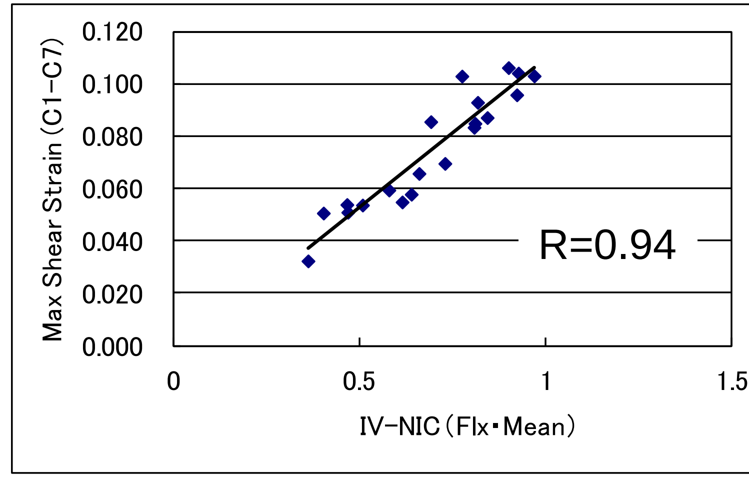
CASE		RECORDED CRASH PULSE			REPORTED INJURY			PASSENGER CHARACTERISTICS			
No.	D/P	⊿v [km/h]	Mean Acc.[g]	Peak Acc.[g]	Neck/Spine	Symptoms	WAD	Gender	Age	Height	Weight
1	Driver	28.2	5.8	10.6	Injured	1-6 m	2	F	26	175	55
4	Driver	26.0	5.6	12.6	Injured	>6 m	3	M	57	178	100
4	Passenger	26.0	5.6	12.6	Injured	>6 m	3	F	57	168	80
2	Driver	23.3	6.7	14.7	Injured	>6 m	2	F	59	156	60
8	Driver	20.4	5.2	12.8	Injured	<1 m	1	F	22	171	63
8	Passenger	20.4	5.2	12.8	Injured	<1 m	2	M	18	179	80
7	Driver	19.5	4.0	9.2	No injuries	no	0	M	67	167	84
7	Passenger	19.5	4.0	9.2	Injured	<1 m	1	F	72	165	63
10	Driver	17.6	5.0	12.4	Injured	1-6 m	1	M	74	175	62
10	Passenger	17.6	5.0	12.4	Injured	1-6 m	2	F	74	160	57
6	Driver	16.3	4.9	12.1	No injuries	no	0	F	59	165	65
6	Passenger	16.3	4.9	12.1	Injured	<1 m	1	M	88	170	70
11	Driver	16.3	6.5	15.2	No injuries	no	0	M	61	176	77
11	Passenger	16.3	6.5	15.2	No injuries	no	0	F	61	154	69
21	Driver	14.3	4.5	10.6	No injuries	no	0	M	50	171	85
23	Driver	11.1	3.7	8.9	Injured	<1 m	1	F	35	178	65
20	Driver	10.8	3.7	7.1	Injured	<1 m	1	M	65	176	82
20	Passenger	10.8	3.7	7.1	No injuries	no	0	M	68	176	77
24	Driver	8.8	3.5	7.5	Injured	1-6 m	1	F	35	165	55
3	Driver	14.7	5.2	7.5	Injured	>6 m	2	M	35	165	55

◆ Correlation between Strain (Rate) and IV-NIC(R) at the Flexion

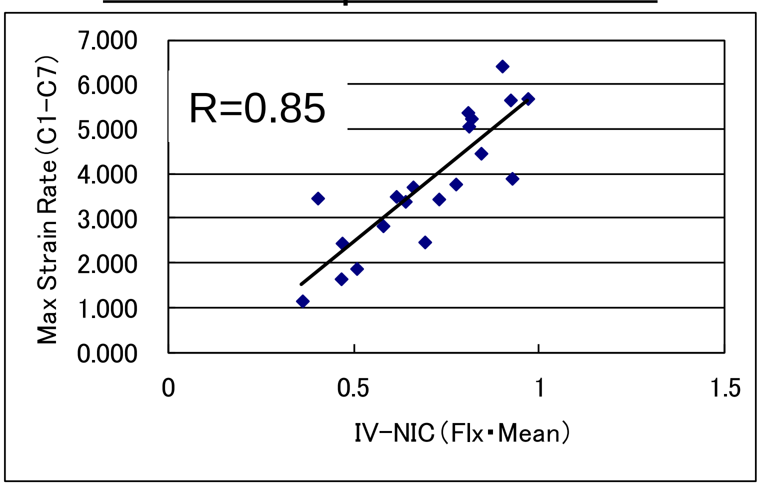
Max. Principal Strain



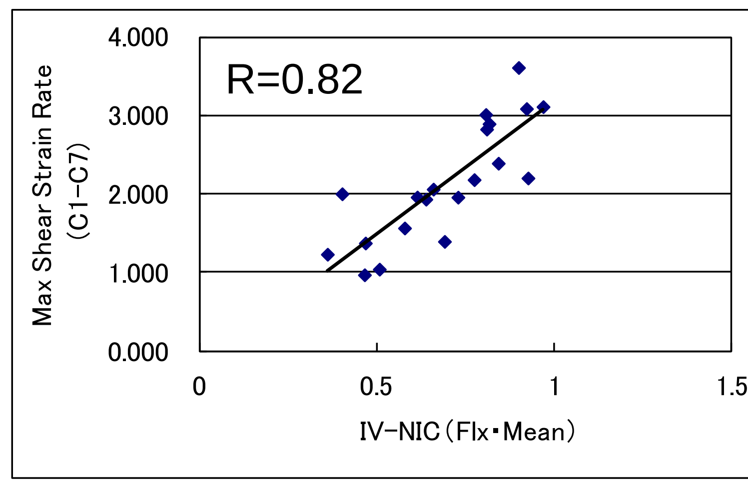
Max. Shear Strain



Max. Principal Strain Rate



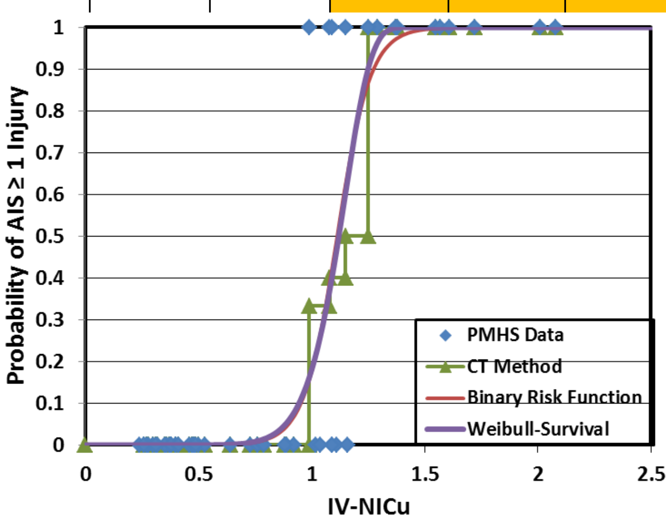
Max. Shear Strain Rate



As for the correlation coefficient at the Flexion, the strain is around 0.9, strain rate is 0.8, and has correlation.

◆ Risk Curve of IV-NIC(R) in NHTSA

	IV-NIC (Rotation)											
	PMHS03		PMHS04		PMHS05		PMHS06		PMHS07		PMHS08	
	Low	Moderate	Low	Moderate	Low	Moderate	Low	Moderate	Low	Moderate	Low	Moderate
C2/C3	-0.85	-0.79	-1.06**	-0.87	-1.84	-1.52	-0.40	-0.49	-0.90	-0.99	-0.34	-0.45
	+0.26	+0.67	+0.17	+0.26	0.46	0.86	0.23	+0.41	+0.21	+0.30	+0.04	+0.19
C3/C4	-1.18	-1.07	-0.27	-0.41	-1.59	-1.54	-0.09	-0.07	-0.87	-1.00	-0.68	-0.90
	+0.48	+1.05	+1.02**	+0.51	+0.05	+0.18	+0.54	+0.94	+0.15	+0.10	+0.19	+0.28
C4/C5	-1.47	-1.87	-1.17	-1.40	-1.37	-1.16	-0.13	-0.19	-1.48	-1.44	-0.54	-0.79
	+0.01	+0.01	+0.00	+0.00	+0.00	+0.05	+0.39	+0.62	+0.05	+0.09	+0.05	+0.10
C5/C6	-0.56	-0.40	-0.96	-1.00	-1.08	-1.19	-0.09	-0.09	-0.85	-0.91	-0.69	-0.69
	+0.27	+0.30	+0.00	+0.01	+0.01	+0.00	+0.36	+1.00	+0.00	0.00	+0.00	+0.50
C6/C7	-0.33	-0.54	-1.15	-1.33	-0.84	-1.20	-0.16	-0.16	-0.72	-0.73	-0.79	-1.05
	+0.05	+0.68	+0.00	+0.00	+0.44	+0.20	+0.05	+0.47	+0.06	+1.69	+0.00	+0.35



- ➢ Risk Curve was created with the data in this table.
- ➢ The highest value of either Flexion and Extension were selected as IV-NIC(R), and the Risk Curve of AIS1+ and IV-NIC(R) was created.

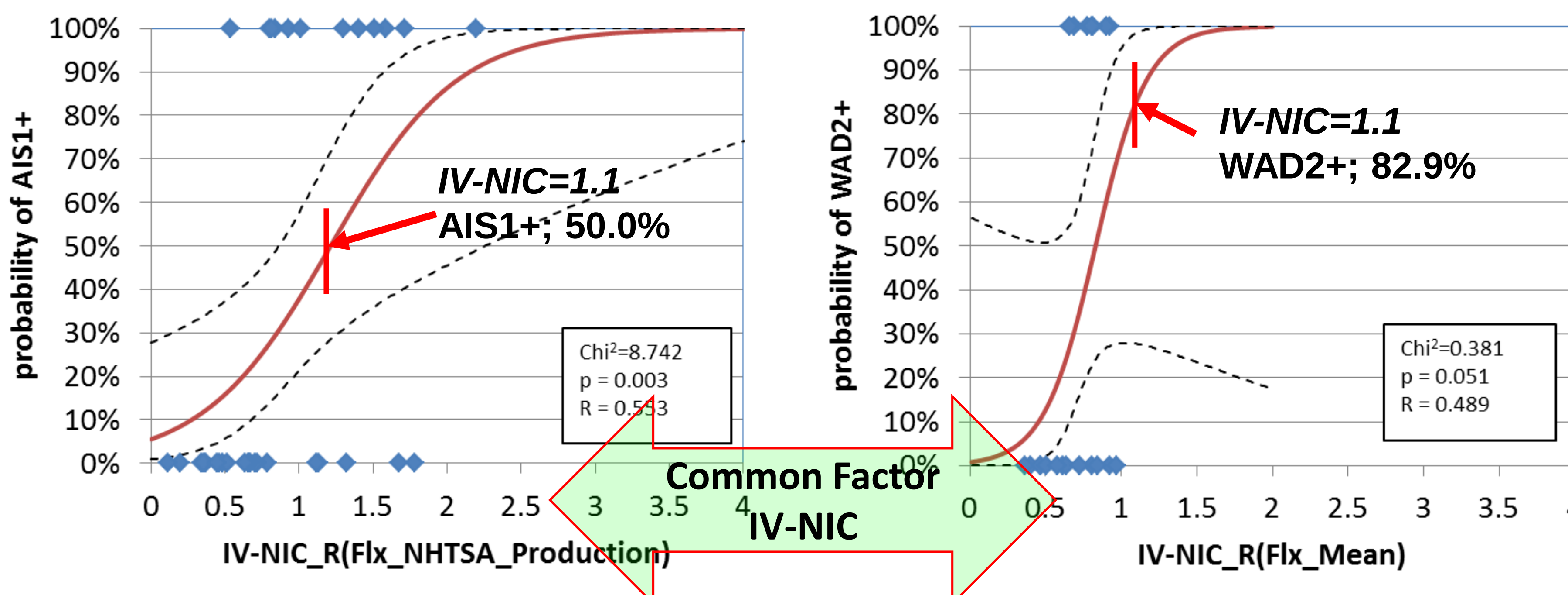
Difference of the Risk Curve in Japan and NHTSA

1) WAD（Japan） and AIS（NHTSA）

2) Selection of IV-NIC values of either Flexion and Extension

◆ Setting Methods of Neck Injury Criteria

- Fig. 1 shows that IV-NIC value corresponding to the AIS1+ 50% on the risk curve obtained by the PMHS Tests (Production seat)
- The IV-NIC value 1.1 corresponds to the AIS1+50% on the risk curve obtained by the PMHS tests shown in Fig.1. This IV-NIC value 1.1 also corresponds to 82.9% of WAD2+ risk curve wrt the IV-NIC.
- The IC of NFM, NIC, and NDCr will be created by WAD2+82.9% based on the risk curve of WAD2+ wrt IV-NIC (see Table on the next E) page).



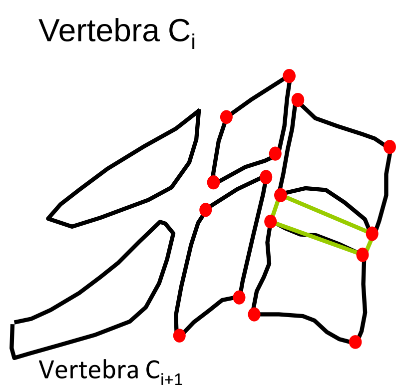
<u>Fig. 1 Injury Risk Curve (AIS1+; PMHS: Production Seat)</u>

<u>Fig. 2 Injury Risk Curve (WAD2+; CAE: Accident Reconstruction)</u>

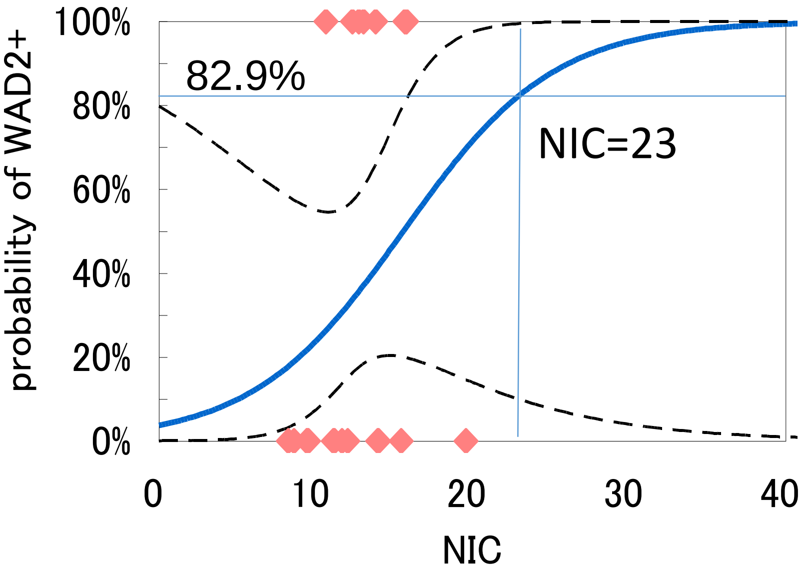
◆ Correlation between neck force/moment and IV-NIC (R) based on Accident Reconstruction Simulation and Human Volunteer Test

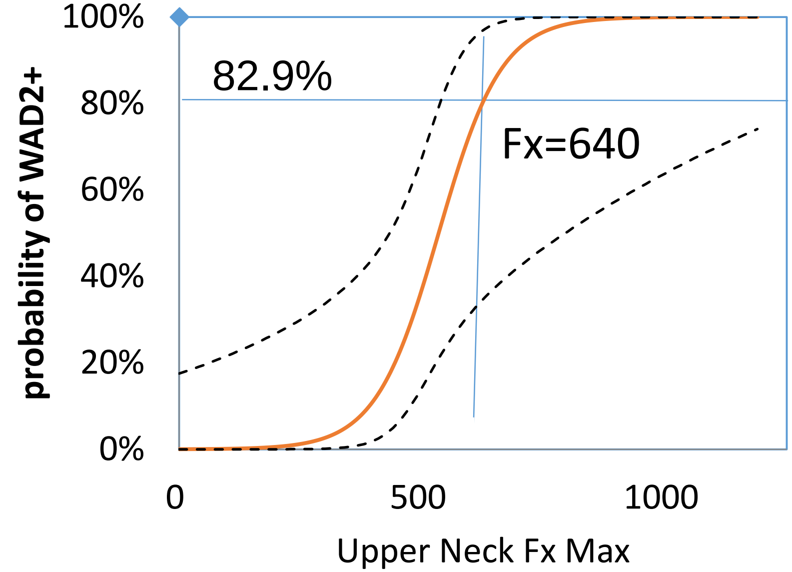
	Overall	IV-NIC Flexion Mean	Simulation		Volunteer	
			Strain	Shear Strain	Strain	Shear Strain
NIC	○	△	△	△	○	○
UNFX-HeadRear	○	× (*)	× (*)	× (*)	○	○
UNMY-Fle./Ext.	○	△	○	○	×	△
LNFX-HeadRear	○	△	○	○	○	○
LNMY-Fle./Ext.	○	△	○	○	×	△

Overall : Judgment from result of volunteer test and simulation
Symbol（Column of yellow and pink）:
○: Positive correlation and correlation coefficient of 0.5 or more
△: Positive correlation and less than correlation coefficient of 0.5
×: Low (~0.2) correlation
(*): Due to the different sizes of occupants



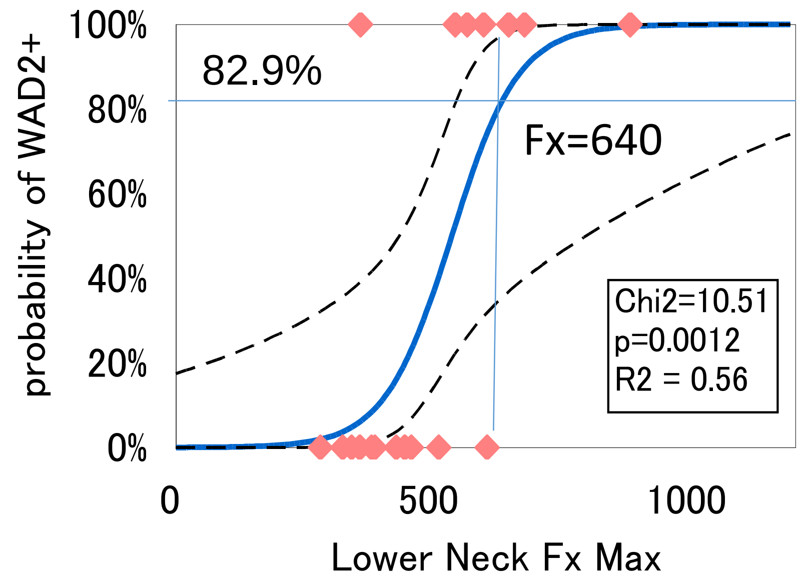
Max. Principal Strain and Max. Shear Strain



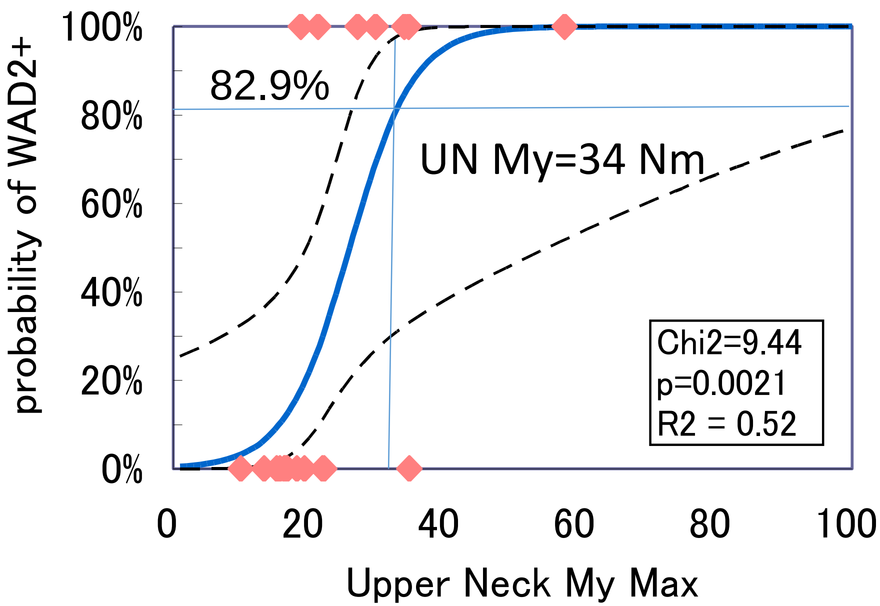


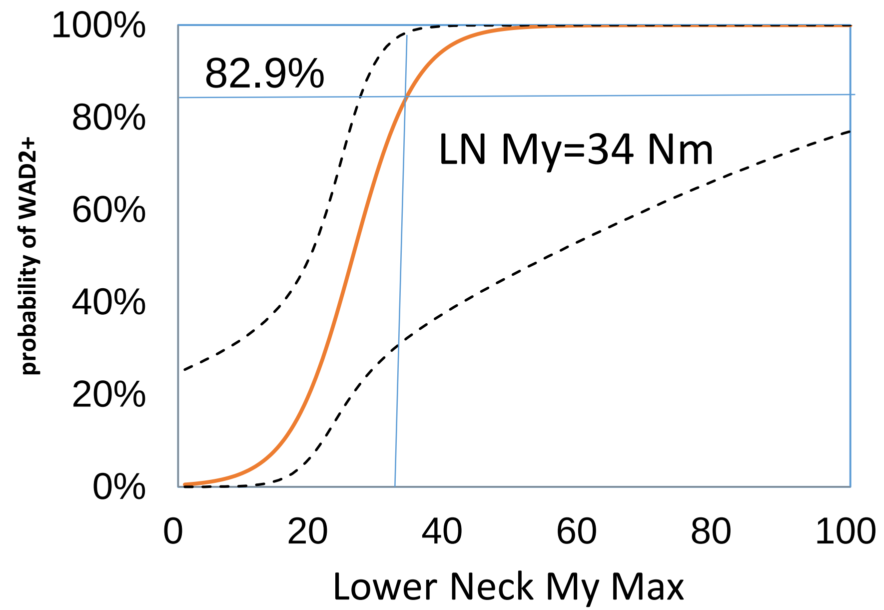
NDCr＝？？

Alternative
Neck Moment (MY)



Japanese Recommendation
Injury Parameters and Injury Criteria





Alternative Injury Criteria for NDCr

Neck Moment (MY)

Japanese Recommendation
Injury Parameters and Injury Criteria

Conclusion

Japan Proposal
Injury Evaluation Parameters and Injury Criteria for GTR7

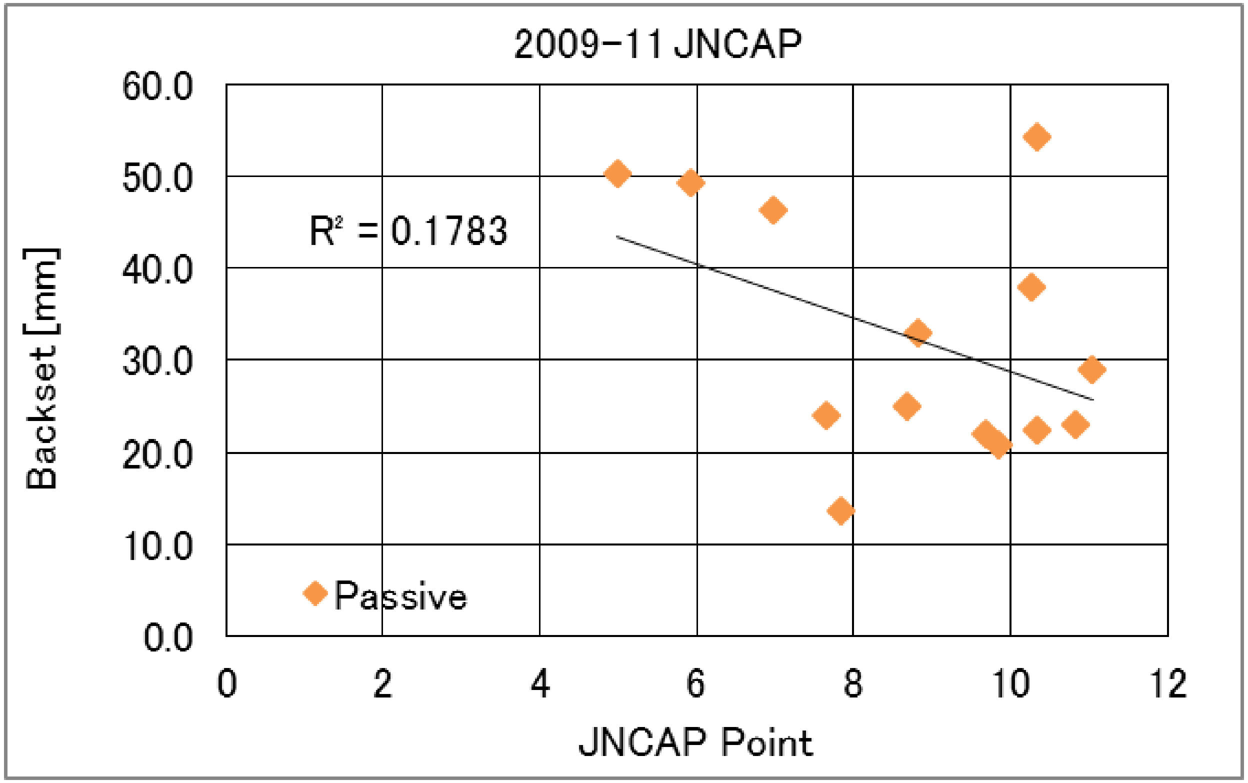
Injury Criteria		AIS1+: 50% Value <Equivalence> WAD2+: 82.9% Value
		IV-NIC=1.1
NIC Max		23
Upper Neck	FX (Backward)	640
	MY(Flx/Ext)	34
Lower Neck	FX (Backward)	640
	MY(Flx/Ext)	34

Units: Force (N)
Moment (Nm)

4) Relationship between the Backset and the JNCAP scores

<Backset and JNCAP scores>

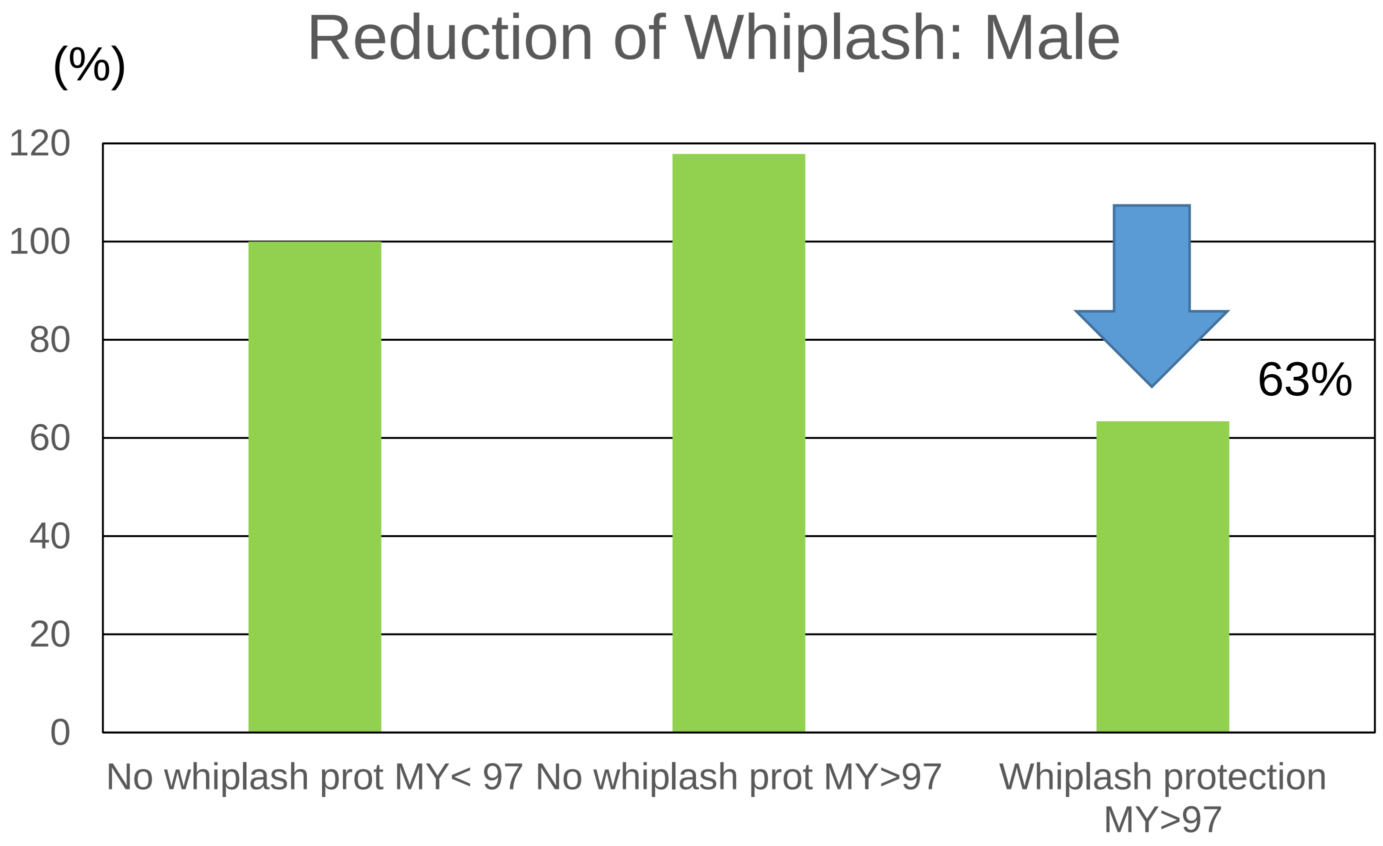
Based on the results of the JNCAP tests (2009~2011), the relationship between the Backset and the JNCAP scores are shown in the figure below.



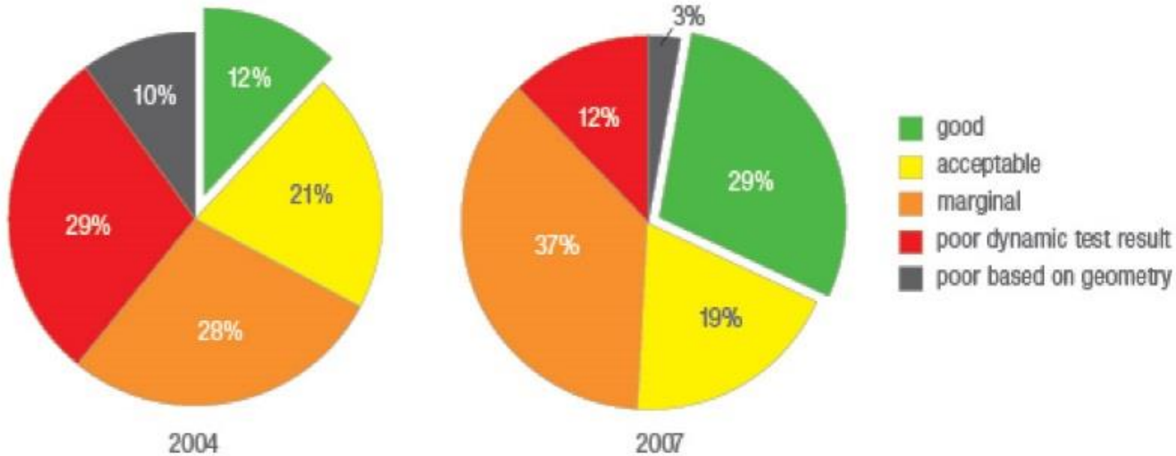
- ➢ The JNCAP scores, even if the seat with the same backset are shown in the variety, (the correlation coefficient is under 0.2).
- ➢ It is definitely said that the evaluation of the seat characteristics is difficult using only the seat-backset.

<u>Please find more detailed information in the appendices at the end</u>.

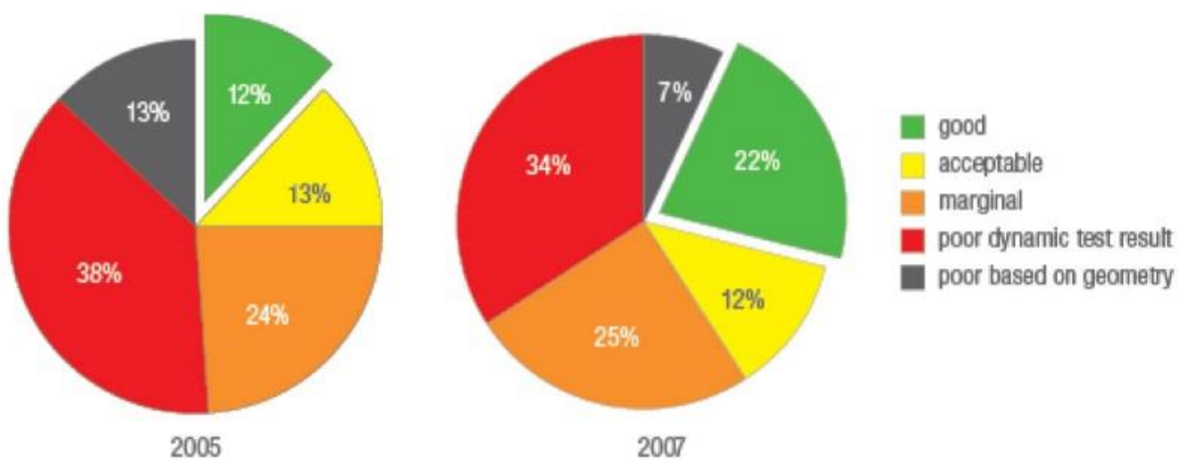
5) Discussion of the safety benefits (Effectiveness of ENCAP/JNCAP/IIHS adoption in the market)



A. Kullgren et al., GENDER ANALYSIS ON WHIPLASH SEAT EFFECTIVENESS: RESULTS FROM REAL-WORLD CRASHES, Proceedings of the 2012 IRCOBI



SUVs, pickup trucks, and minivans

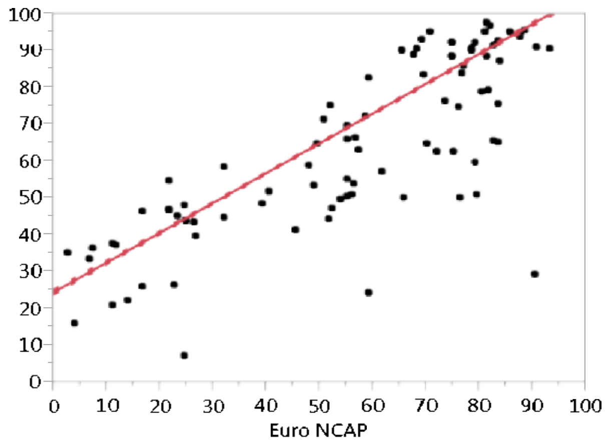


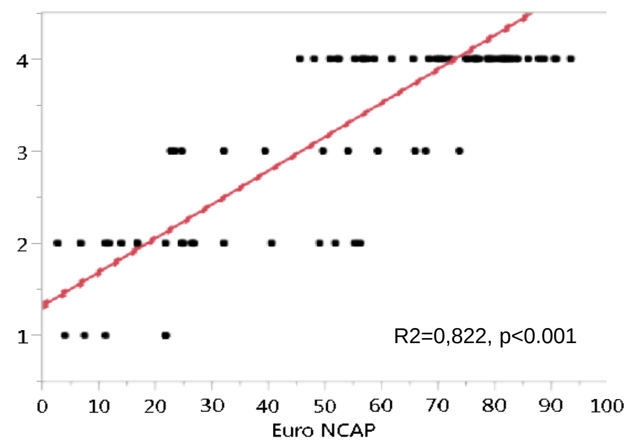
IIHS Status Report, Vol.42, No.8 August 4, 2007, Head Restraints are improving but not fast enough

24th ESV Conference
Paper Number 15- 0267

EVALUATION OF THE EURO NCAP WHIPLASH PROTOCOL USING REAL-WORLD CRASH DATA

A. Kullgren, B. Fildes, M. Ratingen, J. Ellway, M. Keall





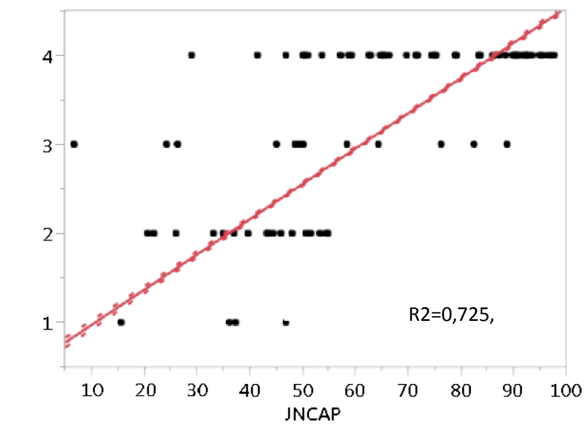
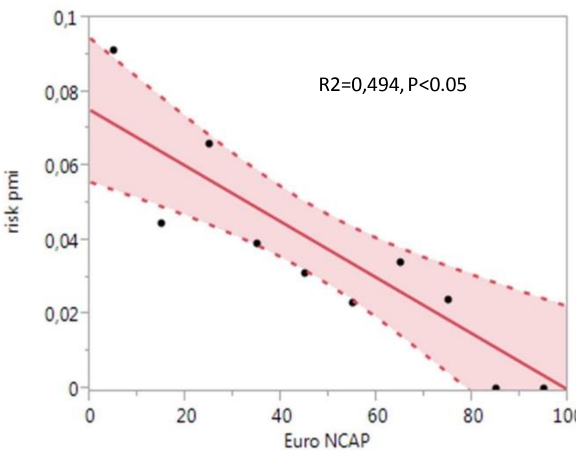
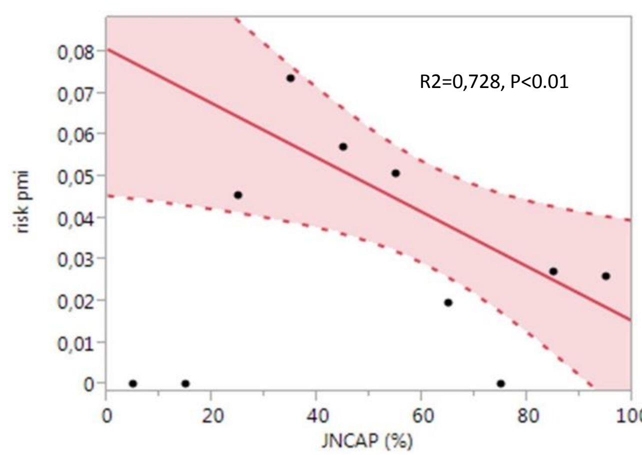


Fig 2: Euro NCAP and JNCAP scores. **Fig 3: Euro NCAP and IIWPG scores.** **Fig 4: JNCAP and IIWPG scores**





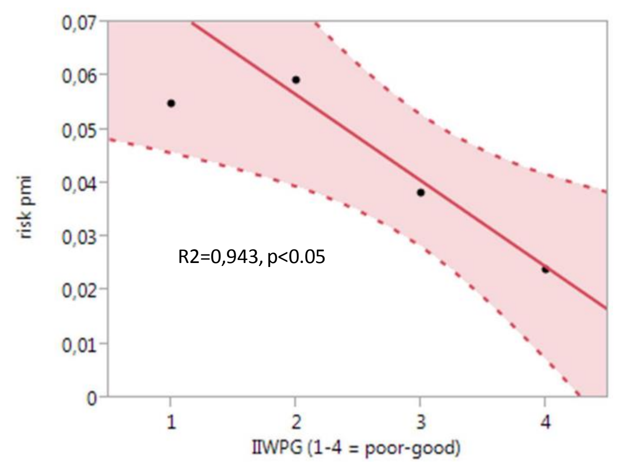


Fig 5: Risk for pmi vs Euro NCAP score. **Fig 6: Risk for pmi vs JNCAP score.** **Fig 7: Risk for pmi vs IIWPG score**

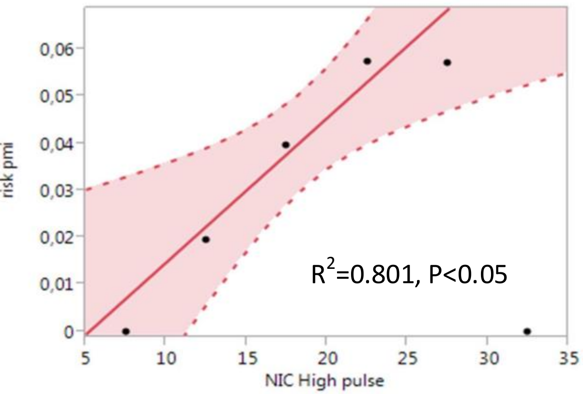


Fig14: PMI risk vs Euro NCAP NIC measure with High test pulse

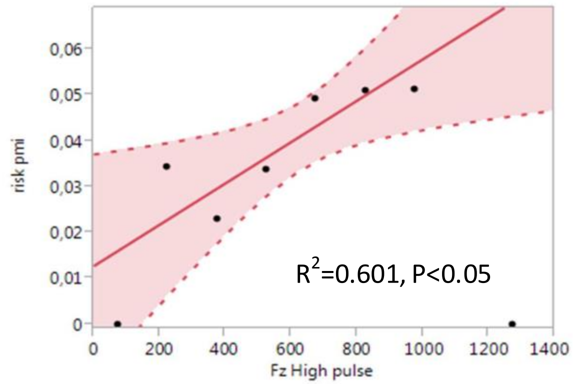


Fig15: PMI risk vs Euro NCAP Fz measure with High test pulse

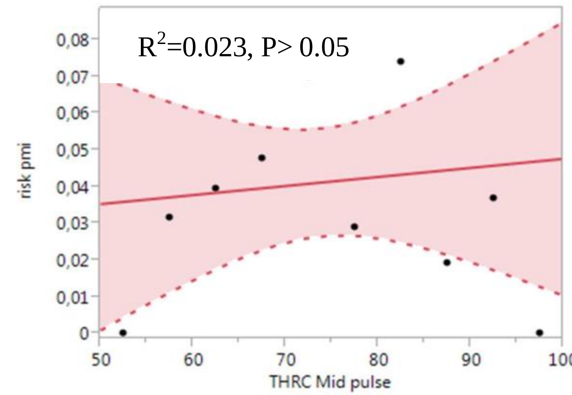


Fig16: PMI risk vs Euro NCAP THRC measure with Mid pulse

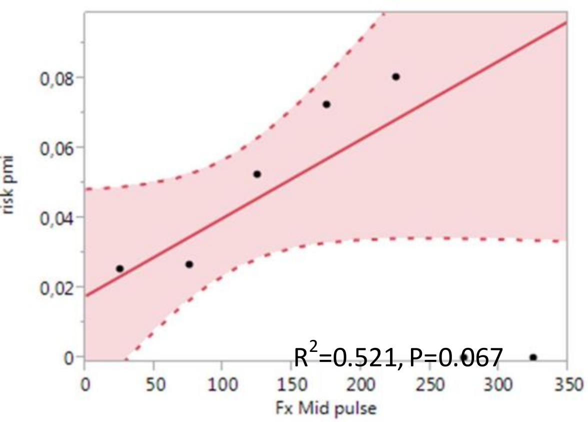


Fig17: PMI risk vs Euro NCAP Fx measure with Mid test pulse

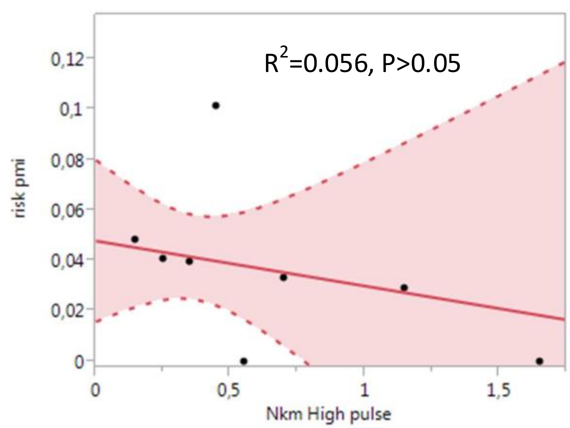


Fig18: PMI risk vs Euro NCAP Nkm measure with High test pulse

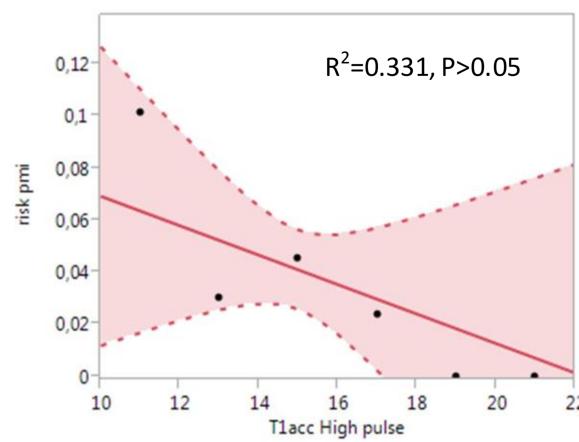


Fig19: PMI risk vs Euro NCAP T1accel measure with High test pulse

SUMMARY AND CONCLUSIONS

The analyses conducted here were aimed at identifying real-world whiplash associations with existing test protocols used by Euro NCAP, J-NCAP, and IIWPG.

Given the paucity in the data available, the finding here should be regarded as preliminary findings at this stage. **Of interest, Euro NCAP, JNCAP and IIWPG were all found to be significantly correlated with each other and correlated to some degree with the risk for WAD leading to permanent medical impairment.**

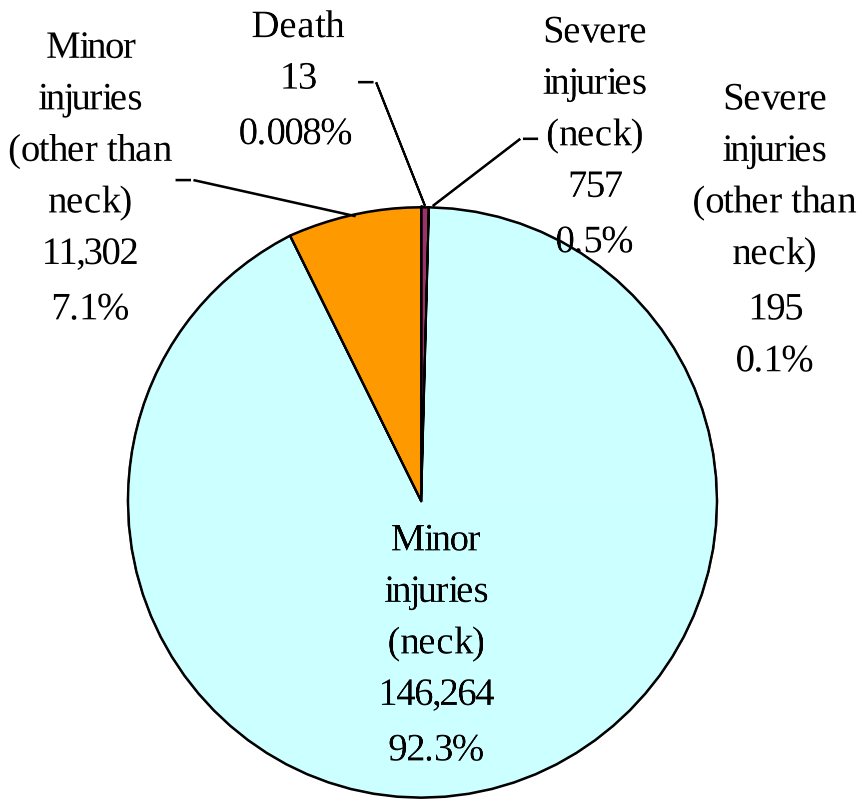
There were signs that that there could be refinements in the number of test criteria. There was a suggestion that reductions in both the number of tests and criteria could still provide significant associations with Permanent Medical Impairment, but that further research is warranted to further test its robustness.

Note: An analysis was undertaken of the relationship between sensitivity and specificity of variations of the three test protocols (ENCAP, JNACP and IIWPG). However, the sensitivities of Upper/Lower My are not mentioned in the paper.

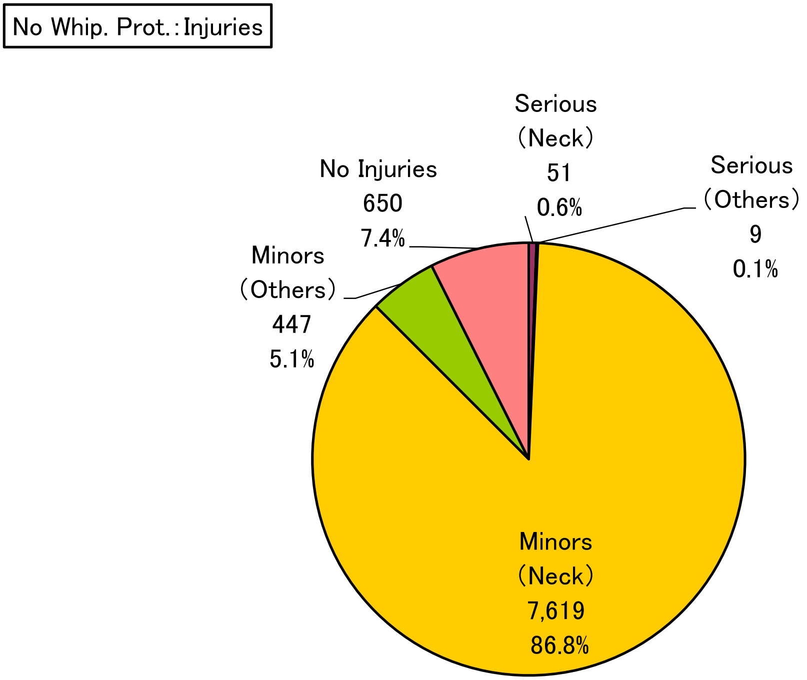
2008 traffic accidents statistics in Japan

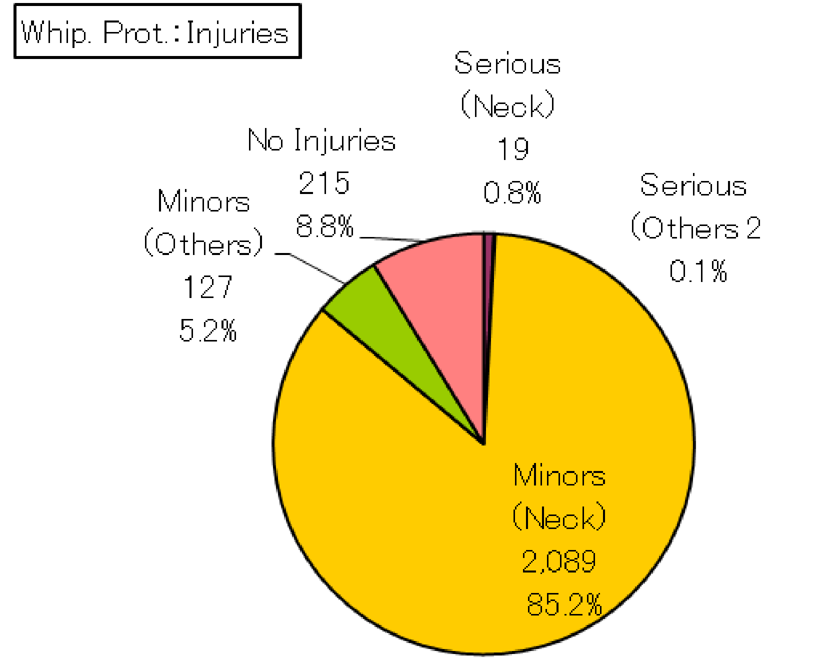
(1995-2004)
Car to Car
Rear-end Collisions
Drivers in Struck Car

Type of Injuries due to Rear-end Collisions

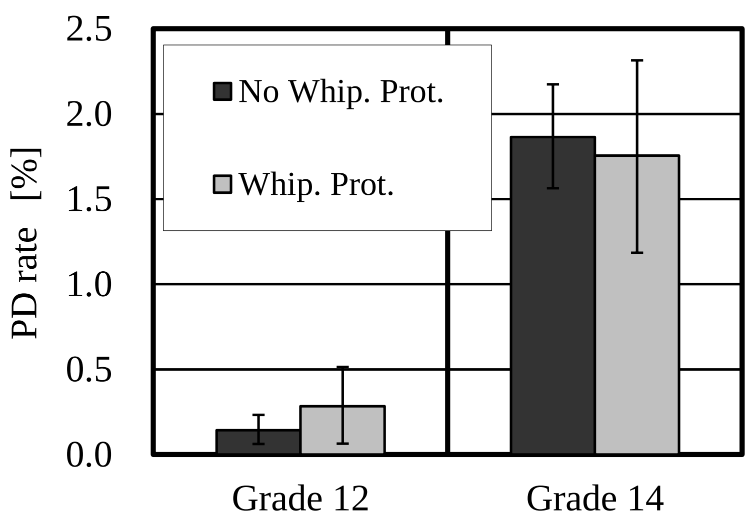


- Subject year：2008（excluding multiple accidents）. Drivers of Rear Impacted Vehicles, Rear Impacted Vehicles : all vehicles
- Minor neck injuries account for 90% of the injuries suffered by drivers from rear- end accidents.





1995-2004（Acc. Statistics in 2008） Car to Car: Drivers in Struck Car



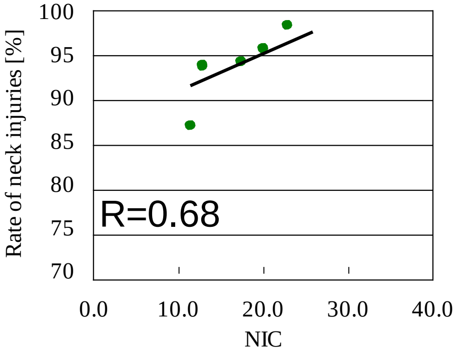
Reduction	Deg.of P.D.	Injuries [Persons]	PD Rates [%]	95% Confidense Interval	
No Whip.	Grade 12	11	0.14	0.06	0.23
	Grade 14	143	1.86	1.56	2.17
Whip.	Grade 12	6	0.28	0.06	0.51
	Grade 14	37	1.76	1.19	2.32

1995-2004（Acc. Statistics in 2008） Car to Car (Rear-end Collisions, Permanent Disabilities (PD))

Neck Injury Criteria and Rate of Neck Injuries

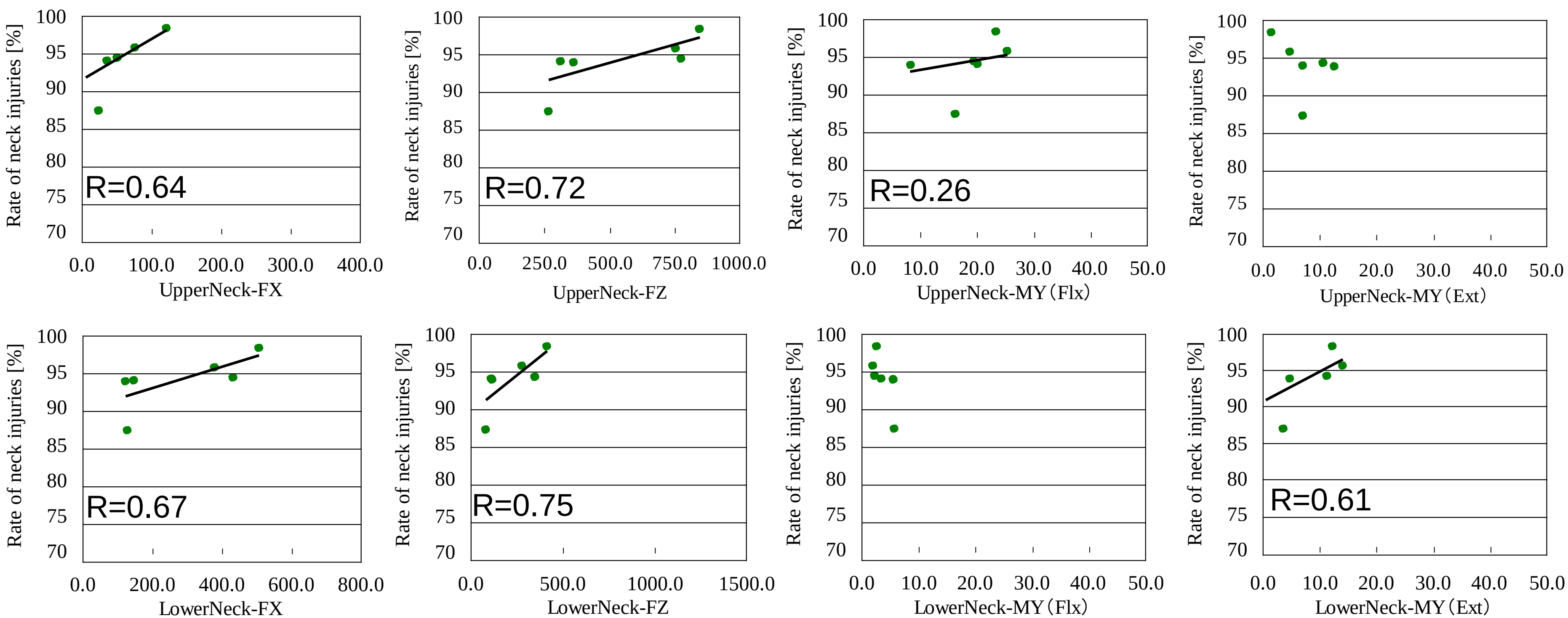
(Excluding injuries whose number of occurrences is 50 or less

The neck injury parameters proposed by Japan to UN/ECE/WP.29/GRSP/grt7 and the rate of neck injuries in Japan were based on the accident analysis as shown below:



– Although there are not a lot of data, the correlation coefficient to the rate of neck injury and injury value is 0.26-0.75.

– In each injury criteria, when an injury value rises, there was also a tendency for the rate of neck injury to go up. And these had correlation with real world accident and injury criteria.



Occurrence Rates of Neck Injuries Classified as With/Without Anti-Whiplash Equipped Seat for Rear-End Collisions in Japan (2009~2012)

Effectiveness of Anti-Whiplash Seat; 12% (2009~2012) according to the adoption of JNCAP Seat Assessment in Rear-End Collisions

Anti-whiplash Seat	Degree of Neck Injuries	Injured Body Regions	Rate of Injured Persons
With	Severe/Minor	Neck	**21.7**
		Others	1.8
	No injuries	Others	22.9
Without	Severe/Minor	Neck	**24.7**
		Others	2.4
	No injuries	Others	26.4

Source: ITARDA Information Report (No.111) published by May 2015

Note:

- Total number of persons involved in rear-end crashes; N=534,736
- Only Domestic OEM in Japan: 8 car makers
- Equipment Rate of Anti-Whiplash Seat in the Passenger Cars (only 2012): 56.3%

6) Additional Discussion on the BioRID-II dummy maintenance conditions

Questions about the dummy maintenance procedure reported in BioRID-II dummies maintenance conditions in the works on “Evaluation of seat performance criteria for rear-end impact testing: BioRID-II and insurance data (WCWID-1-03e/pdf” p*resented at the GTR No7 Injury Criteria Meeting Gothenburg, Sept 10-11*th *2013*, by *Johan Davidsson, Chalmers University of Technology*

- Applied Dummies to the tests: BioRID-II built Level E or G

Questions;

- Identify the dummy calibration tests:
    a. How to maintain the dummy conditions,
    b. Maintenance periods of the dummies
    c. Replacement of the neck bumper, etc.
- How to check the dummy’s repeatability and reproducibility, and CV values?

Current Status of BioRID-II dummy Maintenance & Condition (Calibration Tests) for Implementations of the JNCAP tests at JARI

<Implementation of Calibration Tests at JARI>

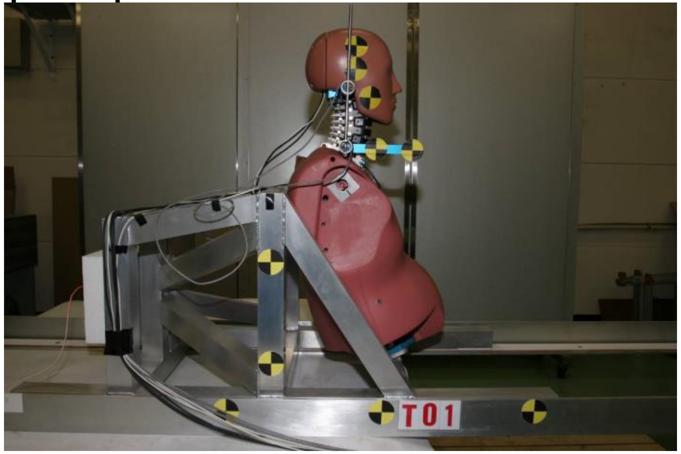
- After 5 sled test and/or every 3 months, all neck bumpers are replaced with a new one.
- After that, calibration test for BioRID-II with the replaced new neck bumpers is performed and verified whether or not the response will get into the corridor.
- When abnormality responses of the BioRID-II dummy happen, the calibration test will be performed regardless of the rule mentioned above.

Calibration Test Device (Without Headrest)

Weight of Sled: 44.25 kg+/- 0.05 kg

Weight of Impactor Probe: 37.61 kg +/- 0.1 kg

Use of ETD (Energy Transfer Device) in order to achieve a repeatable impact pulse



<u>Measurement items</u>

- Impactor acceleration
- Sled acceleration
- T1 acceleration
- Head rotation（Pot.A）
- Neck rotation（Pot.B）
- T1 rotation（Pot.C）

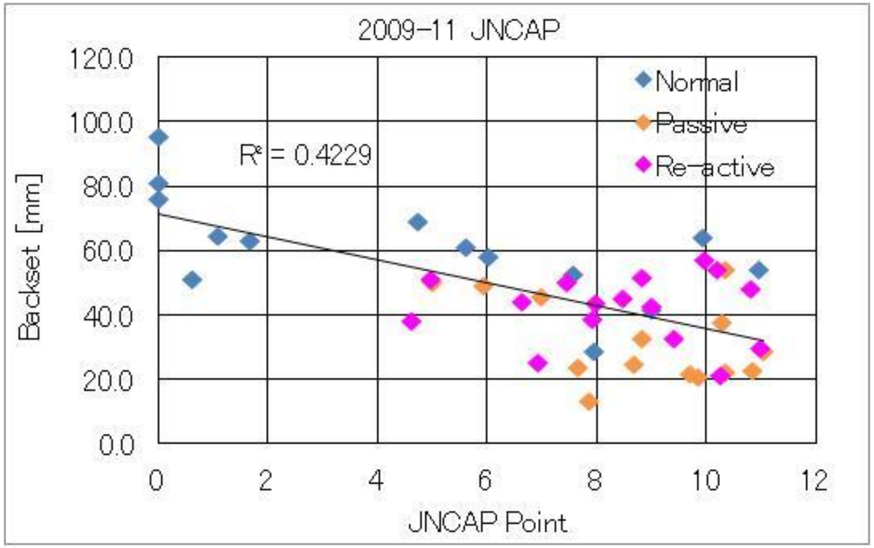
Appendices

a. Relationship between the injury values and the backset under the JNACP

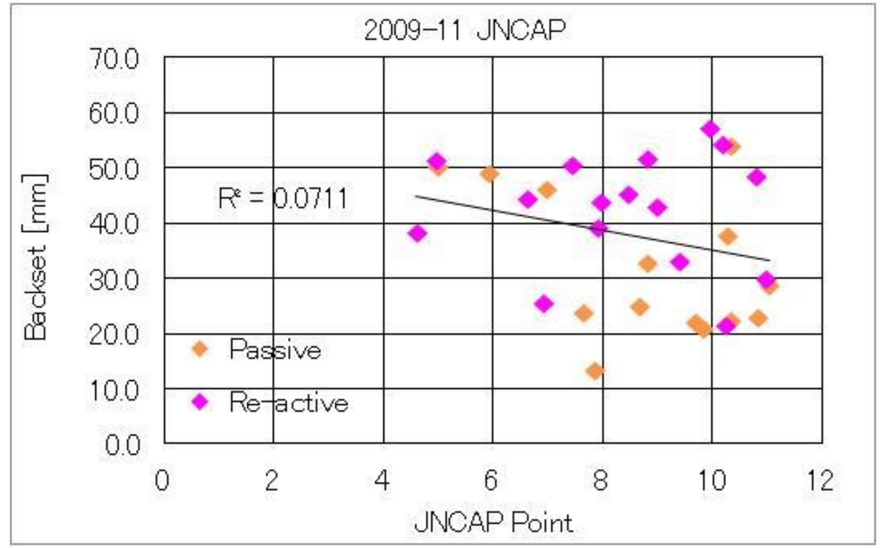
b. Comparison between 17.6 km/h and 20 km/h with respect to the test results on under the JNACP

<Backset and JNCAP scores>
Relationship between the injury values and the backset under the JNACP

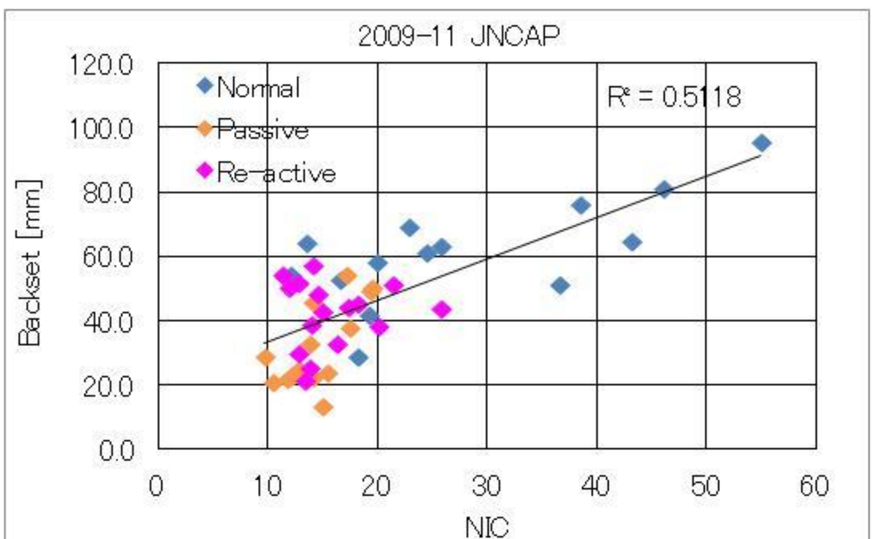
JNCAP Point（with Normal Seat）



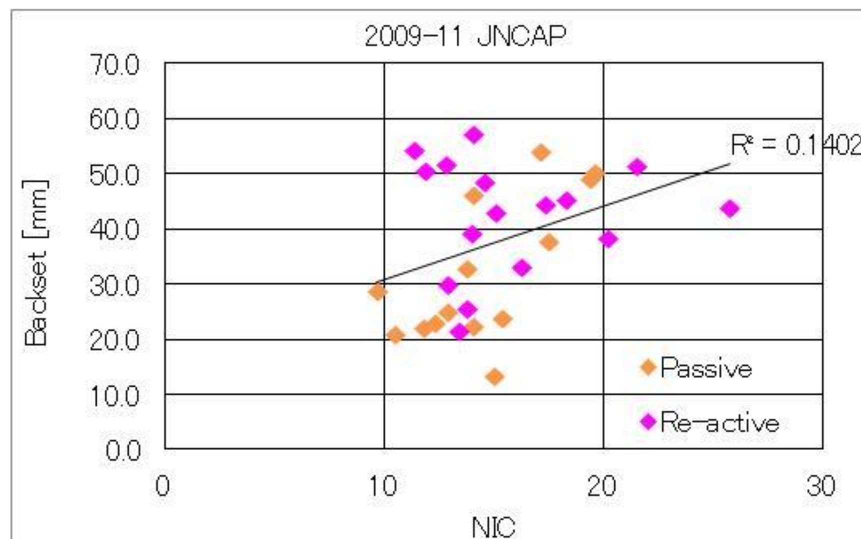
JNCAP Point（without Normal Seat）



NIC（with Normal Seat）



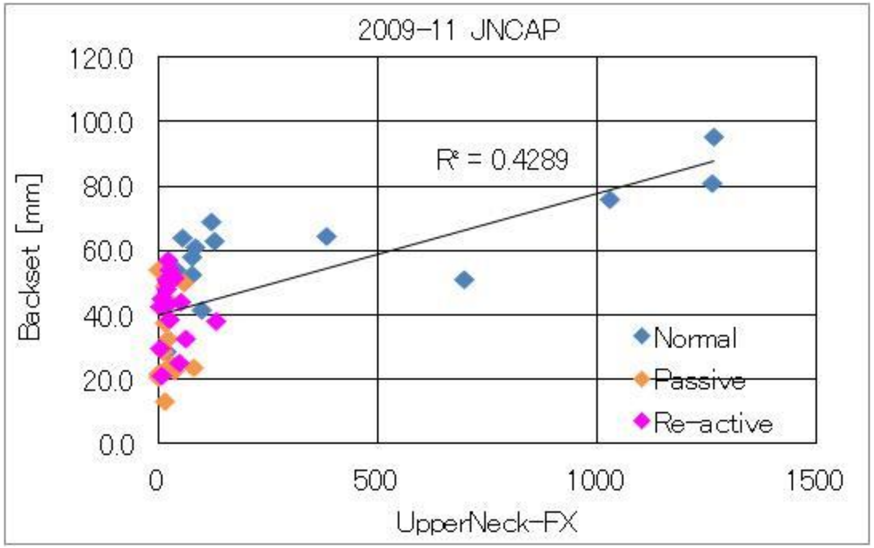
NIC（without Normal Seat）



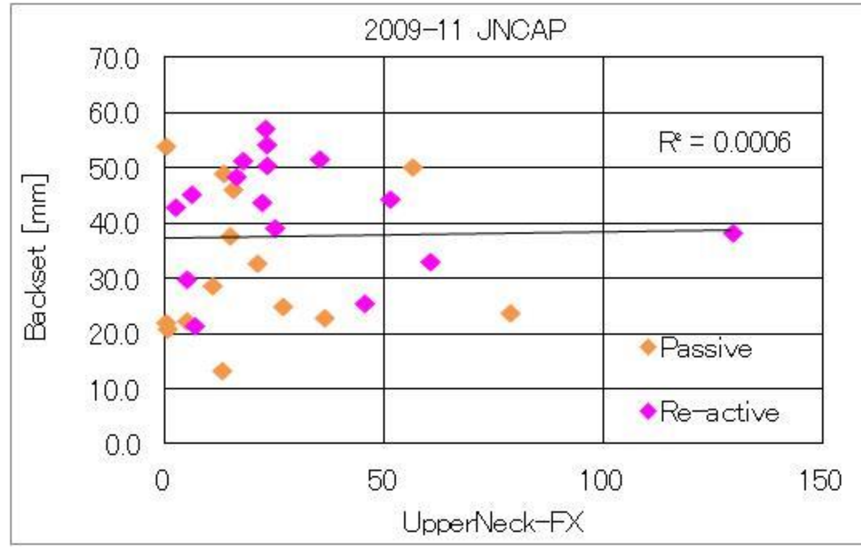
<Backset and JNCAP scores>

Relationship between the injury values and the backset under the JNACP

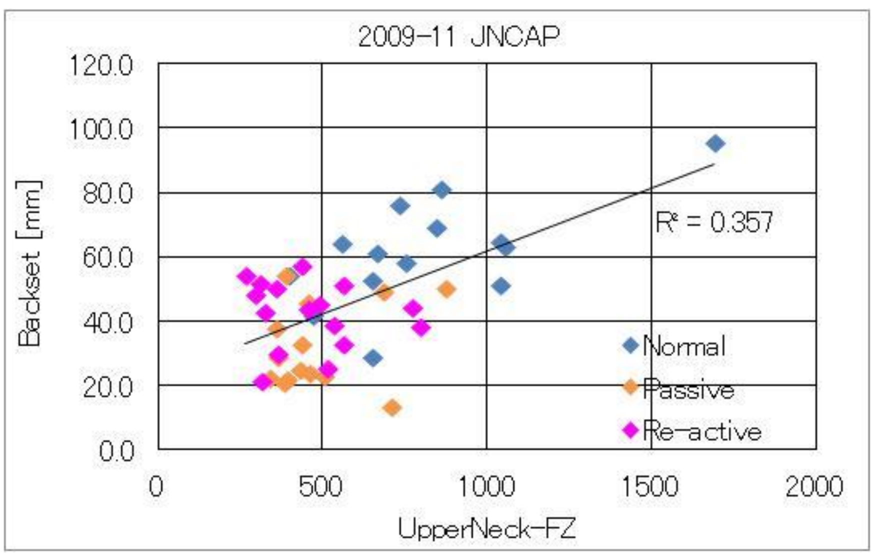
UpperNeck-FX（with Normal Seat）



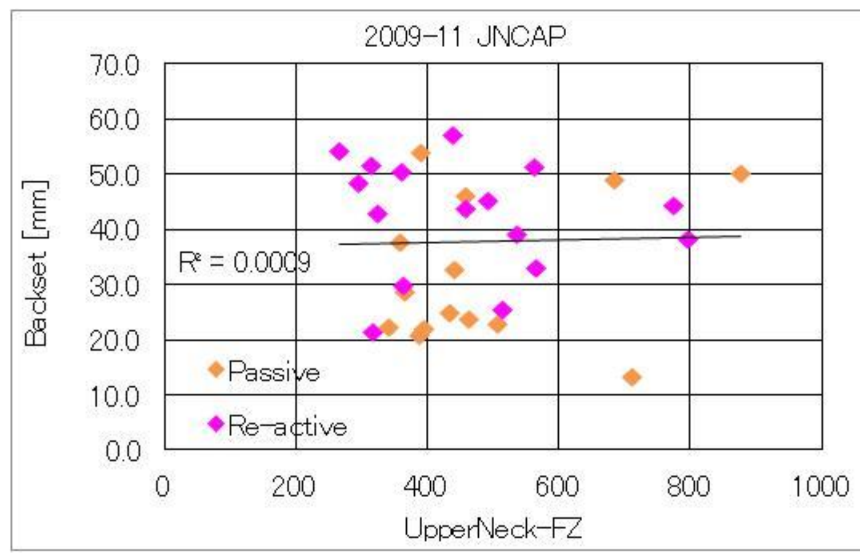
UpperNeck-FX（without Normal Seat）



UpperNeck-FZ（with Normal Seat）

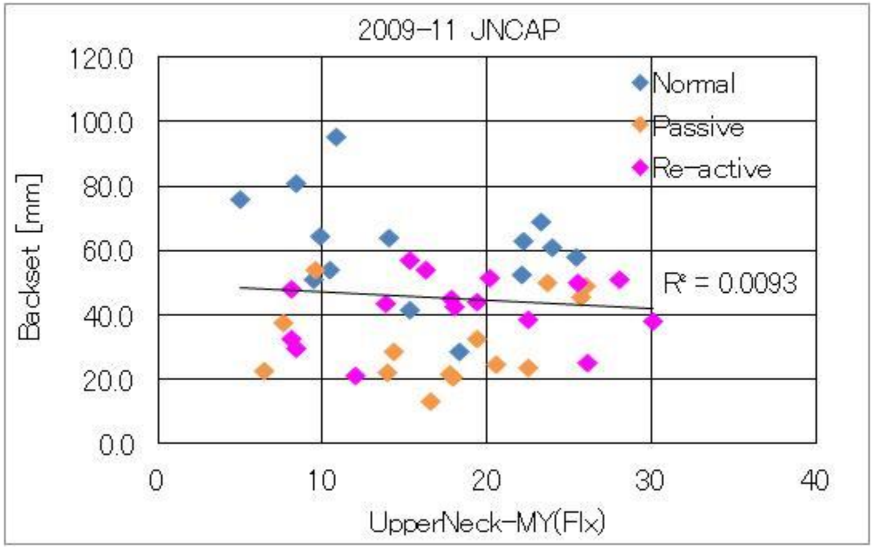


UpperNeck-FZ（without Normal Seat）

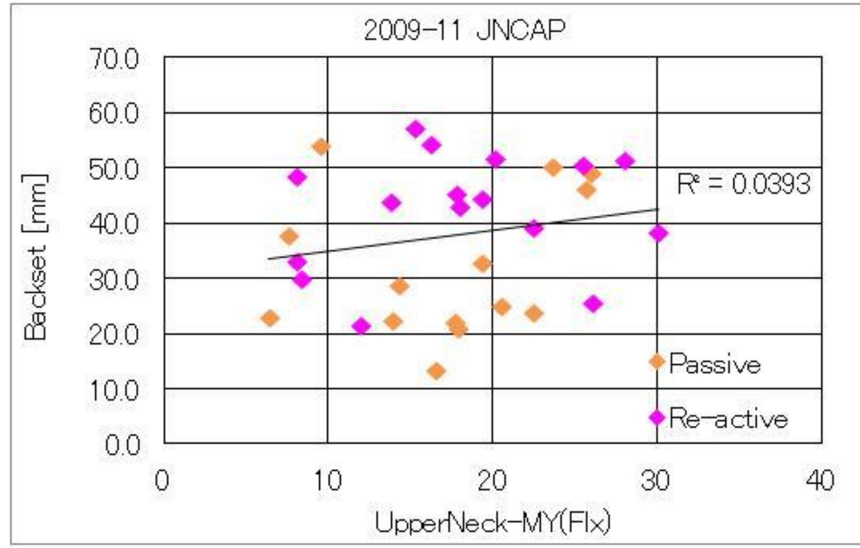


<Backset and JNCAP scores>
Relationship between the injury values and the backset under the JNACP

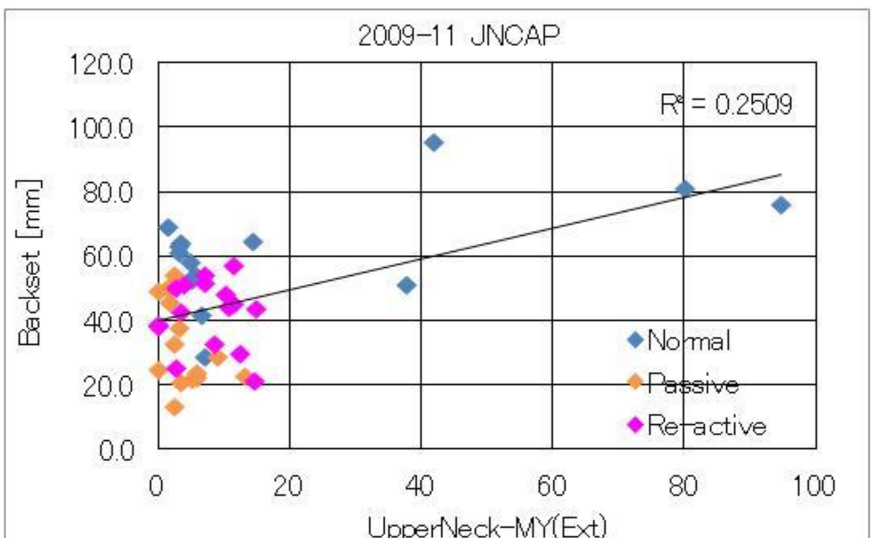
UpperNeck-MY・Flx（with Normal Seat）



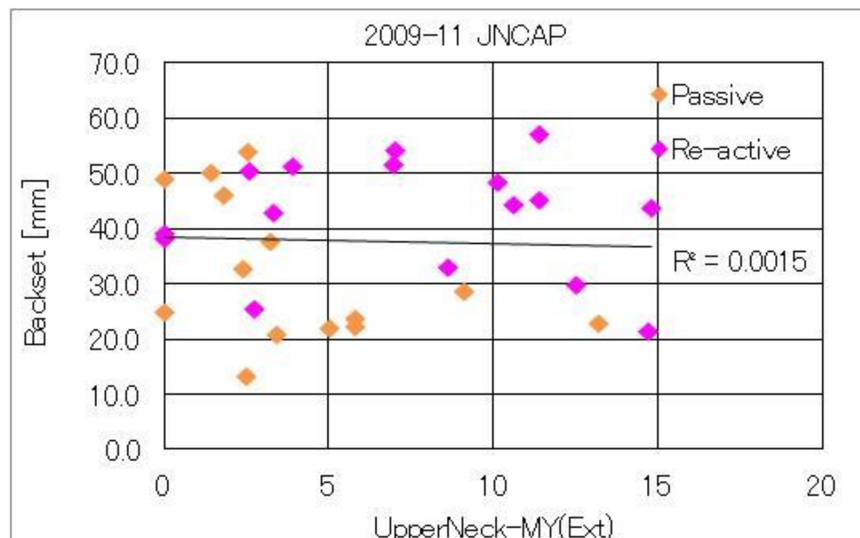
UpperNeck-MY・Flx（without Normal Seat）



UpperNeck-MY・Ext（with Normal Seat）

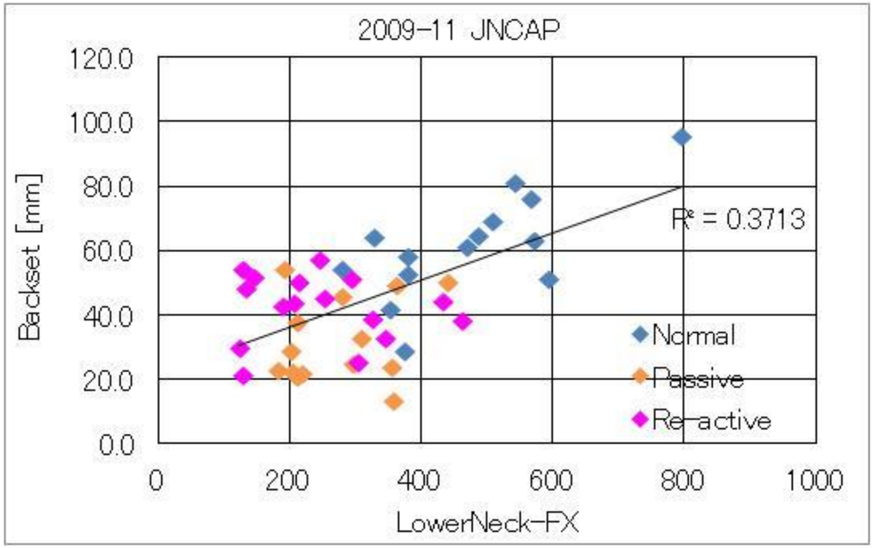


UpperNeck-MY・Ext（without Normal Seat）

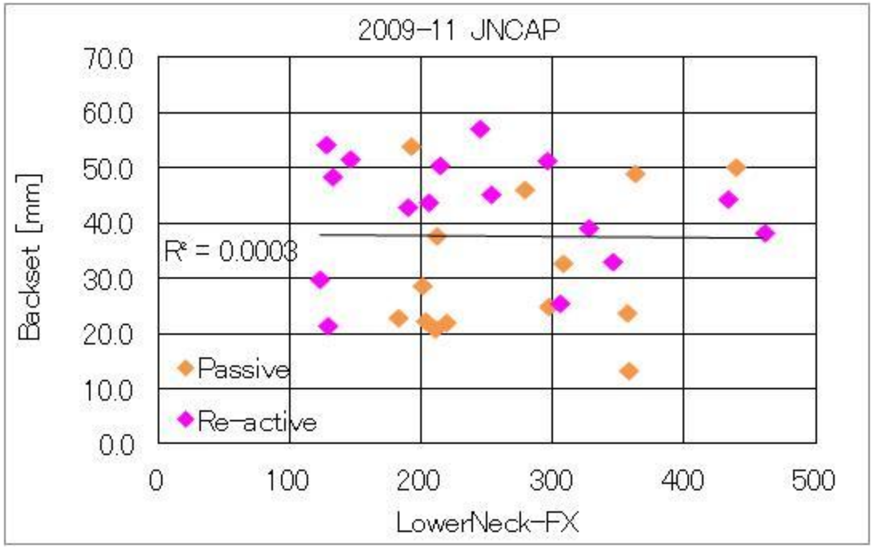


<Backset and JNCAP scores>
Relationship between the injury values and the backset under the JNACP

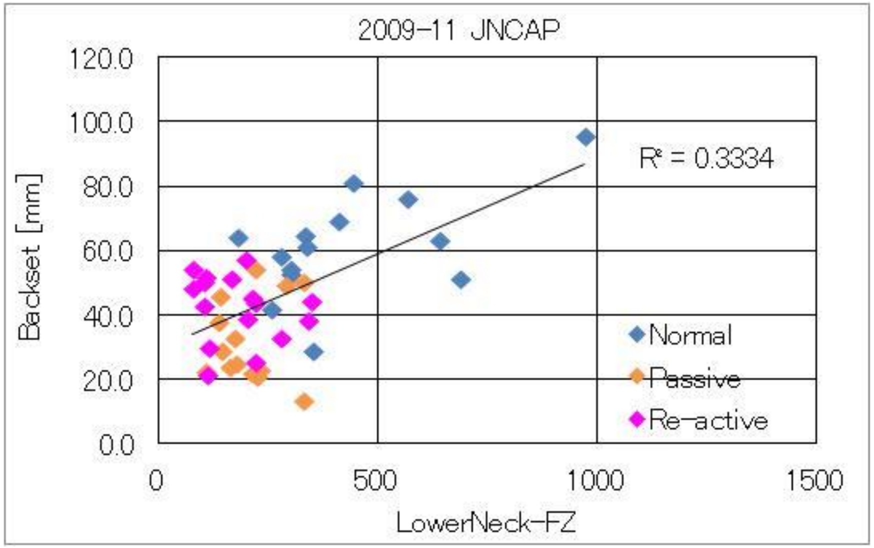
LowerNeck-FX（with Normal Seat）



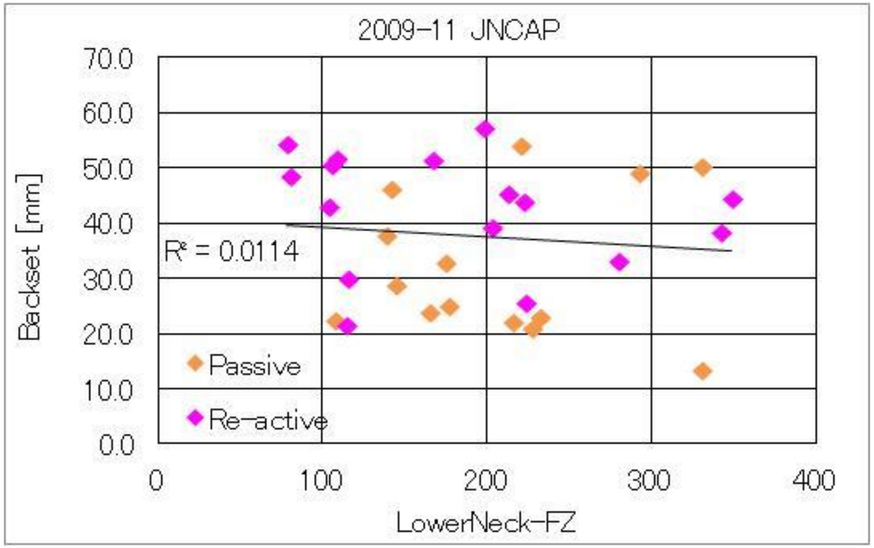
LowerNeck-FX（without Normal Seat）



LowerNeck-FZ（with Normal Seat）

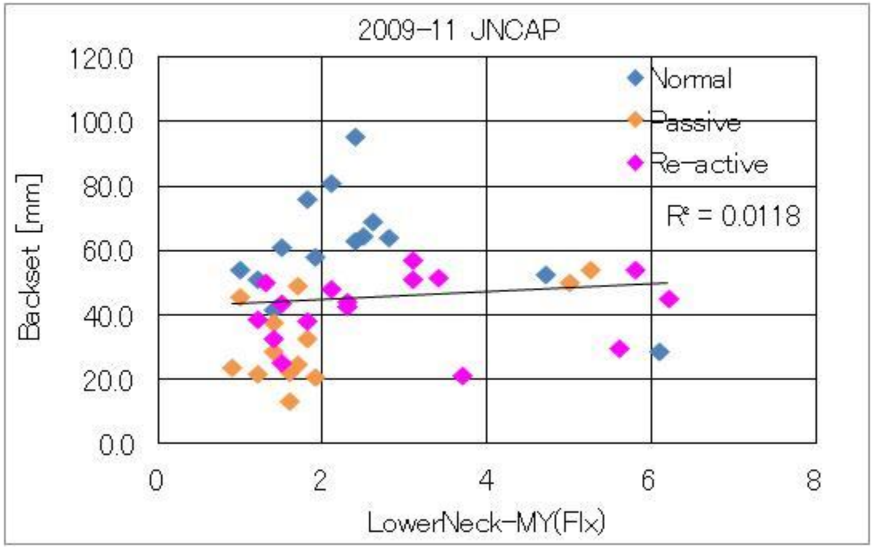


LowerNeck-FZ（without Normal Seat）

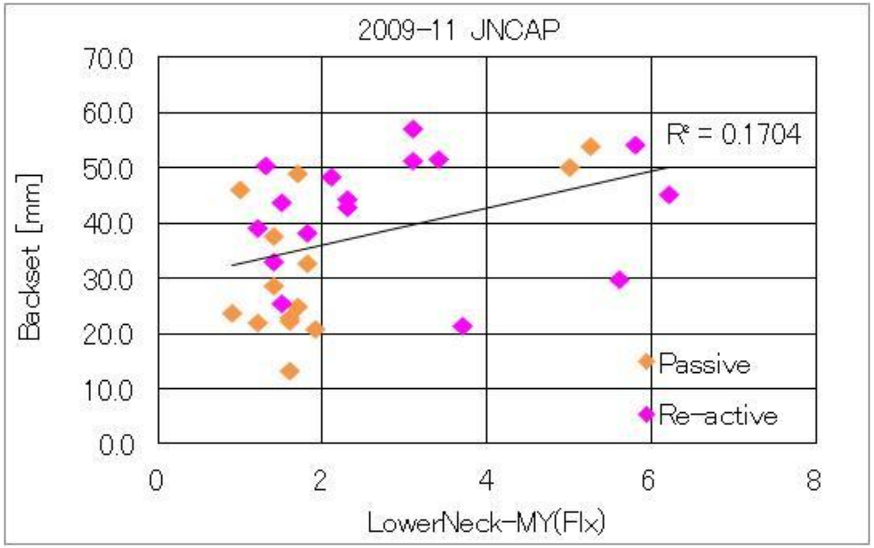


<Backset and JNCAP scores>
Relationship between the injury values and the backset under the JNACP

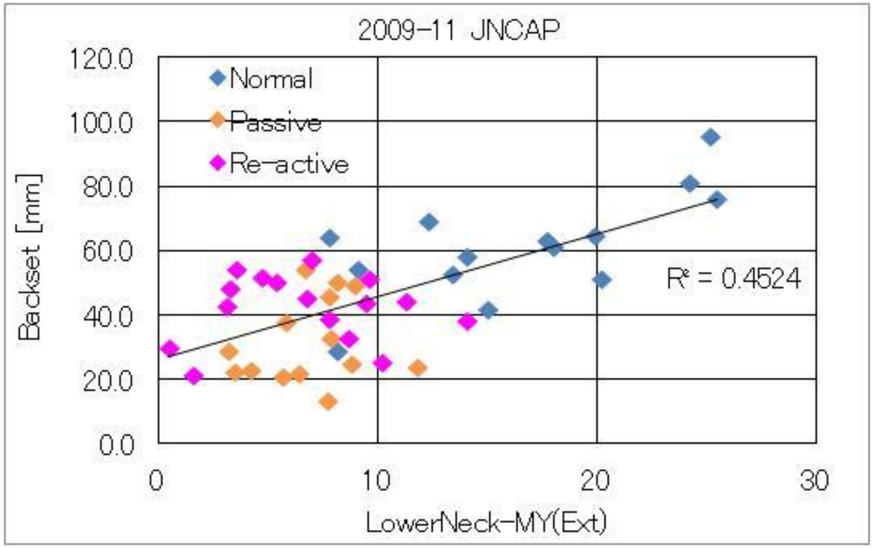
LowerNeck-MY・Flx（with Normal Seat）



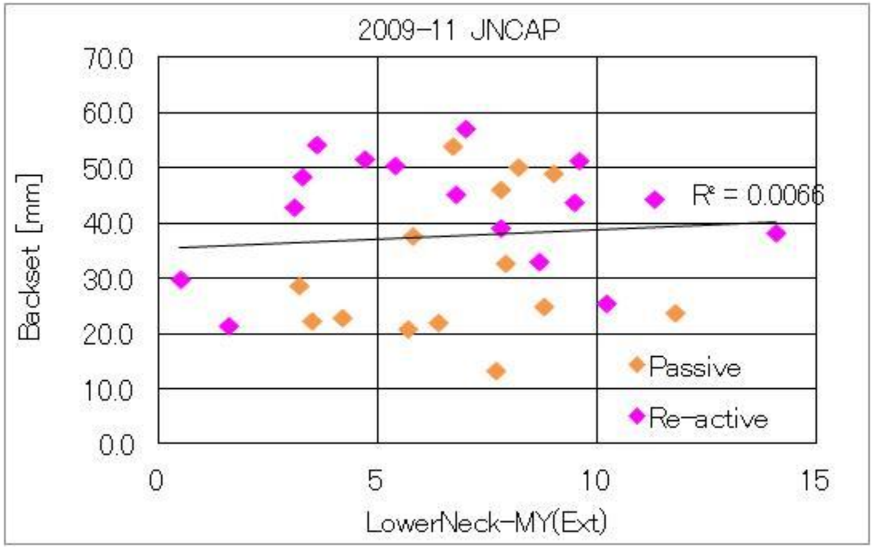
LowerNeck-MY・Flx（without Normal Seat）



LowerNeck-MY・Ext（with Normal Seat）

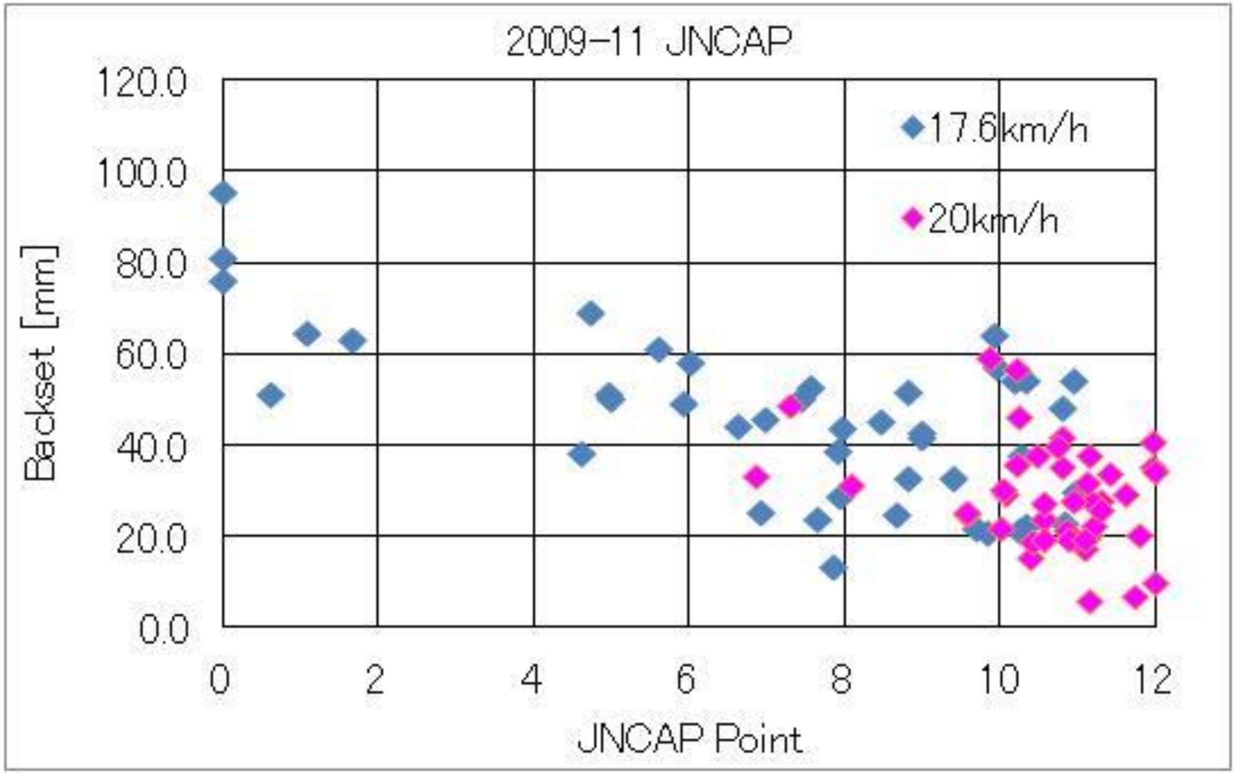


LowerNeck-MY・Ext（without Normal Seat）



<Backset and JNCAP scores>

Comparison between 17.6 km/h and 20 km/h with respect to the test results under the JNACP



- The latest results of the JNCAP show a safer protection seat in the market compared with the test series under the different sled test velocities on 17.6 km/h (2009-11) and 20.0 km/h (after 2012).
- It is definitely said that recent production seat performance has become drastically safer after 2012.

Questions?