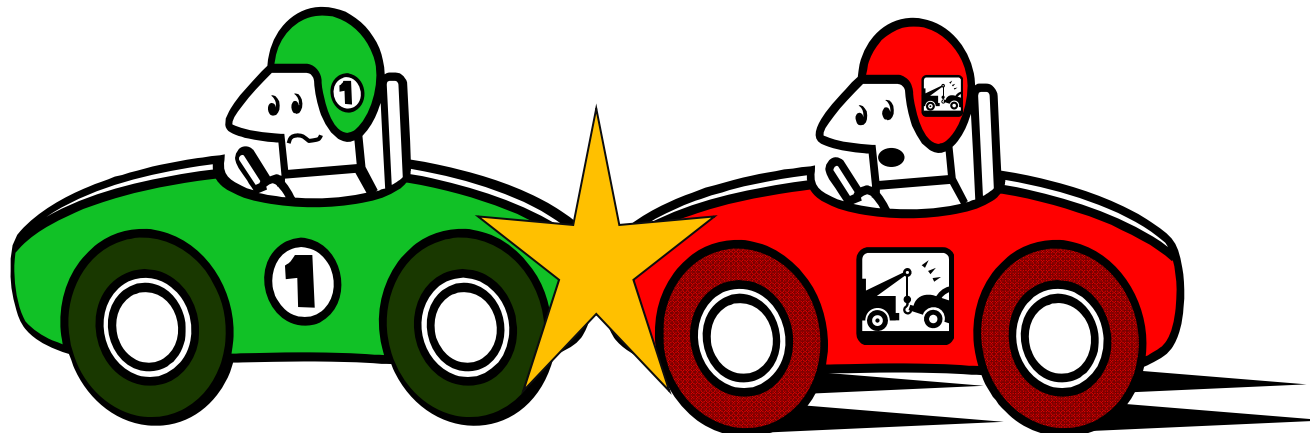


Evaluation of seat performance criteria for rear-end impact testing: BioRID II and insurance data

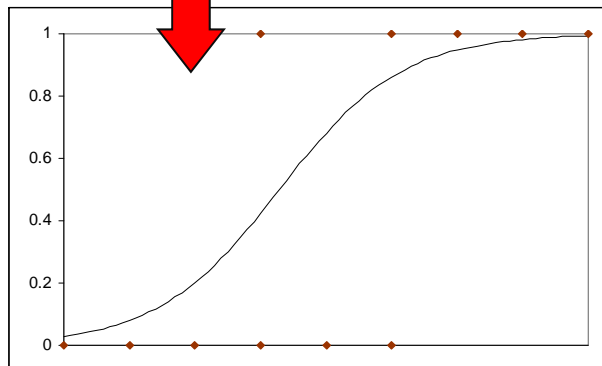
*Johan Davidsson
Chalmers University of Technology*

*Anders Kullgren
Folksam Research and Chalmers University of
Technology*

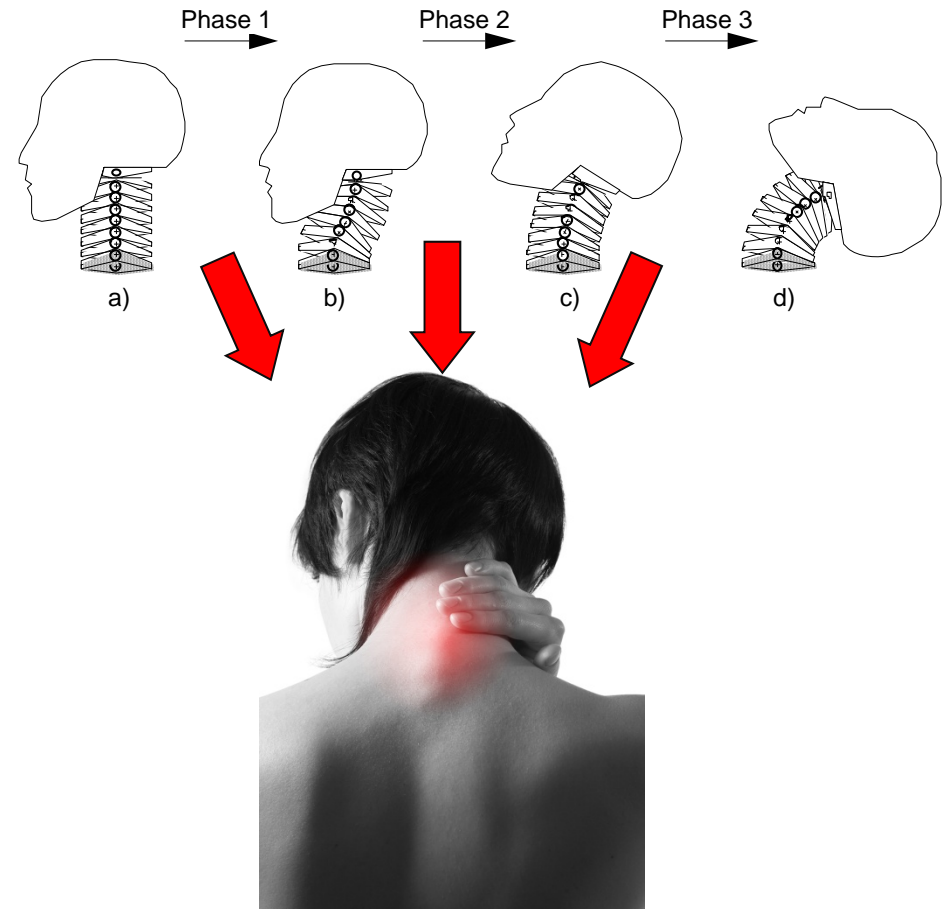


Background

- Traditional approach



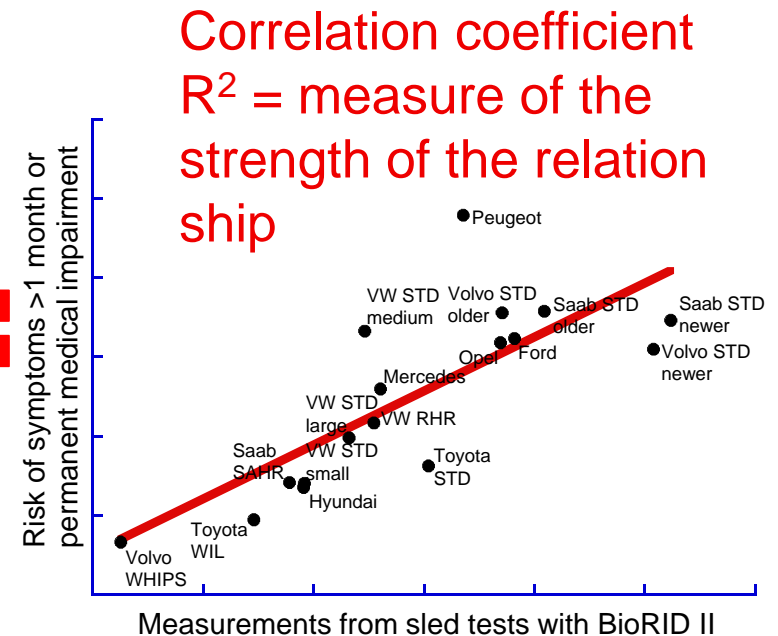
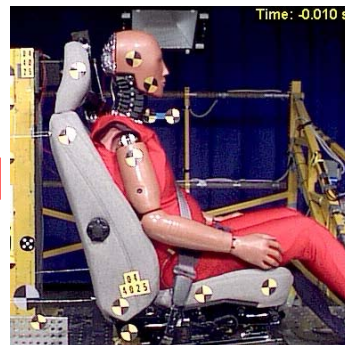
- Whiplash Associated Disorders



Objective and Principle method

- Suggest seat performance criteria to be used in rear-end impact seat tests with BioRID II

Folksam
Injury Claim data
from rear-end
impacts



Methods: Data used

Insurance data

- Folksam, Sweden
 - 1998 - 2012
 - Only drivers
 - Only rear +/-30 degrees
 - Only neck and spine injuries
- Risks used:
 - Symptoms for more than one month in case of initial symptoms
 - Permanent medical impairment in case of initial symptoms

BioRID II seat test data

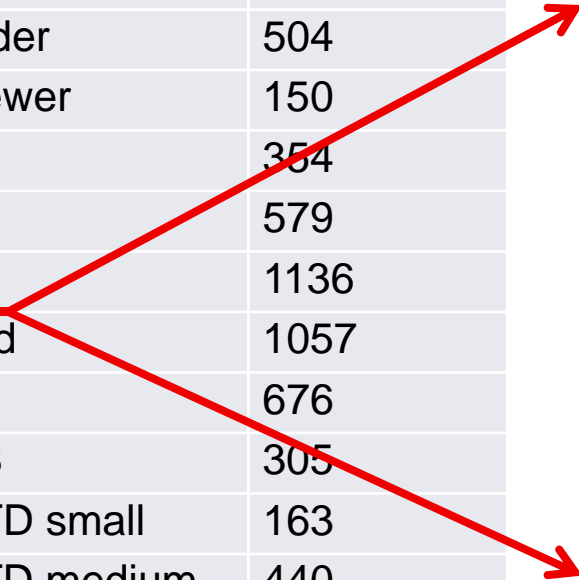
- Euro NCAP medium pulse rear-end impact test data
 - Autoliv, 2004, 2005 and 2006
 - Thatcham, 2004 and 2012
- BioRID II build level E or G
- H-point tool:
 - TechnoSports, Inc.,
 - Automotive Accessories, Ltd.,

Methods: Grouping insurance data

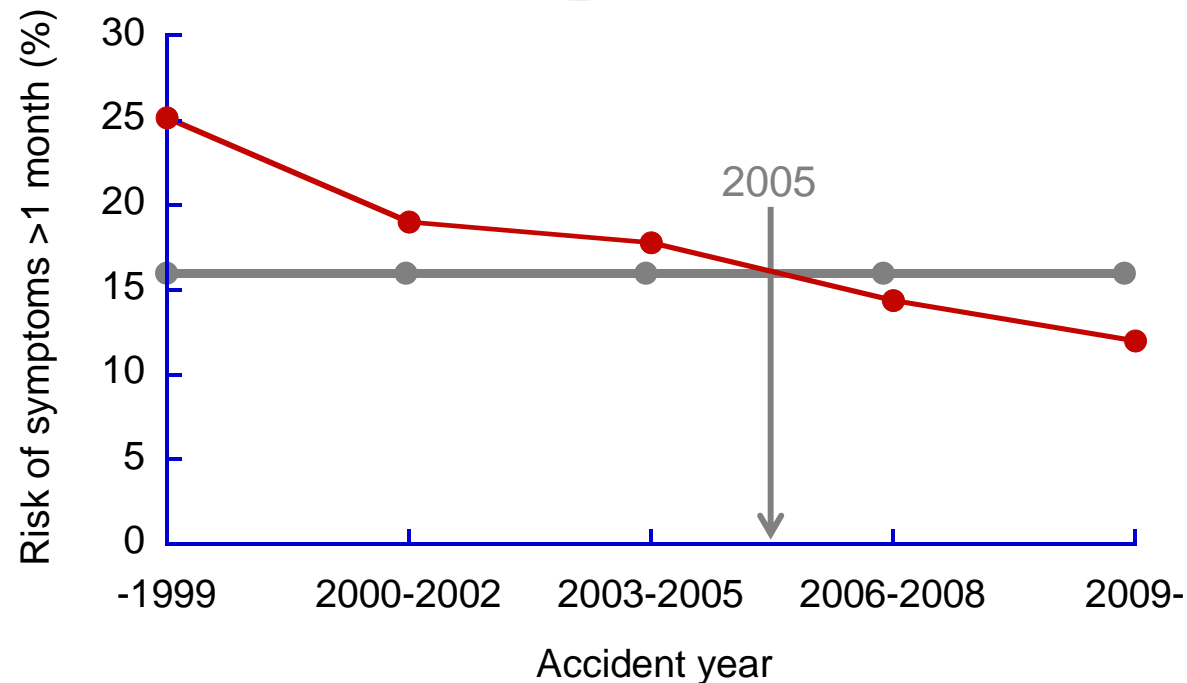
| Group names | No. cases |
|--------------------------|-----------|
| Ford with STD | 382 |
| Hyundai with STD | 195 |
| Mercedes with STD | 191 |
| Opel with STD | 500 |
| Peugeot with STD | 397 |
| Saab with STD older | 504 |
| Saab with STD newer | 150 |
| Saab with SAHR | 354 |
| Toyota with STD | 579 |
| <u>Toyota with WIL</u> | 1136 |
| Volvo with STD old | 1057 |
| Volvo with STD | 676 |
| Volvo with WHIPS | 305 |
| VW group with STD small | 163 |
| VW group with STD medium | 440 |
| VW group with STD large | 683 |
| VW group with RHR | 181 |

| Insurance data for group Toyota with WIL | |
|--|-------|
| Auris | 07- |
| Avensis | 03-08 |
| Avensis Verso | 01-05 |
| Camry | 01-03 |
| Corolla | 02-07 |
| Corolla Verso | 02-03 |
| Corolla Verso | 04-10 |
| Prius | 00-03 |
| Prius | 04-09 |
| Rav4 | 00-04 |
| Rav4 | 05- |
| Yaris and Yaris Verso | 99-05 |
| Yaris | 05- |

| BioRID tests for group Toyota with WIL | |
|--|----------|
| Model | Yaris |
| Production year | 99-05 |
| Test year | 2004 |
| Test facility | Thatcham |
| BioRID II version | G |

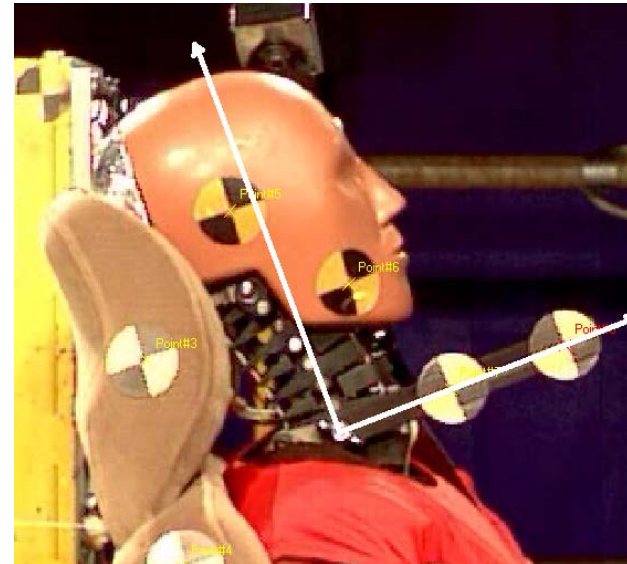


Methods: Compensation for classification of injury

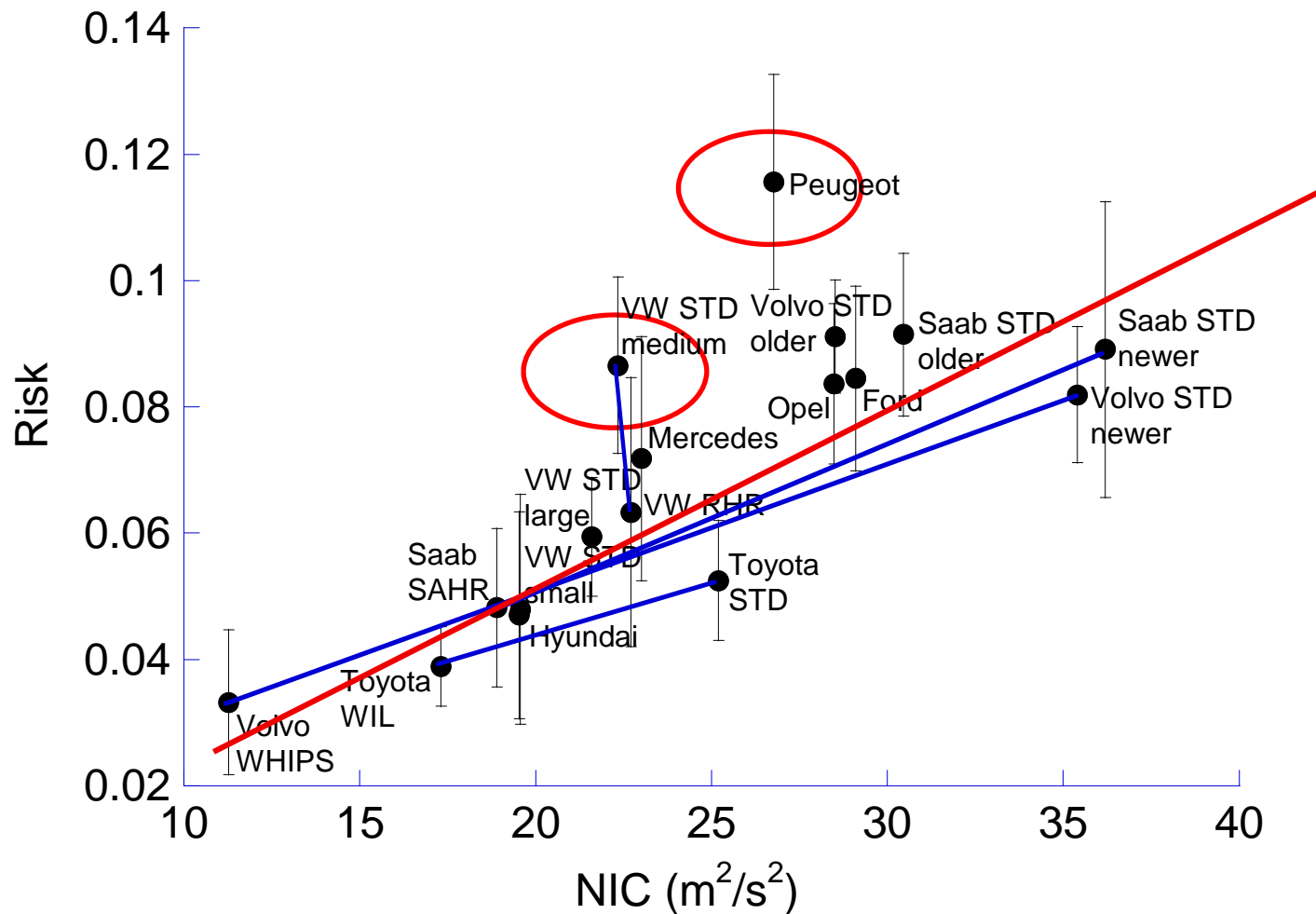


Methods: Studied parameters

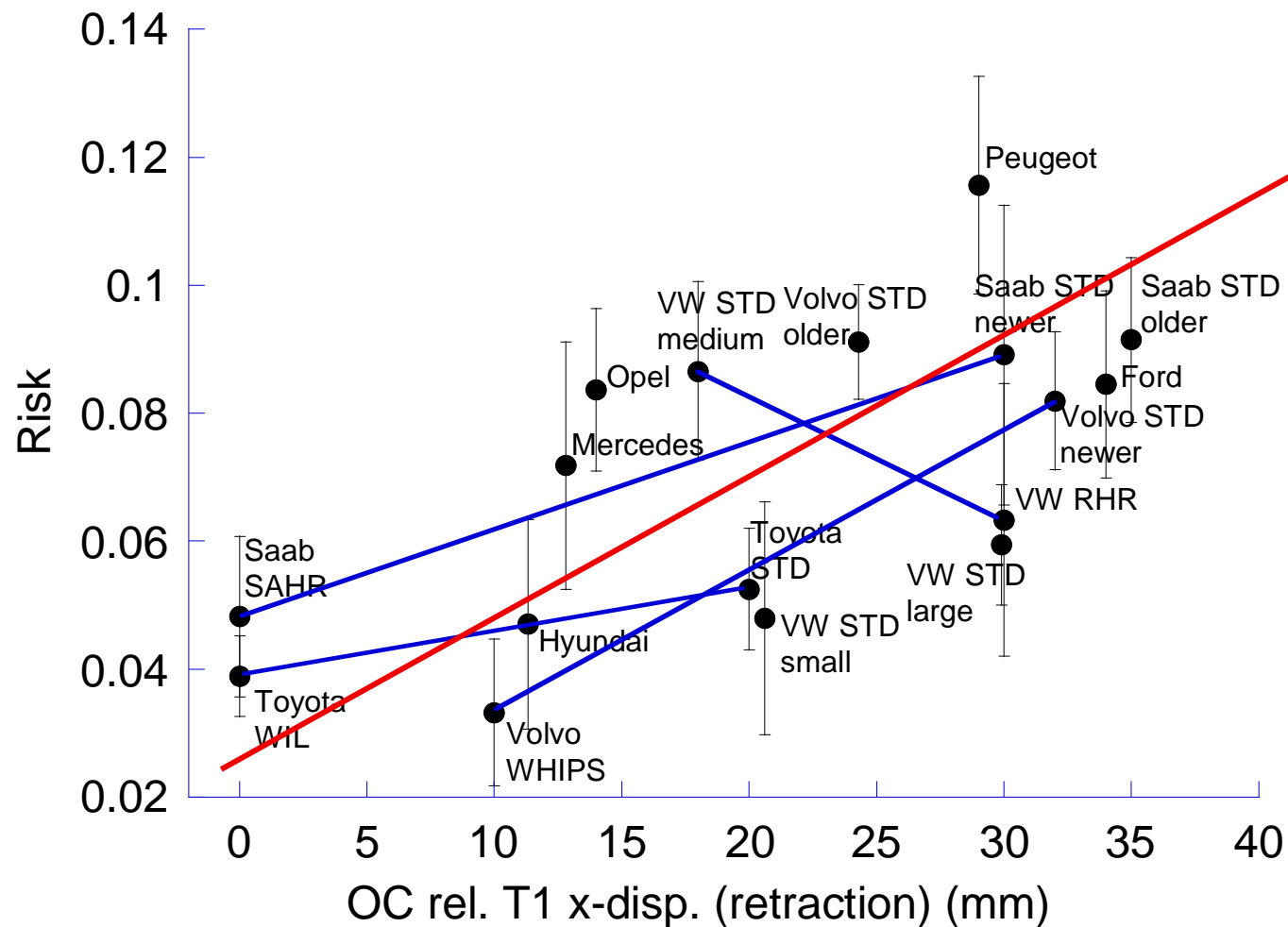
- Maximum Neck Injury Criteria (NIC)
- Maximum Neck Force Criteria (N_{km})
- Maximum Lower Neck Loads Criteria (LNL)
- Maximum Head x- and z-acceleration
- Maximum C4 x- and z-acceleration
- Maximum T1 x- and z-acceleration
- Maximum T8 x- and z-acceleration
- Maximum L1 x- and z-acceleration
- Maximum Pelvis x- and z-acceleration
- Maximum and minimum Upper Neck Loads (F_x , F_z and M_y , before head contact stop)
- Maximum and minimum Lower Neck Loads (F_x , F_z and M_y , before head contact stop)
- Maximum Occipital condyle rel. T1 x- and z-displacement in the T1 frame (OC-x and OC-z)
- Maximum Head rel. T1 angular displacement
- Head Contact Time (HCT)
- Maximum Head Rebound Velocity (HRV)



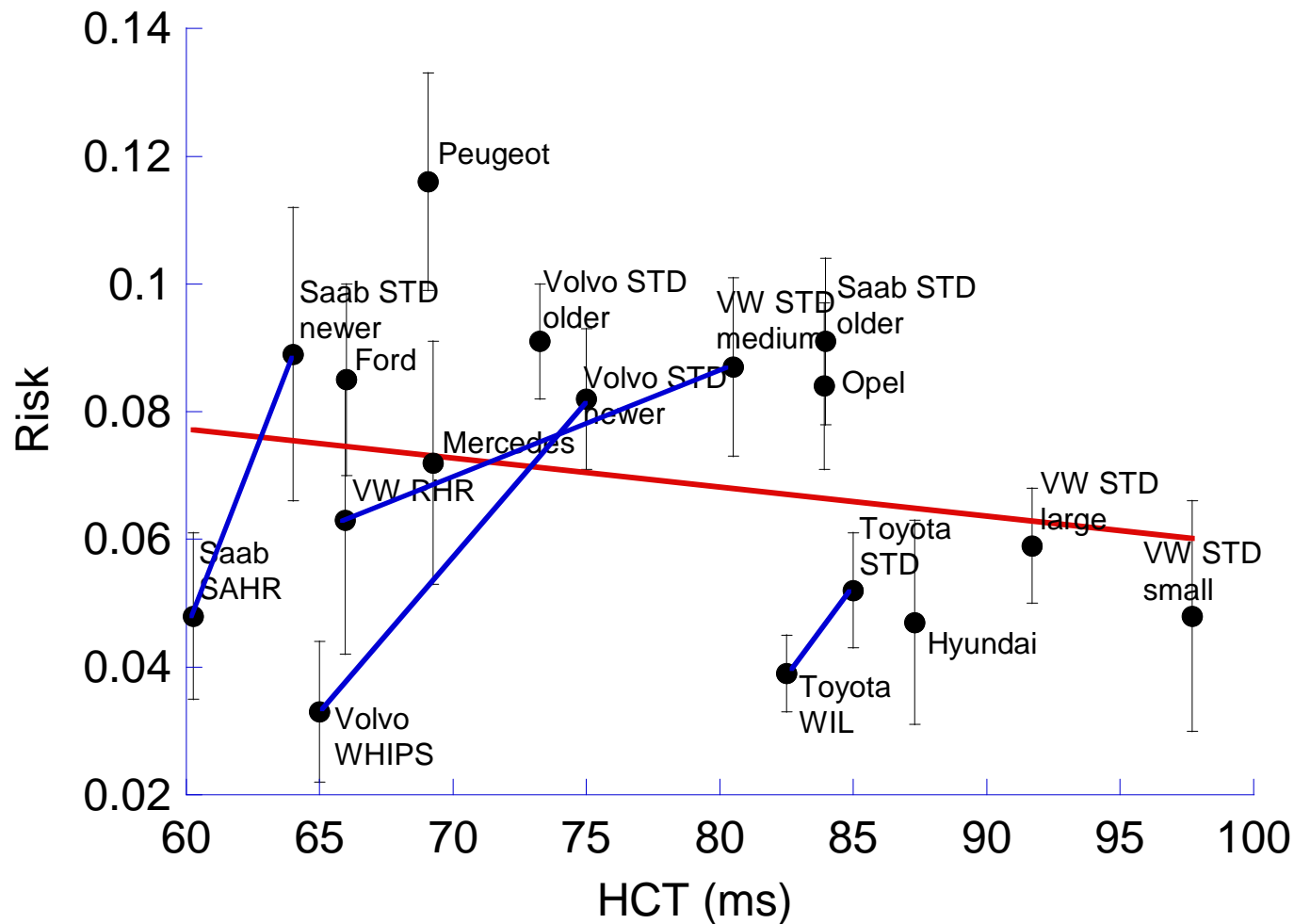
Results: Neck Injury Criteria versus permanent medical impairment



Results: Occipital Condyles rel. T1 x- disp. versus permanent medical impairment



Results: Head Contact Time versus permanent medical impairment



Results: Correlation R^2 values

| Parameter | Permanent medical impairment | Symptoms < 1 month |
|--|------------------------------|--------------------|
| NIC | 0.59 | 0.72 |
| OC rel. T1 x-displacement (retraction) | 0.42 | 0.39 |
| L1 x-acceleration | 0.42 | 0.32 |
| Pelvis z-acceleration | 0.40 | 0.19 |
| L1 z-acceleration | 0.37 | 0.14 |
| Head rel. T1 y-rot. (extension) | 0.35 | 0.53 |
| N_{km} | 0.33 | 0.38 |
| T8 x-acceleration | 0.28 | 0.29 |
| T8 z-acceleration | 0.22 | 0.07 |
| U. N. F_x (head r.w.) | 0.19 | 0.23 |
| L. N. F_x (head f.w.) | 0.17 | 0.22 |
| L. N. M_y (negative) | 0.16 | 0.20 |
| T1 x-acceleration | 0.15 | 0.40 |

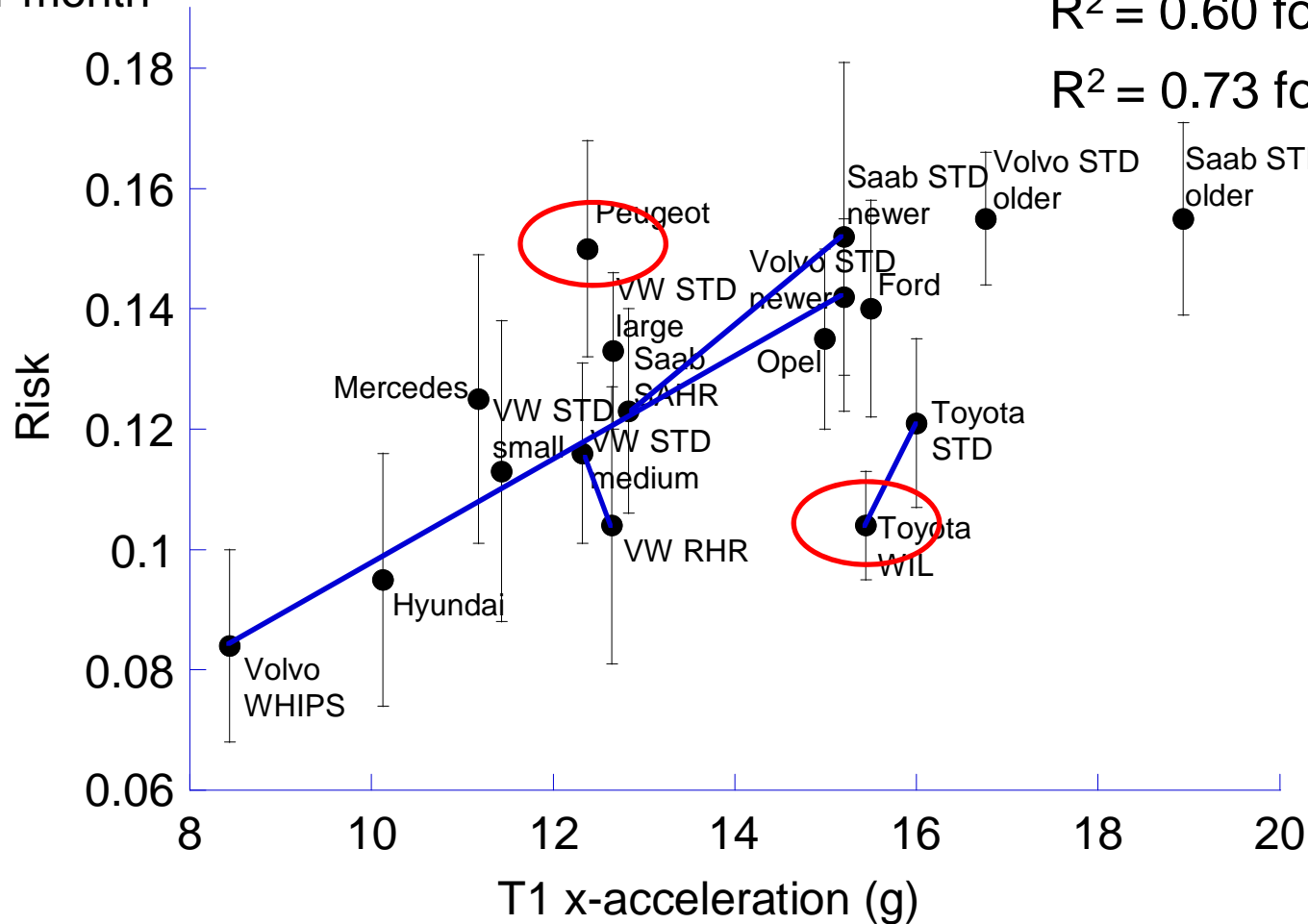
Discussion 1: Effect of outliers

Risk of symptoms
>1 month

$R^2 = 0.40$ for 17 datasets

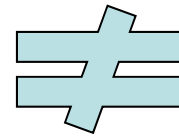
$R^2 = 0.60$ for 16 datasets

$R^2 = 0.73$ for 15 datasets



Discussion 2: Injury risk measures

Risk of long term symptoms and impairments given the occupant had initial symptoms following a rear-end impact



Risk of long term symptoms and impairments given the occupant were in a rear-end impact

Discussion 3: Dummy tests

- Since the BioRID tests were carried out:
 - Test procedures modernized
 - Dummy calibration routines changed
 - Dummy build level updated
- Single sled pulse was used
 - Evaluate injury predictability of the complete sled test method

Conclusions

- NIC, L1-acceleration and Occipital condyles relative T1 x-displacement correlate with long term injury risk:
 - NIC 25 m^2/s^2
 - L1 x-acceleration 120 m/s^2
 - Occipital Condyle x-displacement 22 mm
- Neck extension and T1 x-acceleration may be candidates but appear to be sensitive to set model inclusion
- These findings are in partial agreement with other studies on this
- Additional parameters may predict PMI and long term symptoms

End!

Many thanks to Thatcham and Autoliv for providing
BioRID seat test data!