

**Whiplash injury
June 2004**

Press conference
2004-06-04

How do Volvo and
Saab seats protect
from whiplash injury in
real-life crashes

How do car seats
protect from whiplash
injury in rear-end crash
tests

Evaluation of Whiplash Injury Risk

-

**Results from Crash Tests
and Real-life Crashes**

Folksam

**Swedish National Road Administration
June 2004**

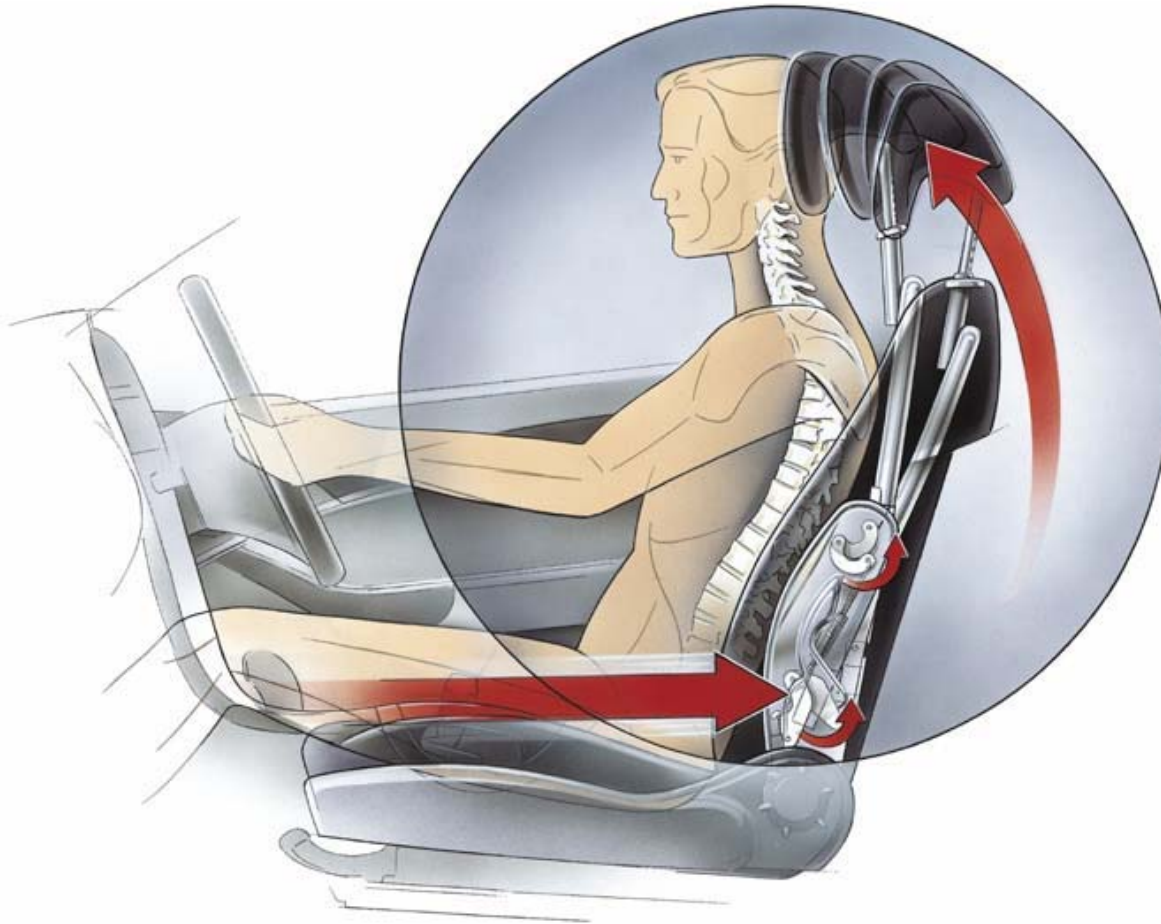
INJURY REDUCING EFFECT IN REAL-LIFE CRASHES

- Whiplash protection in
 - Volvo and Saab Cars since 1998
 - After market device in Toyota Corolla model year 1993

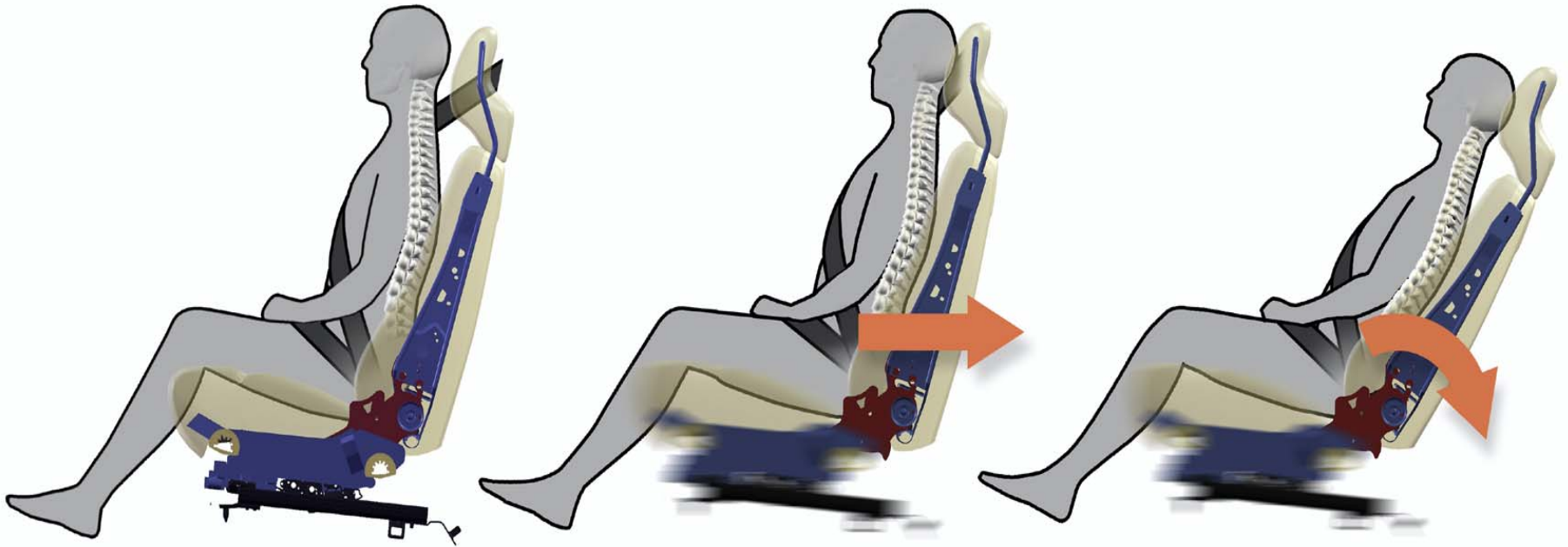
Volvo-Saab study - material and method

- Volvo and Saab models with and without whiplash protection system were compared
- Crashes reported to Folksam between January 1998 - February 2003
- Injuries classified according to duration of whiplash symptoms

Saab Active Head Restraint (SAHR)



Volvo - Whips



Car models compared in the study

Cars without whiplash protection system

SAAB 9000

SAAB 900, 1993-97

Volvo S40/V40, 1996-99

Volvo 850

Volvo V70/S70 1998-00

Cars with whiplash protection system

SAAB 9-5

SAAB 9-3

Volvo S40/V40, 2000-

Volvo S70/V70, 2000-

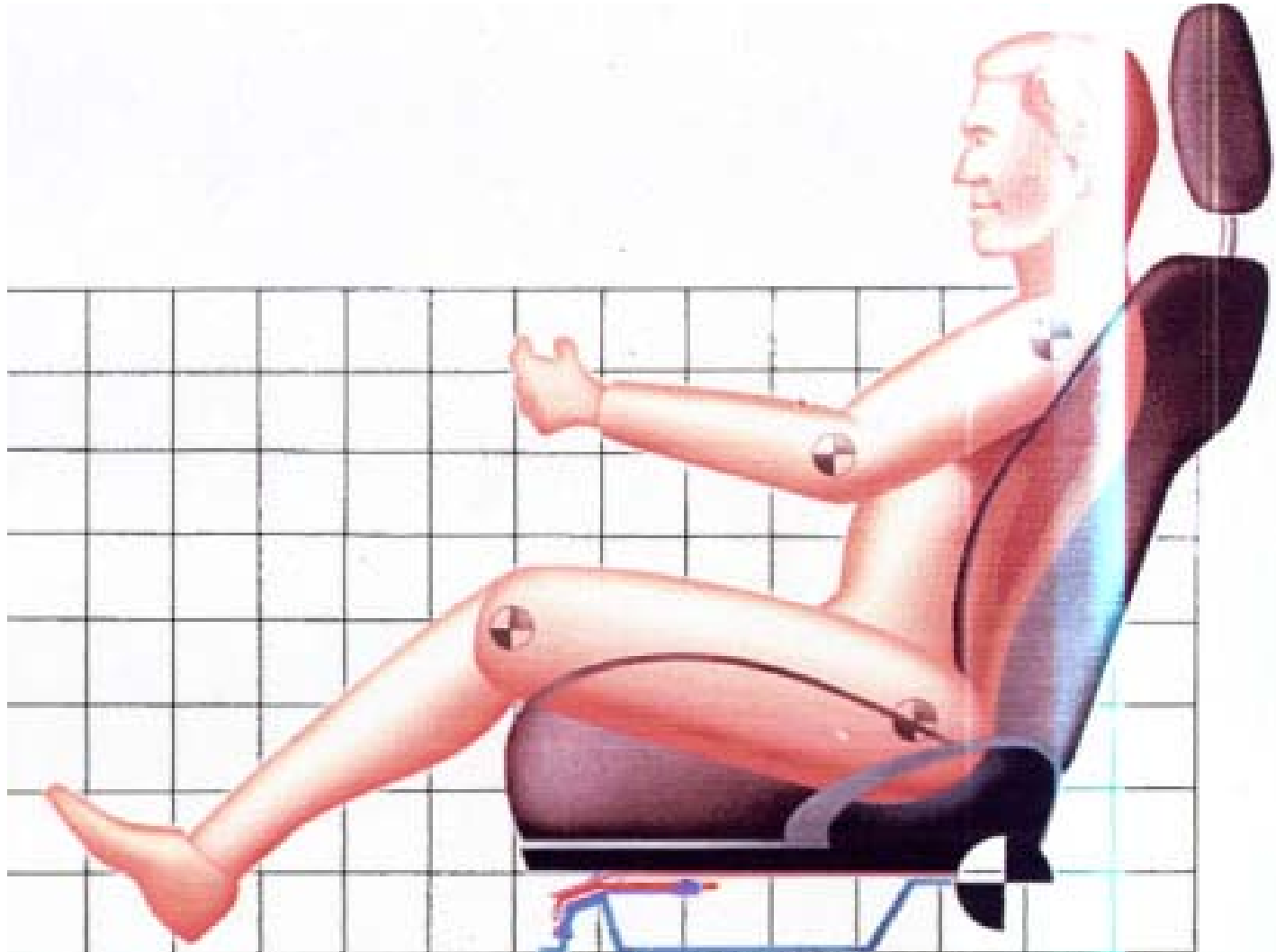
Volvo S80

Average injury reducing effect of whiplash systems in Volvo and Saab cars (Whips and SAHR)

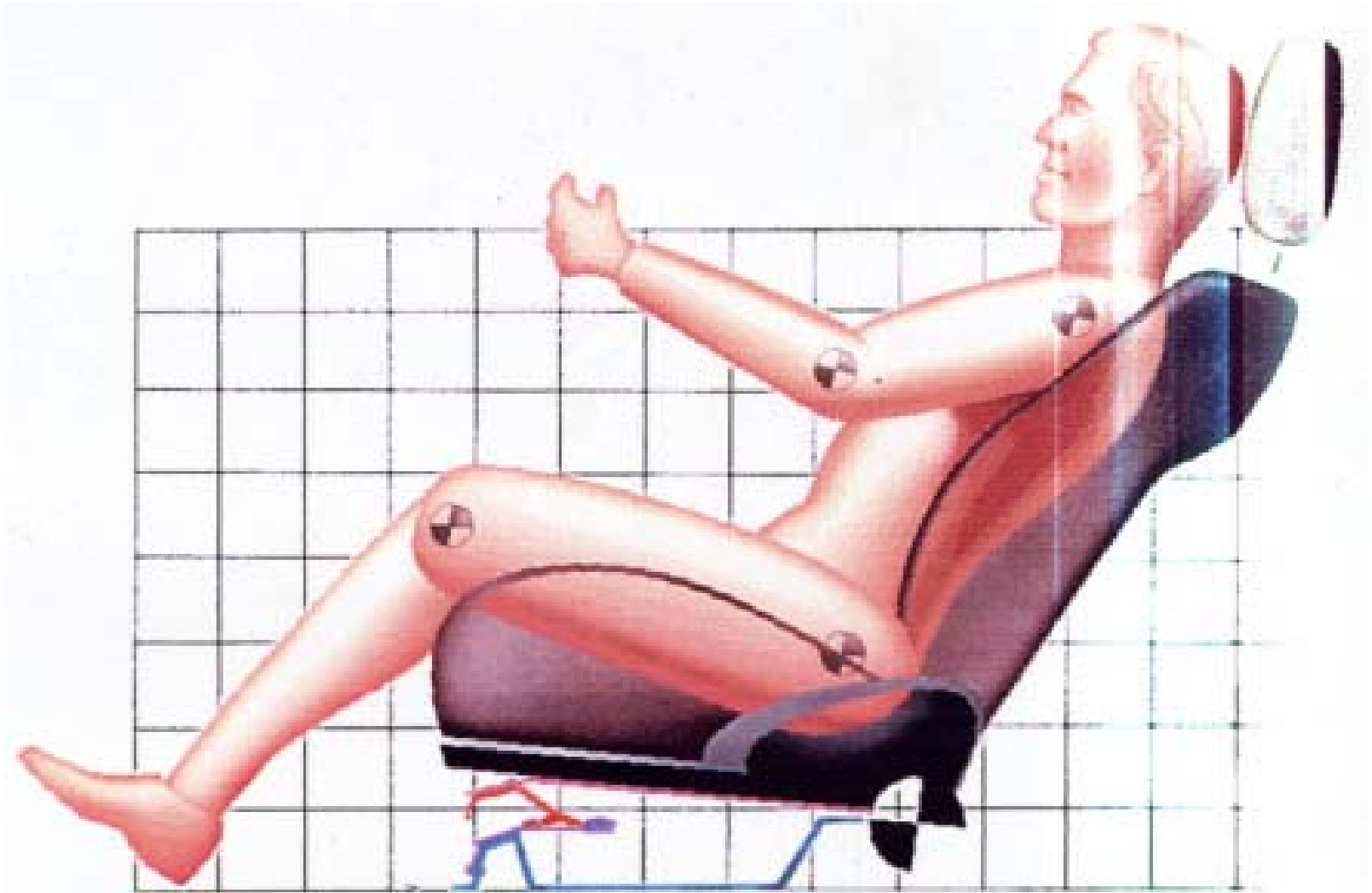
40% (+/- 21%) lower risk for whiplash injury with symptoms for more than 6 months

Whiplash system	Number of crashes (all impact directions)	Symptoms 0-6 months (rear-end)	Symptoms > 6 months (rear-end)
Without	15 892	403	202 (1,3%)
With	1 813	43	14 (0,8%)

Aftermarket whiplash device



Aftermarket whiplash device



Injury reducing effect of Aftermarket device in real-life crashes

Injury level	With device	No device	Inj. reducing effect
Initial symptoms	14/58	31/82	37% (sign> 0)
Symptoms > 1 m	5/58	15/82	52% (not sign)
Symptoms > 6 m	1/58	9/82	84% (sign>0)

**WHIPLASH PERFORMANCE
RATINGS OF CAR SEATS
-
RESULTS FROM CRASH TESTS**

Crash tests

- Determination of test specifications based on real-life data from Folksam
- Dummy measurements - injury criteria
- Risk classification
- Results

Determination of test specifications

Real-life data from Folksam

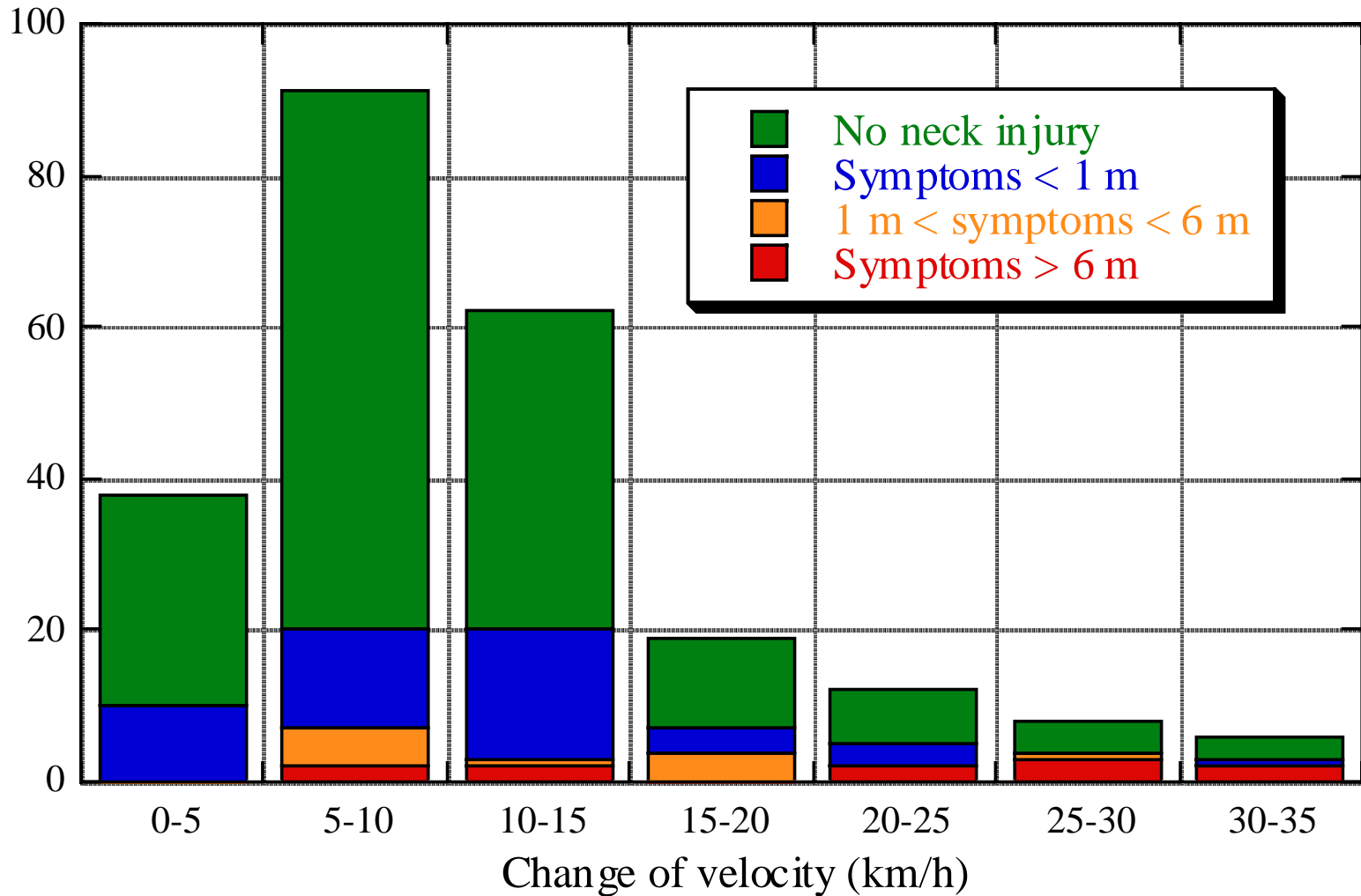
- Crash severity from crash pulse recorders
- Injuries classified in duration of whiplash symptoms
- The data entails us the possibility to:
 - Correlate change of velocity, acceleration levels to injury outcome
 - Evaluate injury criteria (predictability)

Inclusion criteria

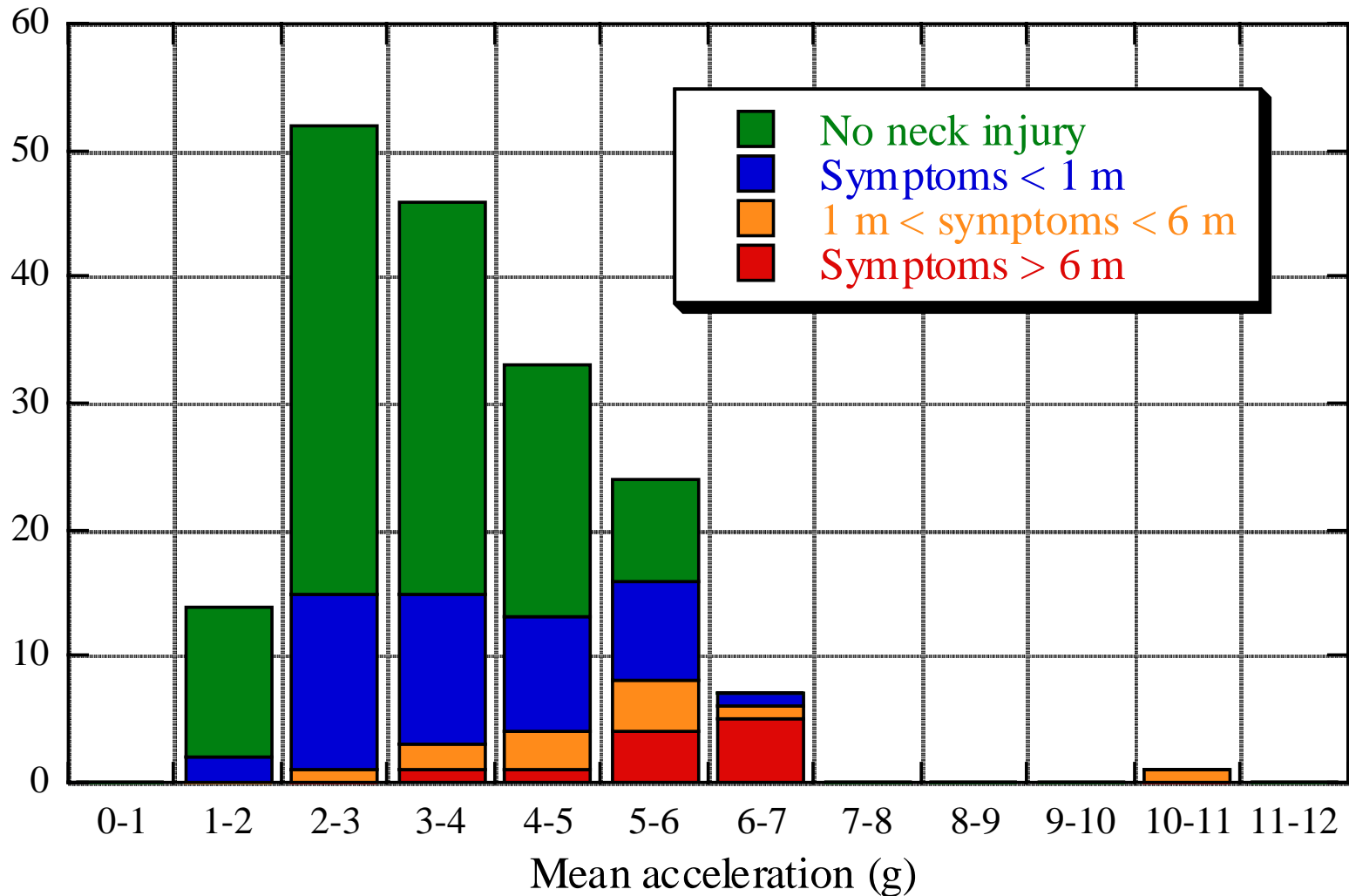
- Toyota models in Folksam database
 - Corolla 93-97 + 98-01 + 02->
 - Yaris
 - Avensis
- No previous whiplash injury
- No multiple events

=> 131 crashes with 177 occupants
23 with symptoms > 1 month
11 with symptoms > 6 months

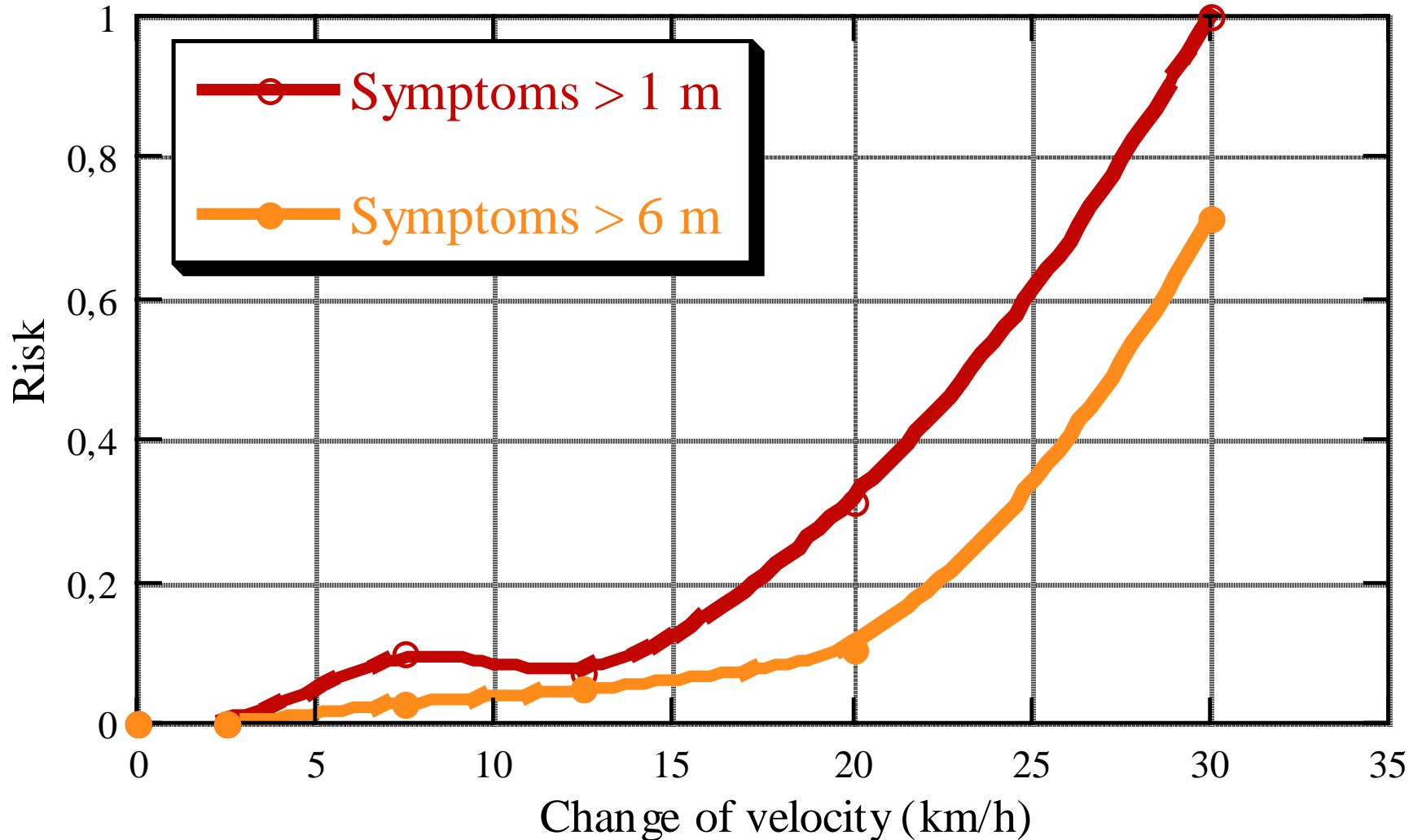
Number of crashes and injured in intervals of change of velocity (n=177)



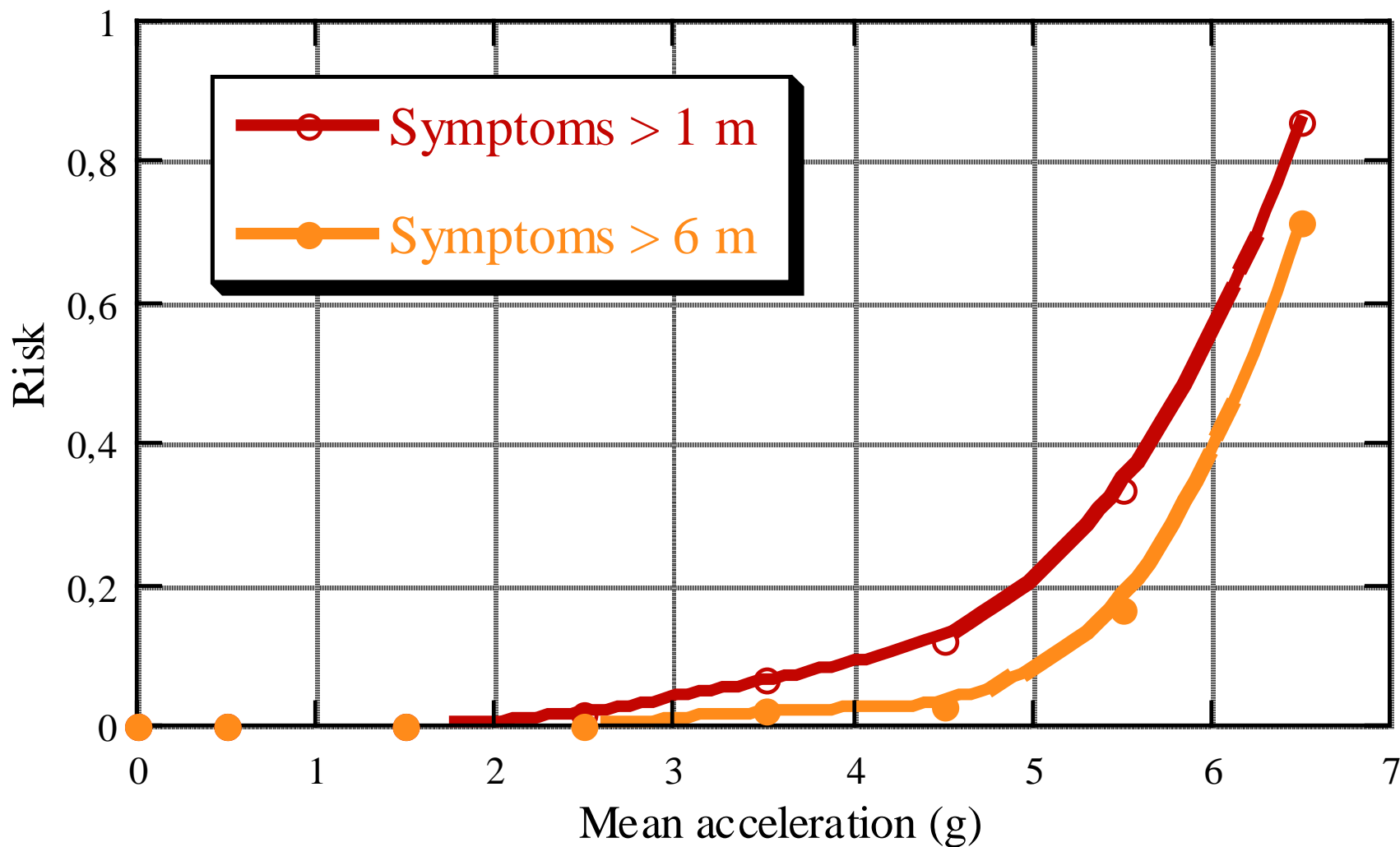
Number of crashes and injured in intervals of mean acceleration (n=177)



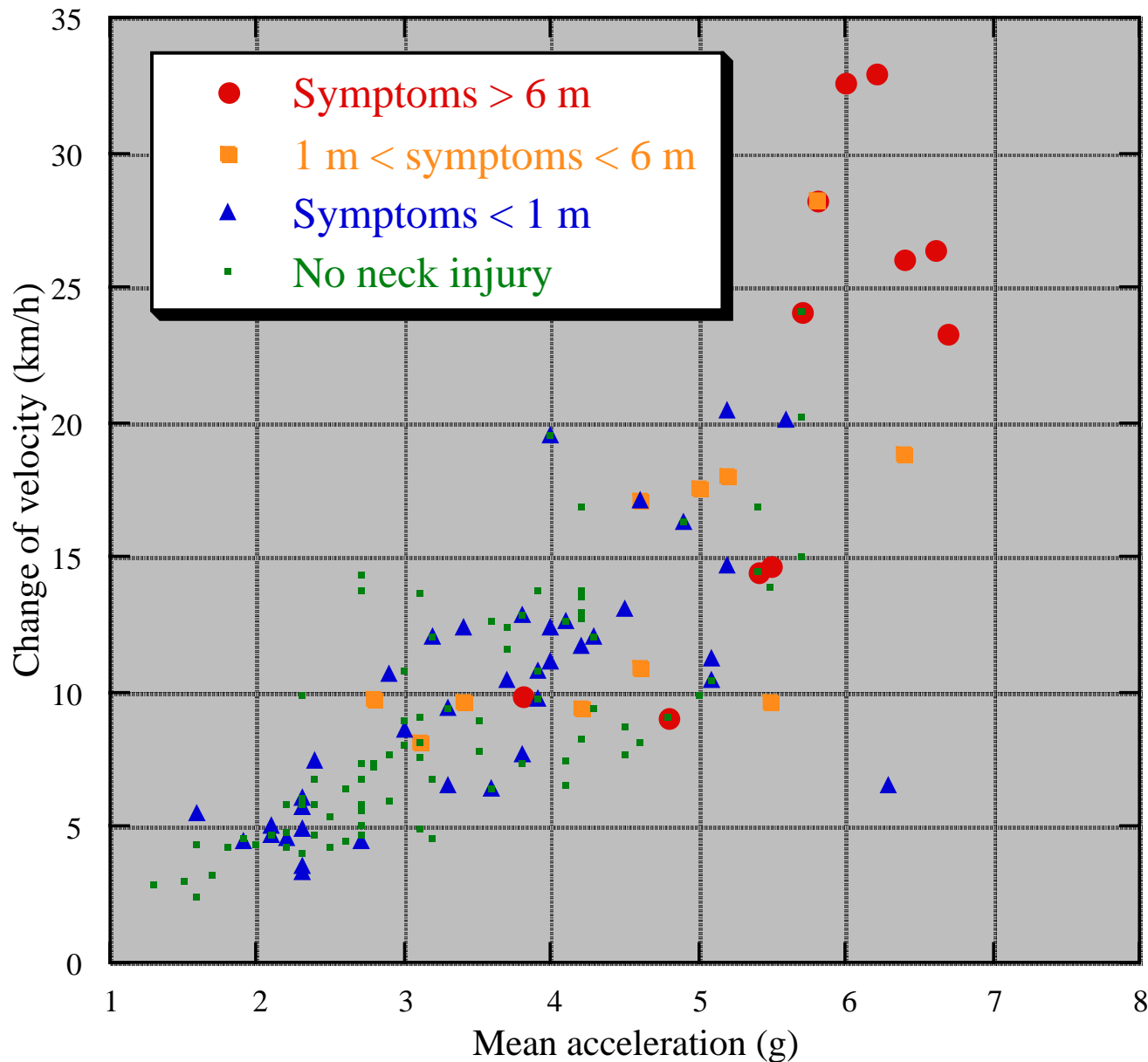
Risk of long-term whiplash injury risk versus change of velocity



Risk of long-term whiplash injury risk versus mean acceleration



Change of velocity and mean acceleration for all occupants



Test speed and acceleration

Test	Speed	Mean acceleration
1 - "Low" severity	16 km/h	4,5 g
2 - Medium severity	16 km/h	5,5 g
(small difference 2003 to 2004)		
3 - High severity	24 km/h	6,5 g

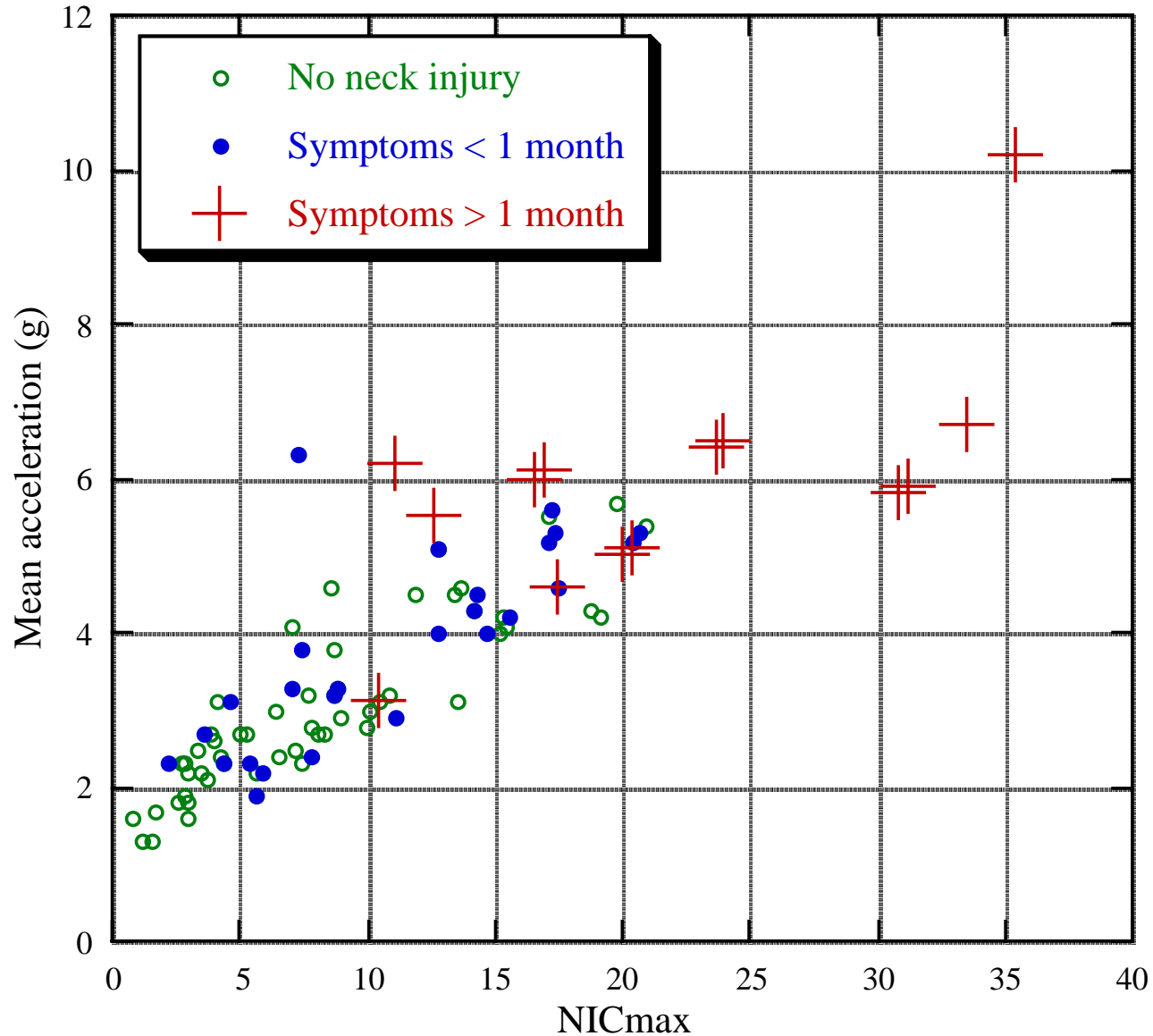
Dummy measurements (BioRID II)

3 parameters related to

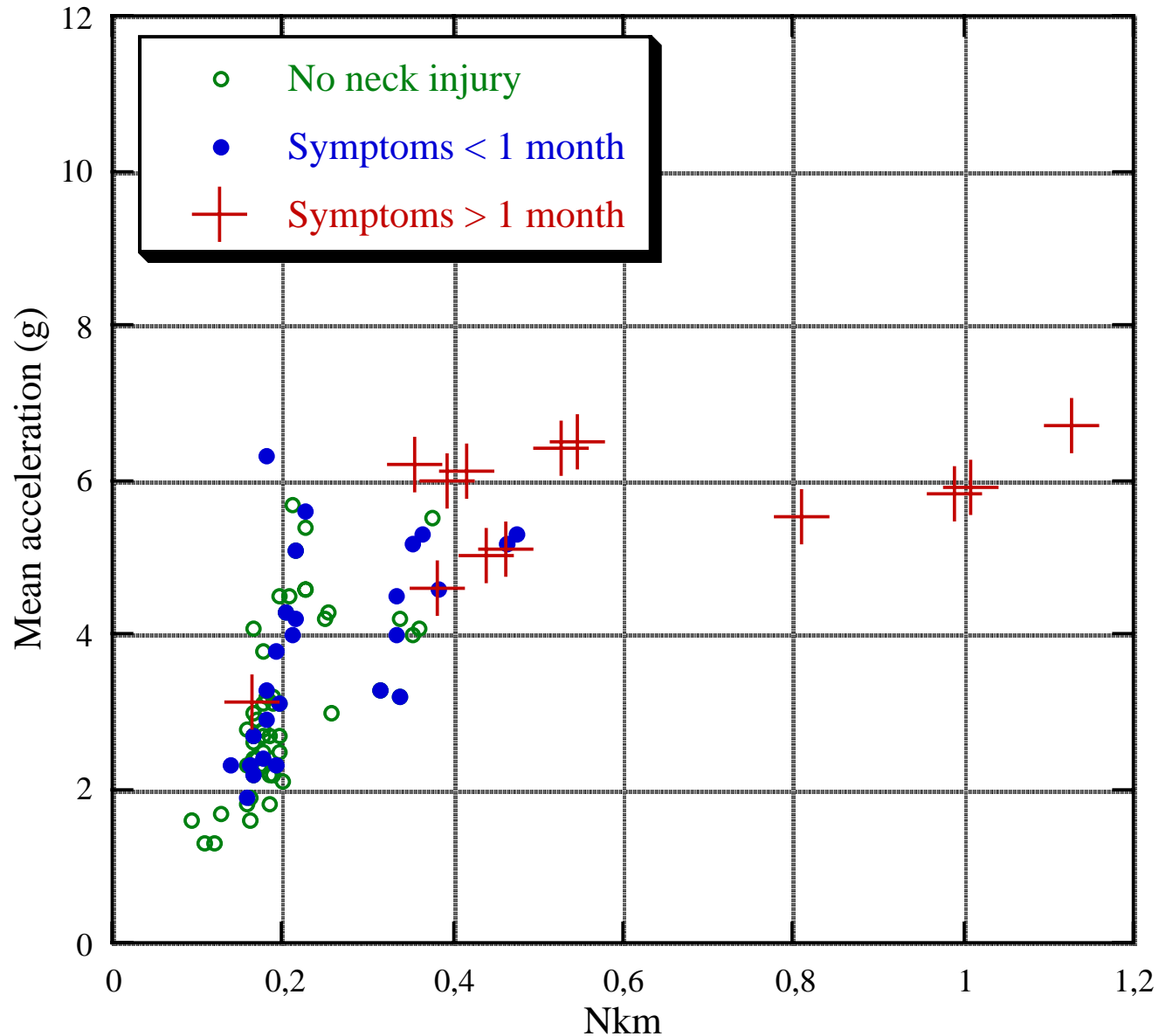
3 proposed injury mechanisms

- NIC_{max} based on relative acceleration between head and thorax (T1), Maximum value often occur before head rest contact
- N_{km} measures forces and moments in the upper neck
Maximum value during contact with head rest
- Head rebound velocity (instead of neck injury criteria in the flexion motion of the head), Mirrors the energy absorption of the seat

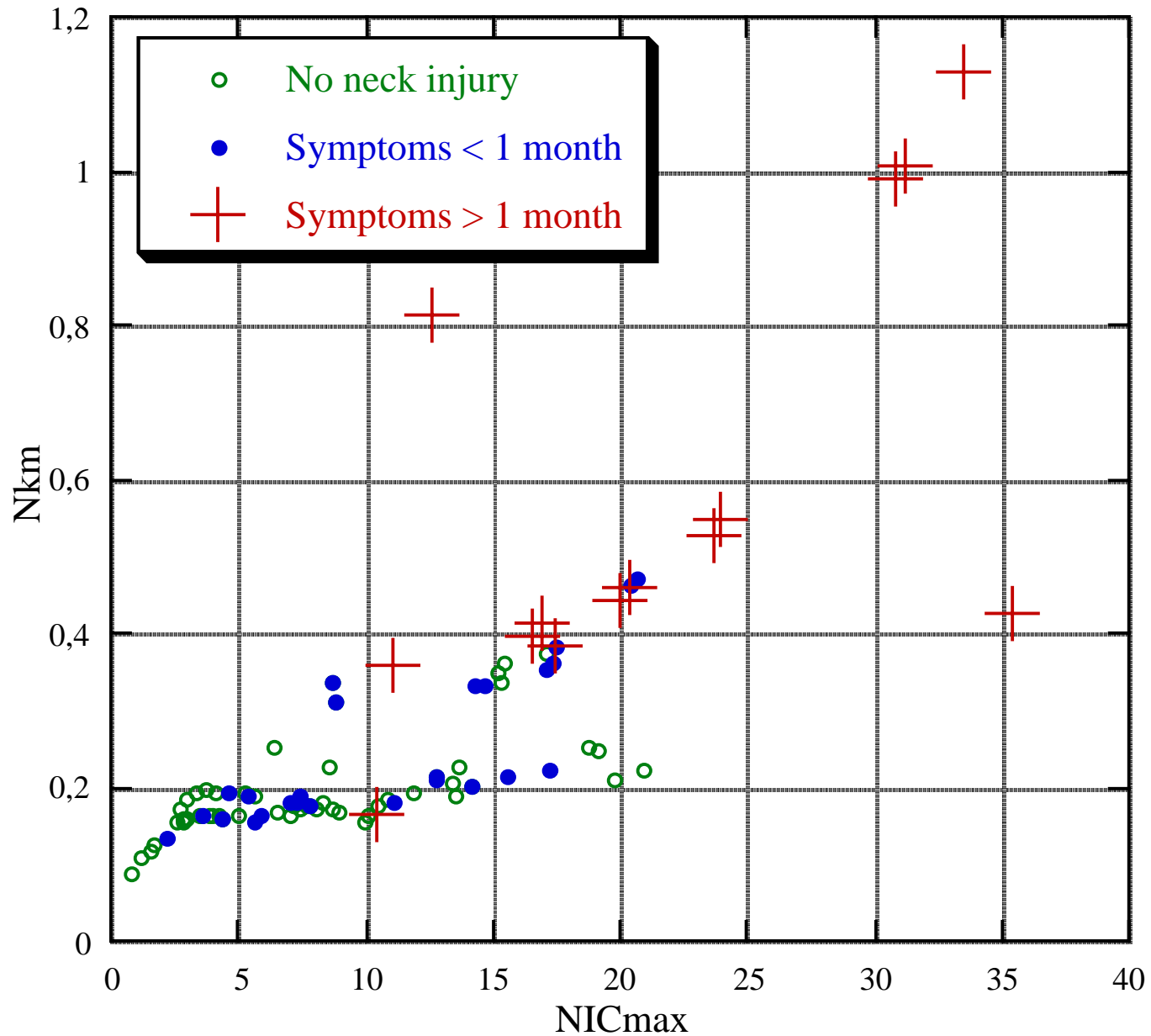
Simulated BioRID-NICmax and recorded mean acceleration



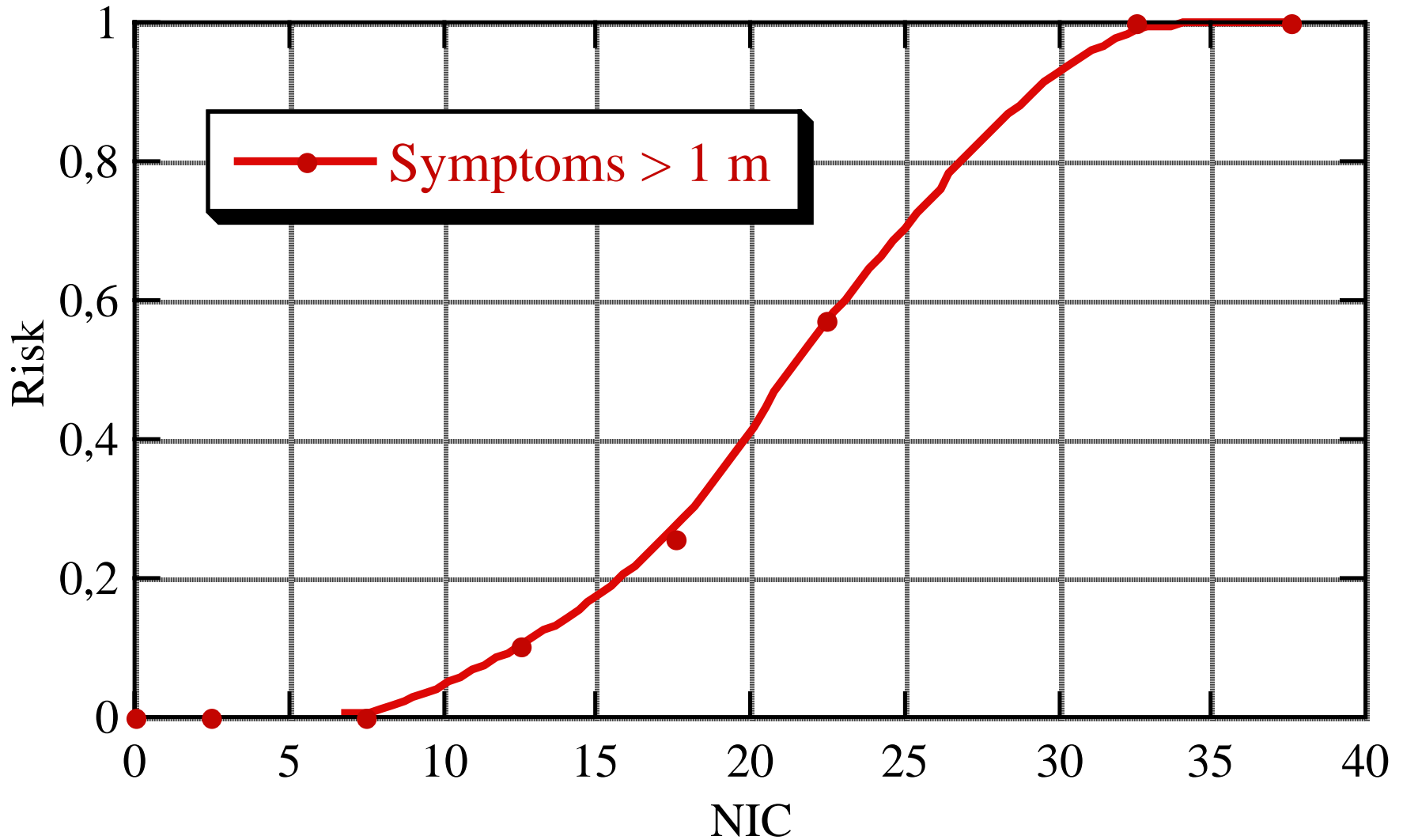
Simulated BioRID-Nkm and recorded mean acceleration



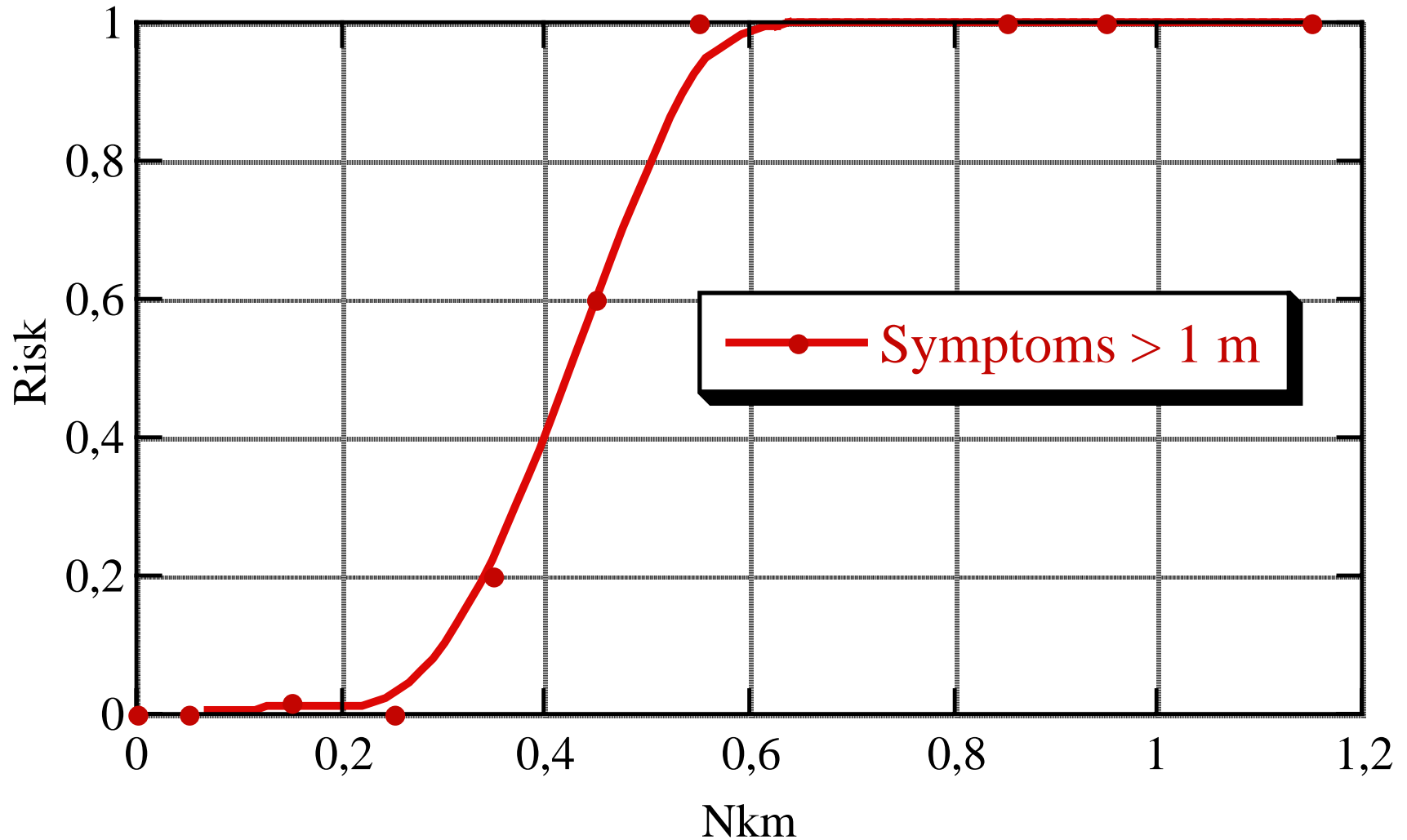
Simulated NICmax and Nkm



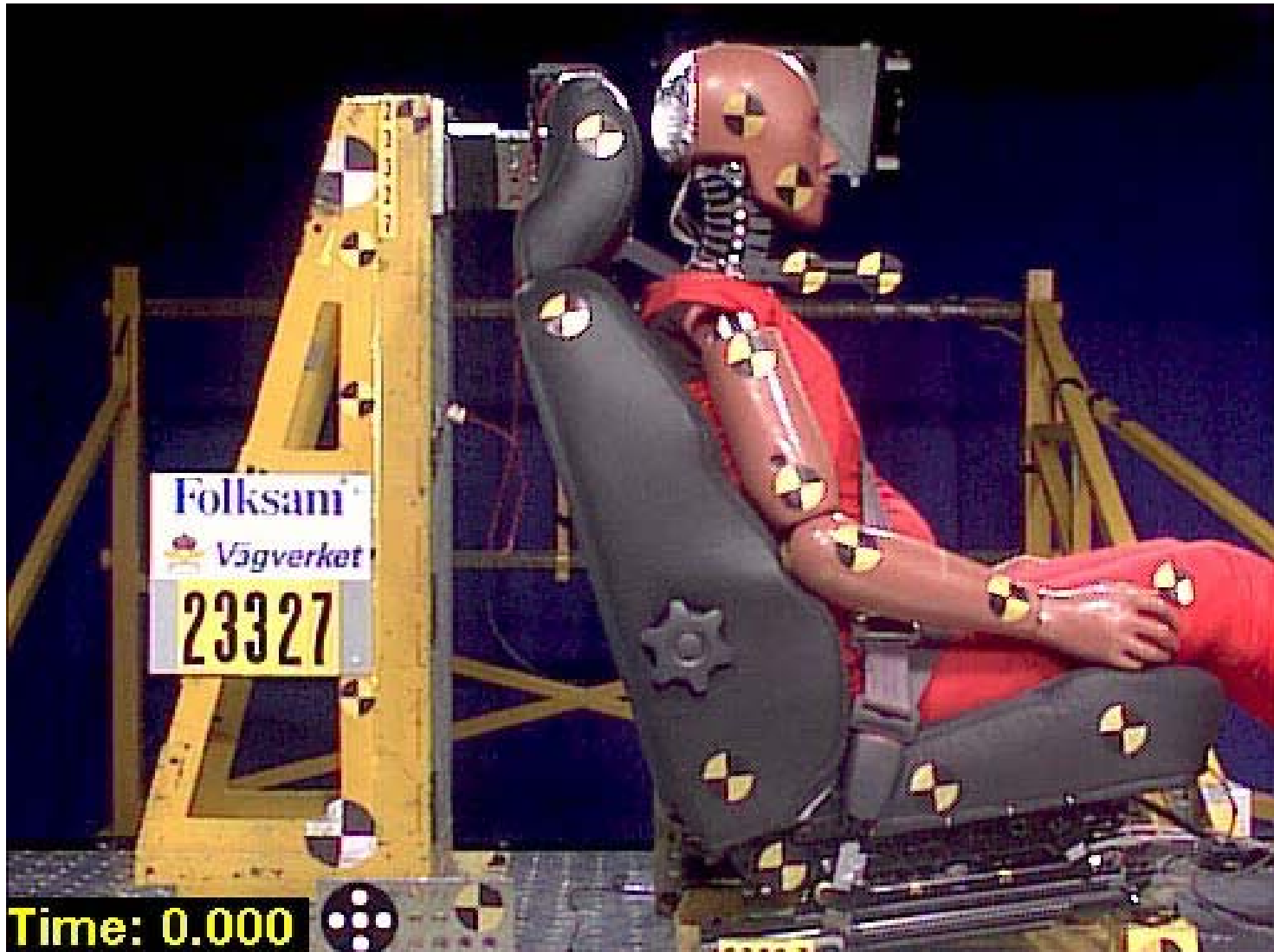
Neck injury risk versus NIC_{max}



Neck injury risk versus N_{km}



Example of seat attached to the sled



Risk classification, points and limits

Points	NIC	Nkm	Rebound vel.
0	< 15	< 0,3	< 4,5
0-1,9	15,1 - 18,0	0,31 - 0,40	4,6 - 6,0
2	> 18	> 0,40	> 6,0 (1 point)

Group	Points
Green+	0,0 - 2,5
Green	2,6 - 5,0
Yellow	5,1 - 10,0
Red	10,1 - 15,0

Best Pick

Test results 2004

0 - 5,0 Points

Ford C-max
Green+ (2,2) **Best Pick** ☆
No whiplash protection system

Volvo S40
Green+ (1,1) **Best Pick** ☆
Equipped with whiplash protection system

Nissan Primera
Green (3,1)
Equipped with whiplash protection system

SAAB 9-5
Green (4,2)
Equipped with whiplash protection system

5,1 - 10,0 Points

Audi A3 - Model year 2005
Yellow (8,5)
Equipped with whiplash protection system

Citroen C3
Yellow (9,0)
No whiplash protection system

Ford Focus
Yellow (7,9)
No whiplash protection system

Mitsubishi Space Star
Yellow (9,4)
No whiplash protection system

Opel Meriva (Extra equipment)
Yellow (7,2)
Equipped with whiplash protection system

Seat Ibiza
Yellow (9,4)
No whiplash protection system

Toyota Avensis
Yellow (7,3)
Equipped with whiplash protection system

VW Touran
Yellow (9,1)
Equipped with whiplash protection system

10,1 - 15,0 Points

Audi A3 - Model year 2004
Red (13,5)
Equipped with whiplash protection system

Opel Meriva (Standard equipment)
Red (13,4)
No whiplash protection system

Test results 2004

Audi A3 - Model year 2005

Yellow (8,5)

Equipped with whiplash protection system

Audi A3 - Model year 2004

Red (13,5)

Equipped with whiplash protection system

Citroen C3

Yellow (9,0)

No whiplash protection system

Ford C-max

Green+ (2,2)

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Best Pick

Ford Focus

Yellow (7,9)

No whiplash protection system

Mitsubishi Space Star

Yellow (9,4)

No whiplash protection system

Nissan Primera

Green (3,1)

Equipped with whiplash protection system

	Pulse	NIC	Points	Nkm	Points	Rebound	Points
Low	14,6	0,0	0,37	1,4	4,60	0,1	
Medium	23,9	2,0	0,49	2,0	4,80	0,2	
Severe	21,1	2,0	0,31	0,2	5,50	0,7	
Low	19,7	2,0	0,40	2,0	4,80	0,2	
Medium	27,6	2,0	0,41	2,0	5,02	0,3	
Severe	27,5	2,0	0,40	2,0	6,32	1,0	
Low	18,0	2,0	0,23	0,0	4,62	0,1	
Medium	30,9	2,0	0,28	0,0	5,06	0,4	
Severe	26,9	2,0	0,39	1,8	5,58	0,7	
Low	11,4	0,0	0,10	0,0	4,11	0,0	
Medium	15,8	0,5	0,13	0,0	4,68	0,1	
Severe	14,9	0,0	0,33	0,6	6,06	1,0	
Low	17,2	1,5	0,16	0,0	3,99	0,0	
Medium	29,1	2,0	0,26	0,0	4,61	0,1	
Severe	27,3	2,0	0,54	2,0	4,97	0,3	
Low	17,0	1,3	0,32	0,4	4,62	0,1	
Medium	24,7	2,0	0,35	1,0	4,85	0,2	
Severe	23,9	2,0	0,37	1,4	6,00	1,0	
Low	9,2	0,0	0,28	0,0	4,04	0,0	
Medium	10,9	0,0	0,33	0,6	4,37	0,0	
Severe	14,4	0,0	0,60	2,0	5,30	0,5	

Test results 2004

Opel Meriva (Standard equipment)

Red (13,4)

No whiplash protection system

Pulse

Low

Medium

Severe

NIC

Points

Nkm

Points

Rebound

Points

20,0	2,0	0,46	2,0	4,65	0,1
27,0	2,0	0,51	2,0	4,90	0,3
29,5	2,0	0,53	2,0	6,36	1,0

Opel Meriva (Extra equipment)

Yellow (7,2)

Equipped with whiplash protection system

Low

Medium

Severe

14,8	0,0	0,12	0,0	4,35	0,0
19,3	2,0	0,10	0,0	4,77	0,2
20,1	2,0	0,41	2,0	6,09	1,0

SAAB 9-5

Green (4,2)

Equipped with whiplash protection system

Low

Medium

Severe

10,9	0,0	0,26	0,0	3,77	0,0
18,0	2,0	0,28	0,0	3,55	0,0
24,6	2,0	0,31	0,2	4,33	0,0

Seat Ibiza

Yellow (9,4)

No whiplash protection system

Low

Medium

Severe

16,4	0,9	0,47	2,0	3,83	0,0
27,2	2,0	0,23	0,0	4,12	0,0
23,0	2,0	1,11	2,0	5,28	0,5

Toyota Avensis

Yellow (7,3)

Equipped with whiplash protection system

Low

Medium

Severe

15,3	0,2	0,16	0,0	4,06	0,0
19,7	2,0	0,27	0,0	4,62	0,1
25,0	2,0	2,19	2,0	6,31	1,0

Volvo S40

Green+ (1,1)

Equipped with whiplash protection system

Best Pick

Low

Medium

Severe

10,9	0,0	0,12	0,0	2,75	0,0
14,2	0,0	0,19	0,0	3,33	0,0
15,5	0,3	0,31	0,2	5,40	0,6

VW Touran

Yellow (9,1)

Equipped with whiplash protection system

Low

Medium

Severe

13,1	0,0	0,34	0,8	4,79	0,2
22,2	2,0	0,38	1,6	5,27	0,5
22,3	2,0	0,35	1,0	6,56	1,0

Summary of results 2003

Not directly comparable with 2004 results

0 - 5,0 points

5,1 - 10,0 points

10,1 - 15,0 points

Ford Mondeo

Green (2,6 points)

Whiplash protection system

Audi A4

Yellow (5,5 points)

No whiplash protection system

BMW 3-serie

Red (11,3 points)

No whiplash protection system

Opel Astra (Optional)

Green (4,7 points)

Whiplash protection system

Peugeot 307

Yellow (8,4 points)

Whiplash protection system

Mercedes C-class

Red (10,6 points)

No whiplash protection system

Saab 9-3

Green+ (0,9 points)

Whiplash protection system

Best Pick

Renault Megane

Yellow (9,9 points)

No whiplash protection system

Opel Astra (Standard)

Red (12,1 points)

No whiplash protection system

Toyota Corolla

Green (3,0 points)

Whiplash protection system

Skoda Fabia

Yellow (7,5 points)

No whiplash protection system

VW Polo

Red (11,1 points)

No whiplash protection system

Volvo V70

Green+ (0,0 points)

Whiplash protection system

Best Pick

Toyota Corolla Model year 1993

Yellow (6,8 points)

With after market whiplash system

Toyota Corolla Model year 1993

Red (10,7 points)

No whiplash protection system

Test results I

Model	Pulse	Head rebound					
		NIC	Points	Nkm	Points	vel.	Points
Audi A4	16kph/4,5g	16,3	0,9	0,22	0,0	4,11	0,0
Yellow (5,5 points)	16kph/5,5g	23,3	2,0	0,29	0,0	4,35	0,0
No whiplash protection system	24kph/6,5g	24,5	2,0	0,31	0,2	5,18	0,5
BMW 3-serie	16kph/4,5g	15,7	0,5	0,68	2,0	4,43	0,0
Red (11,3 points)	16kph/5,5g	18,8	2,0	0,81	2,0	4,83	0,2
No whiplash protection system	24kph/6,5g	29,7	2,0	0,57	2,0	5,56	0,7
Ford Mondeo	16kph/4,5g	12,9	0,0	0,28	0,0	3,60	0,0
Green (2,6 points)	16kph/5,5g	16,6	1,1	0,32	0,4	4,57	0,0
Whiplash protection system	24kph/6,5g	15,1	0,1	0,35	1,0	4,60	0,1
Mercedes C-class	16kph/4,5g	24,0	2,0	0,52	2,0	4,41	0,0
Red (10,6 points)	16kph/5,5g	26,4	2,0	0,57	2,0	4,91	0,3
No whiplash protection system	24kph/6,5g	28,4	2,0	0,31	0,2	4,65	0,1
Opel Astra (Standard)	16kph/4,5g	19,7	2,0	0,45	2,0	3,89	0,0
Red (12,1 points)	16kph/5,5g	19,1	2,0	0,55	2,0	3,58	0,0
No whiplash protection system	24kph/6,5g	20,7	2,0	0,53	2,0	4,67	0,1
Opel Astra (Optional)	16kph/4,5g	16,0	0,7	0,30	0,0	3,55	0,0
Green (4,7 points)	16kph/5,5g	18,0	2,0	0,28	0,0	3,67	0,0
Whiplash protection system	24kph/6,5g	19,9	2,0	0,21	0,0	4,17	0,0

Test results II

Model	Pulse	NIC	Points	Nkm	Points	Head rebound	
						vel.	Points
Peugeot 307	16kph/4,5g	17,2	1,5	0,21	0,0	4,25	0,0
Yellow (8,4 points)	16kph/5,5g	19,0	2,0	0,39	1,8	4,68	0,1
Whiplash protection system	24kph/6,5g	22,1	2,0	0,28	0,0	5,99	1,0
Renault Megane	16kph/4,5g	17,0	1,3	0,23	0,0	4,31	0,0
Yellow (9,9 points)	16kph/5,5g	19,8	2,0	0,42	2,0	4,75	0,2
No whiplash protection system	24kph/6,5g	18,3	2,0	0,55	2,0	5,24	0,5
Saab 9-3	16kph/4,5g	11,3	0,0	0,22	0,0	3,24	0,0
Green+ (0,9 points) Best Pick	16kph/5,5g	14,3	0,0	0,18	0,0	3,22	0,0
Whiplash protection system	24kph/6,5g	16,4	0,9	0,29	0,0	4,50	0,0
Skoda Fabia	16kph/4,5g	17,1	1,4	0,29	0,0	2,98	0,0
Yellow (7,5 points)	16kph/5,5g	20,9	2,0	0,24	0,0	3,39	0,0
No whiplash protection system	24kph/6,5g	24,5	2,0	1,05	2,0	4,68	0,1
Toyota Corolla	16kph/4,5g	14,7	0,0	0,14	0,0	3,96	0,0
Green (3,0 points)	16kph/5,5g	15,0	0,0	0,17	0,0	4,14	0,0
Whiplash protection system	24kph/6,5g	16,5	1,0	0,87	2,0	4,25	0,0
Volvo V70	16kph/4,5g	9,1	0,0	0,09	0,0	2,35	0,0
Green+ (0,0 points) Best Pick	16kph/5,5g	12,8	0,0	0,15	0,0	2,38	0,0
Whiplash protection system	24kph/6,5g	14,1	0,0	0,22	0,0	4,44	0,0
VW Polo	16kph/4,5g	16,6	1,1	0,42	2,0	3,68	0,0
Red (11,1 points)	16kph/5,5g	18,0	2,0	0,43	2,0	3,49	0,0
No whiplash protection system	24kph/6,5g	19,2	2,0	0,67	2,0	4,01	0,0