Assessment of Child Restraint Performance in Crash Tests

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This presentation describes a proposal for assessing child restraint performance. It does not necessarily represent the policy of the Australian New Car Assessment Program or any other organisation.

Introduction

- Since 1999 the Australian New Car Assessment Program (ANCAP) has included child dummies and child restraint systems (CRS) in the rear seat of crash-tested vehicles.
- Injury and kinematic data have been obtained for these dummies but, to date, no assessments of performance have been published by ANCAP
- This talk will explore the options that are available for rating CRS performance

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This talk will explore the options that are available for rating CRS performance

World CRS Assessment

- Euro NCAP and ANCAP include CRS in crash tests of vehicles
- Australian CREP conducts sled tests of CRS and usability tests.
- JNCAP conducts sled tests of CRS but does not include CRS in its vehicle crash tests. Usability is also rated
- NHTSA does not currently conduct dynamic tests of CRS but rates usability. IIHS participated in some of these tests. NHTSA is looking at dynamic tests
- Consumers Union of US has apparently conducted some sleds tests and usability tests.
- ICBC conducts research and rates usability

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DATA COLLECTED IN ANCAP TESTS

The offset test is conducted at 64km/h.

Two P-series child dummies are placed in the rear seat, with the 3yro sitting behind the driver. Safe N Sound Series 3 child seats are used unless the vehicle manufacturer nominates another CRS.

The dummies measure head and chest deceleration.

Several video anglers of the crash are available. Analysis of these videos gives an estimate of the forward excursion of the dummy head. Also unusual incidents might be noted. In this clip there was excessive movement of the seat back.

The side impact test is conducted at 49km/h. A deformable barrier strikes the driver's side of the vehicle.

The same dummies and CRS are use in this test but this time the p1.5 sits behind the driver, in accordance with the Euro NCAP protocol. Injury measurements are recorded but not used in analysis.

ANCAP test results

- Data from 24 offset crash tests conducted by ANCAP since 1999 have been analysed.
- The child restraints do not score at all well under the proposed EuroNCAP system that sets limits on head and chest decleration and yet we know they perform exceptionally well in real world crashes
- Due to concerns about the Euro NCAP requirements, ANCAP has not published the results of these tests.

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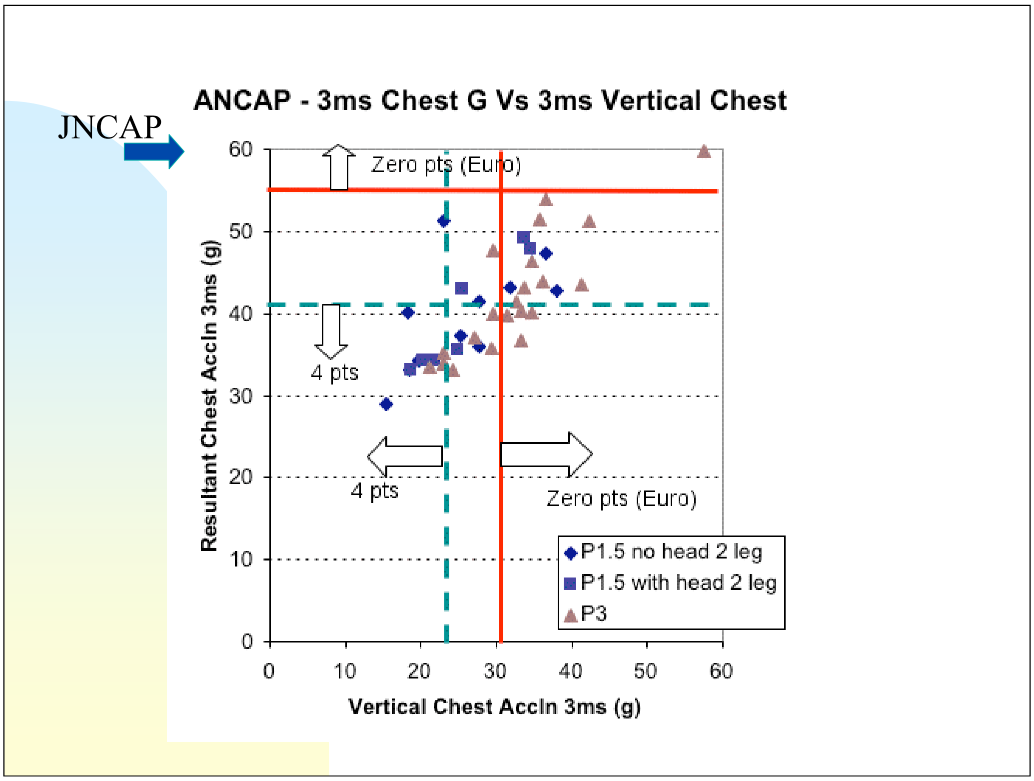
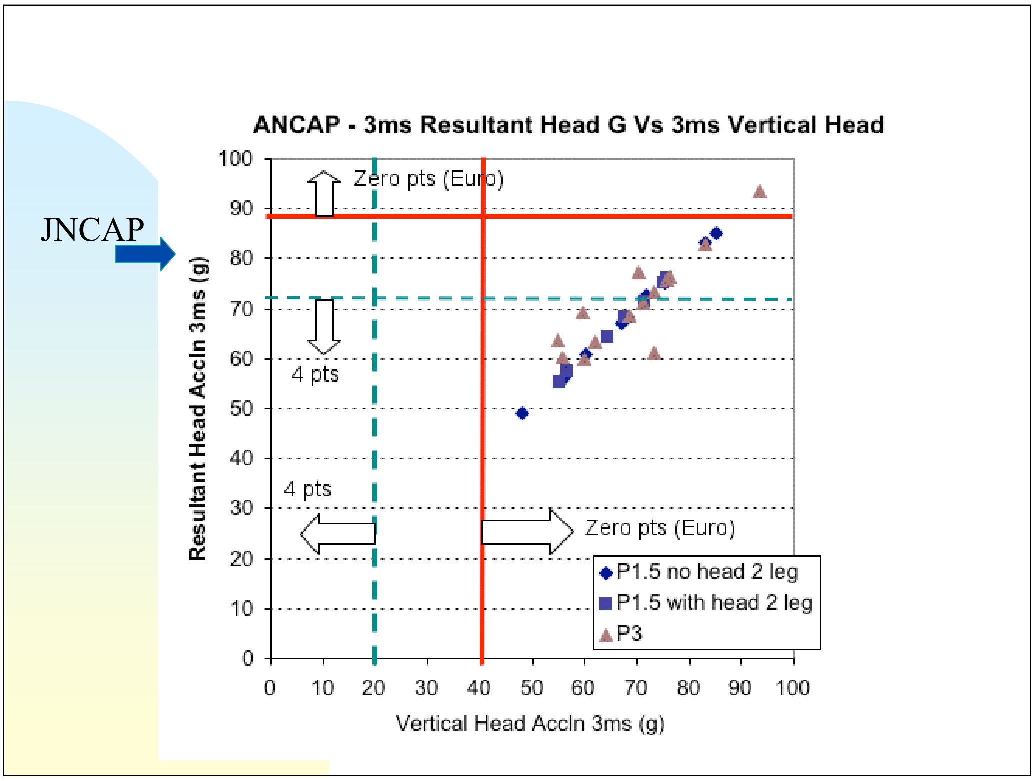


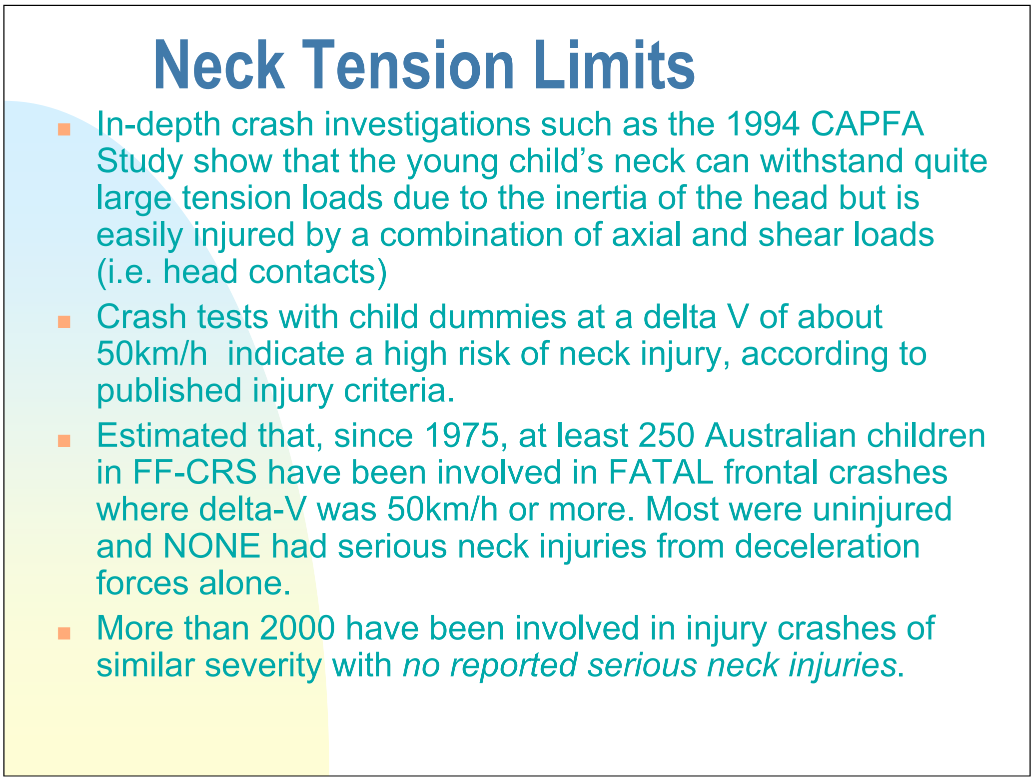
Here are the Australian results for chest deceleration. They perform reasonably well for the resultant chest g (<41g good, >55g poor) but poorly with vertical chest deceleration (>30g poor). My concern is that, although vertical chest deceleration is prescribed in the ECE Regulation, it is only intended to relate to *compression* of the spine that might occur with rearward facing CRS. Limiting *tension* in the spine, as occurs with forward facing CRS, does not make sense.

I have shown the limit applied but JNCAP BUT a different dummy is used.



Here are the Australian results for head deceleration. They all perform reasonable well against the proposed Euro NCAP criteria for resultant deceleration (<72g good, >88g poor) but all perform poorly for vertical deceleration (>40g poor). Euro NCAP intends that vertical head deceleration is used as a surrogate for risk of neck injury but there are serious limitations to this assumption, as I will discuss next.

Again the JNCAP limit is for a different dummy.



NECK TENSION LIMITS

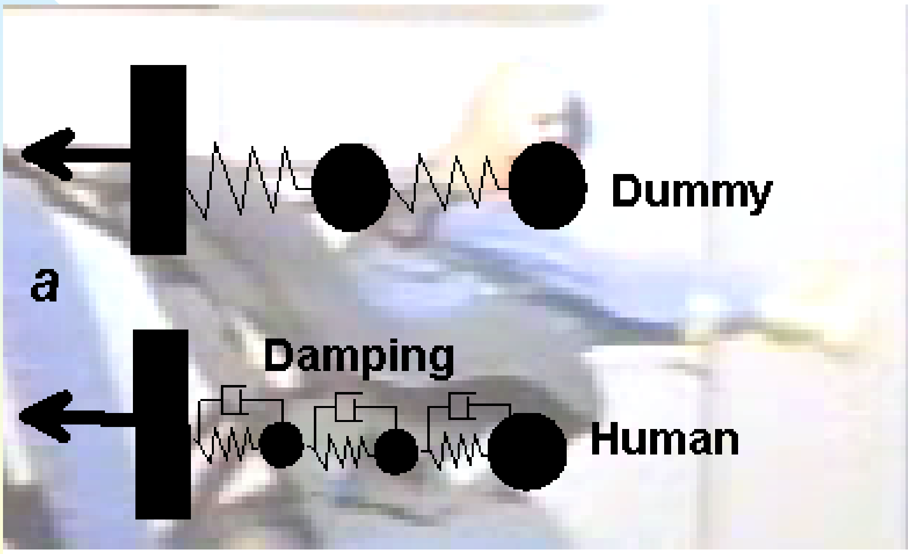
In-depth crash investigations such as the 1994 CAPFA Study show that the young child's neck can withstand quite large tension loads due to the inertia of the head but is easily injured by a combination of axial and shear loads (i.e. head contacts)

Crash tests with child dummies at a delta V of about 50km/h indicate a high risk of neck injury, according to published injury criteria.

Estimated that, since 1975, at least 250 Australian children in FF-CRS have been involved in FATAL frontal crashes where delta-V was 50km/h or more. Most were uninjured and NONE had serious neck injuries from deceleration forces alone.

More than 2000 have been involved in injury crashes of similar severity with *no reported serious neck injuries*.

Dummies are NOT biofidelic in free-flight



Injury criteria apply to specific models of child dummy. Identical RTA sled tests produced a head deceleration of 200g in a TNO P-Series dummy and 60g in a CRABI dummy. This should alert us a problem with dummy biofidelity in this type of crash simulation.

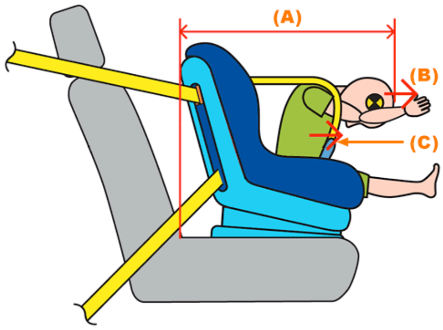
For example, compared with a real human, the child dummy has fewer mass segments, stiffer joints and lacks effective damping between segments.

This means that the acceleration of the head in a free-flight situation can be expected to be much higher in the dummy than in a real human. Neck tension will also be greater.

Dummy measurements in these circumstances cannot be used to predict risk of injury in a child.

Head Excursion

- Euro NCAP proposes to limit forward head excursion
- If head excursion exceeds 550mm score is zero. Otherwise the score is 1 (step function)



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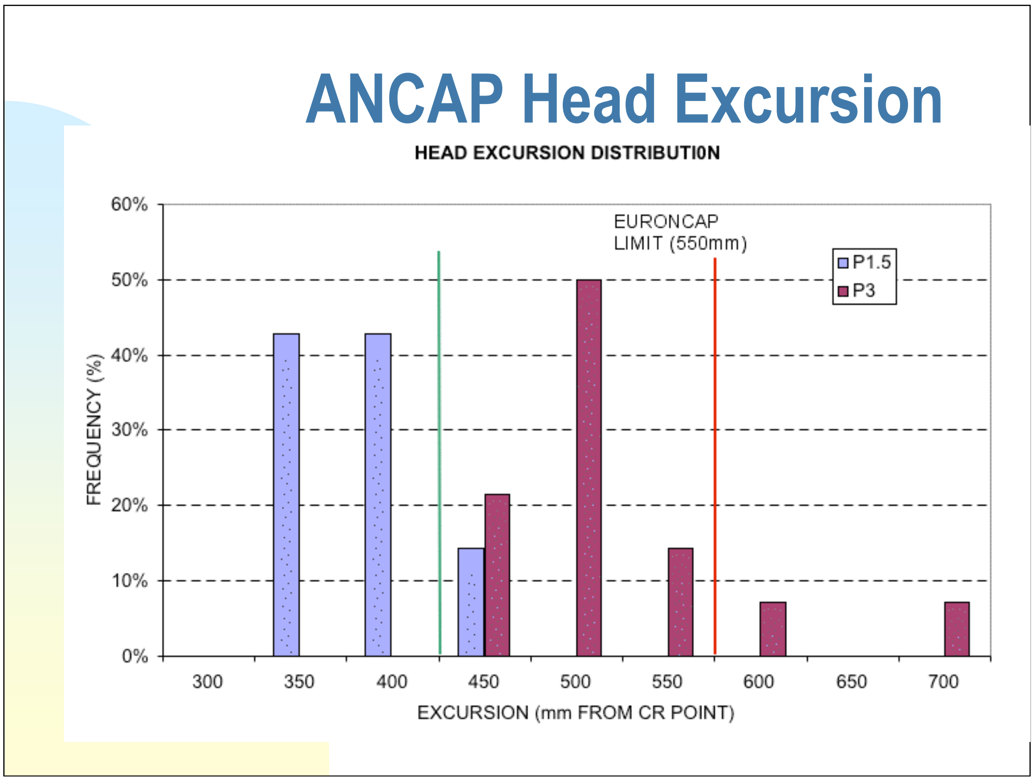


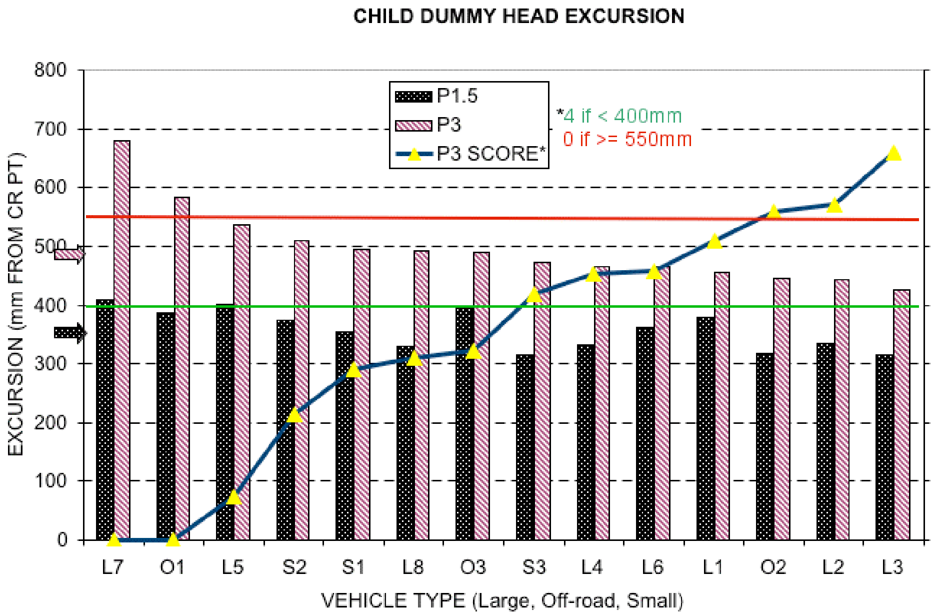
This graph show the distribution of head excursion for 14 ANCAP tests. As expected, the head excursion for the shorter,lighter P1.5 dummy is less than that of the P3 dummy. In two Australian tests the head excursion of the P3 dummy exceeded 550mm.

ANCAP Head Excursion

In one case the lower part of the CRS was poorly restrained by the adult seat belt - this is shown in the top picture.

In the other case the top tether relied on the structure of the seat back, which rocked forwards excessively at the peak of the crash. This is a snapshot from the video that I showed earlier.

Proposed Head Excursion Scoring



It is considered that a sliding scale is more appropriate than a step function for assessing head excursion. This will reward CRS that perform exceptionally well at limiting head excursion. It will also help to reduce the effects of the uncertainty in measuring head excursion - due mainly to parallax effects.

Taking into account the performance of Australian CRS with top tethers and the priority that should be given to reducing the risk of head contacts I am recommending a sliding scale that cuts in at 400mm and reaches zero at 550mm. In this graph the bars show the measured head excursions - the pink bars show P3 results. The line graph shows the P3 dummy scores that would result from my proposal, assuming a maximum score of 4 points. All but one of the P1.5 results would score maximum points.

Misuse

- A misused CRS greatly increases the risk of injury.

The main sources of misuse are:

- Fitting the CRS into the vehicle
- Attaching the top tether to the vehicle
- Using the adult seat belt to restrain the lower part of the CRS (or ISOFIX)
- Adjusting the CRS for the child (particularly shoulder harness height)
- Correctly using and adjusting the harness

Some of these are specific to a particular combination of CRS and vehicle

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JNCAP

1.Instruction Manual
2.Labelling
3.Seat belt path label
4.Adjustments
5.Seat cover removal
6.Installation in vehicle
7.Harness adjustment
8.Buckle
9.Placement of child in CRS

The JNCAP usability tests are illustrated in this picture. They cover instruction manuals, labels, installation of the CRS in the vehicle and securing the child in the CRS.

CREP

- The Australian CREP includes ease-of-use assessments.
- Several volunteers with limikted CRS experience are asked to install the CRS a popular vehicle model.
- An observer notes difficulties these people have installing the CRS in the vehicle and securing the child dummy in the CRS.
- CRS are ranked by performance in these tests. Criteria are similar to JNCAP
- A separate set of tests is conducted to check ease of installation in six popular vehicles.

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NHTSA / ICBC

The NHTSA rating system considers:

- Need to assembly after purchase
- Clarity of labelling
- Clarity of instruction manual
- Ease of securing the child into the seat

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Australian Researchers

In a report published by AAA last year we proposed a comprehensive scoring system that rated:

- Instructions and labelling
- Use of adult seat belt / ISOFIX and belt angles
- Location of TT anchorages (include belt angles)
- Attachment and adjustment of TT
- Yaw rotation of CRS when installed correctly
- Harness shoulder height adjustment
- Securing child in CRS
- Clearances and front seat space
- Extrication of the child
- Ease of cleaning

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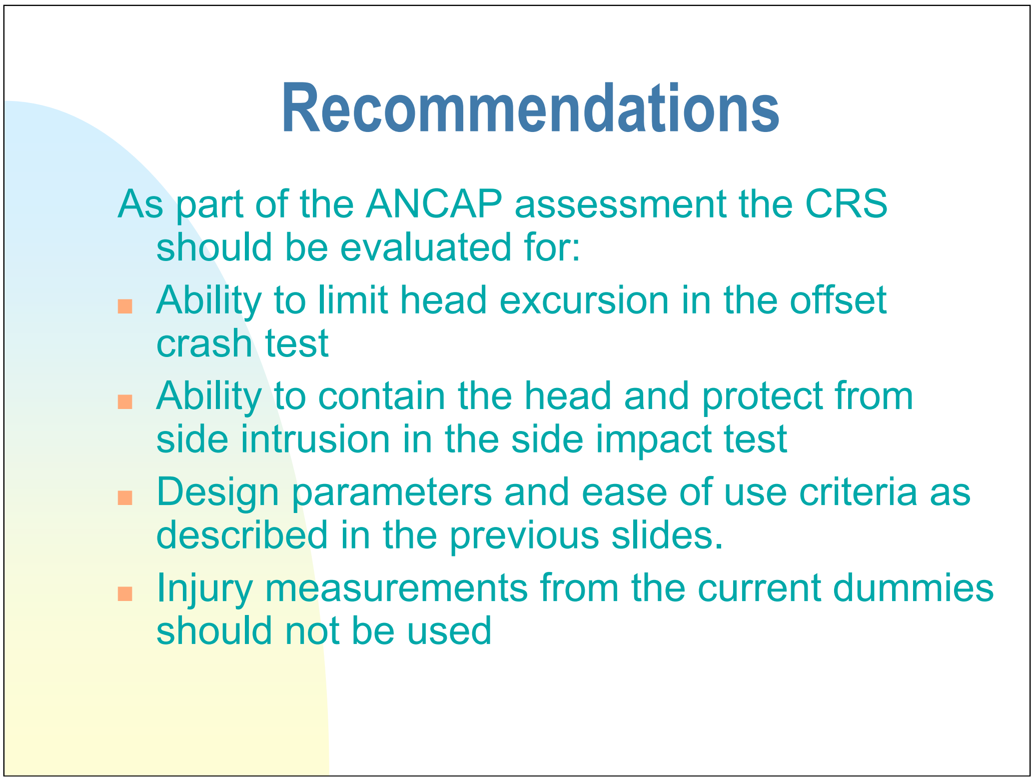

As part of the ANCAP assessment the CRS should be evaluated for:

Ability to limit head excursion in the offset crash test

Ability to contain the head and protect from side intrusion in the side impact test

Design parameters and ease of use criteria as described in the previous slides.

Injury measurements from the current dummies should not be used