Side Impact Child Dummy Development

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Under contract to NHTSA’s Vehicle Research & Test Center (VRTC)
Overview

- Side Child Dummy Concepts
- Biofidelity Evaluation Preliminary Review
- Development of Certification Procedures
- Preliminary Durability Concerns
- Current Developments
- Future Work
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Side Child Dummy Concepts

- NHTSA evaluating two dummies
  - Q3s
  - Hybrid III 3 year-old with modified head/neck (HIII-3Cs)
Side Child Dummy Concepts

- Q3s Dummy
  - Key Features
    - new fiberglass skull
    - improved shoulder design
    - improved pelvis design
    - improved arm design
  - OSRP and NHTSA
Side Child Dummy Concepts

- Hybrid III 3Cs
- History/Development
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Biofidelity Evaluation

head
neck
shoulder
thorax
abdomen
pelvis
Head Biofidelity

- Frontal Drop
- Ref: Irwin (Stapp 973317)
- 376 mm drop
- peak resultant: 255 – 315 g
Head Biofidelity

- Lateral Drop
  - Ref: Irwin (Stapp 2002-22-0016)
  - 200 mm drop
  - 114 – 171 g, measured at non-struck side
  - 94 – 141 g, measured at CG
Head Biofidelity

Frontal Head Drop
376 mm Drop
Q3s vs 3Cs Response
Head Biofidelity

Lateral Head Drop
200 mm Drop
Q3s vs 3Cs Response

resultant acceleration cf1000 (g)

3Cs

Q3s

time (msec)
Neck Biofidelity

Biofidelity References

Lateral: Irwin (Stapp 2002-22-0016)
Frontal: Irwin (Stapp 973317)
Torsion: Mertz, personal communication

Evaluation Methods:
• Standard neck pendulum
• Modified neck pendulum
• Head/neck sled tests
Neck Biofidelity

- Neck Pendulum Pulse Duration Considerations

Hexcel contact for “long” pulse

Hexcel contact for standard test

Comparison of Short and Long Neck Pendulum Pulses

~ 140 ms

~ 30 ms
Neck Biofidelity

Head/Neck Sled Tests – allows for longer pulses
Neck Biofidelity

Results

Standard Neck Pendulum
Neck Biofidelity

Standard Neck FLEXION Pendulum Results
Neck Biofidelity

Standard Neck EXTENSION Pendulum Results

Neck Extension Responses
Q3s vs 3Cs

head angular rotation ctc 60 (deg)
neck y-moment CFC 600 (N-m)
Neck Biofidelity

Standard LATERAL Neck FLEXION Pendulum Results

Neck Lateral Flexion Responses
Lo and Hi Speed Pulses
Q3s vs 3Cs

- Q3s - 3.8 m/s
- Q3s - 5.1 m/s
- 3Cs - 3.8 m/s
- 3Cs - 5.1 m/s

Neck x-moment CFC 600 (N-m)

head rotation cfc 50 (deg)
Neck Biofidelity

Standard Neck TORSION Pendulum Results

3Cs Neck vs Q3s
Neck Torsion Response

- 3Cs #0012
- 3Cs #0008
- Q3s

neck z-moment CFC 600 (Nm)

neck z-rotation (twist) CFC 60 (deg)

Q3s

3Cs
Neck Biofidelity

Results

Modified, Long Pulse

Neck Pendulum
Neck Biofidelity
Q3s LONG PULSE Neck FLEXION Pendulum Results

Q3s Frontal Flexion Response
Long Pulse Pendulum Test

- 5.5 m/s, 144 msec
- 6.9 m/s, 137 msec
- 7.4 m/s, 104 msec
Neck Biofidelity
3Cs LONG PULSE Neck FLEXION Pendulum Results

H-III 3Cs Neck Frontal Flexion Response
Long Pulse Pendulum Test

- 6 m/s, 138 msec
- 6.9 m/s 129 msec
- 7.4 m/s, 115 msec

neck y-moment (Nm)
head rotation (deg)
Neck Biofidelity

Q3s LONG PULSE LATERAL Neck Pendulum Results

Q3s Lateral Neck Response
Long Pulse Pendulum Test

- 6.0 m/s, 143 msec
- 6.9 m/s, 135 msec
- 7.4 m/s, 103 msec

head rotation (deg)
neck x-moment (Nm)
Neck Biofidelity

3Cs LONG PULSE LATERAL Neck Pendulum Results

3Cs Lateral Neck Response
Long Pulse Pendulum Test

- 7.4 m/s, 115 msec
- 7.4 m/s, 108 msec
- 7.4 m/s, 94 msec
Neck Biofidelity

Results

Head/Neck Sled Tests
Neck Biofidelity

Q3s NECK X-MOMENT Head/Neck Sled Test Results
Neck Biofidelity

3Cs NECK X-MOMENT Head/Neck Sled Test Results

Head and Neck Sled Tests
Response of 3Cs Neck and Head

head rotation CFC 60 (deg)
neck X-moment CFC900 (Nm)
Shoulder Biofidelity

Reference #1: Irwin (Stapp 2002-22-0016)
  Lateral impact
  1.7 kg impactor at 4.5 m/s

Reference #2: Bolte (Stapp 2003-22-0003)
  Lateral & oblique padded impact
  1.7 kg impactor at 4.5 m/s
Shoulder Biofidelity

Results

Irwin Impact
Shoulder Biofidelity - Hybrid III 3Cs vs Q3s
1.7 kg impactor at 4.5 m/s

Irwin shoulder impact
Shoulder Biofidelity

Shoulder Biofidelity - Irwin Test
1.7 kg impactor at 4.5 m/s

Note: 3Cs is not equipped to measure shoulder displacement.
Shoulder Biofidelity

Results

Bolte Test

Padded Shoulder Impacts
Shoulder Biofidelity

Lateral Impact

- Force (N)
- Displacement (mm)

Q3s
3Cs
Shoulder Biofidelity
Thorax Biofidelity

Reference: Irwin (Stapp 2002-22-0016)
Lateral impact to thorax w/ 1.7 kg impactor at 4.3 and 6.0 m/s
Thorax Biofidelity

Thorax Biofidelity - Hybrid III 3Cs vs Q3s
1.7 kg Impactor at 4.3 m/s

probe force FIR 100 (N)

0 1000

0 0.05 0.10 0.15 0.20 0.25 0.30

time (sec)

3Cs

Q3s
Thorax Biofidelity

Thorax Biofidelity - Hybrid III 3Cs vs. Q3s
1.7 kg Impactor at 6.0 m/s

- 3Cs #1
- 3Cs #2
- 3Cs #3
- Q3s #1
- Q3s #2
- Q3s #3
Abdomen Biofidelity


- $30^\circ$ oblique impact to abdomen w/ 3.8 kg impactor at 4.8 and 6.8 m/s
Abdomen Biofidelity

Abdomen Biofidelity
30 degree Oblique Impact
3.8 kg probe at 4.8 m/s

probe force CFC180 (N)

3Cs

Q3s

time (msec)
Pelvis Biofidelity

- Reference: Irwin (Stapp 2002-22-0016)
- Lateral impact to pelvis w/ 2.27 kg impactor at 4.5 m/s
Pelvis Biofidelity

Pelvis Biofidelity - Hybrid III 3Cs vs Q3s
2.27 kg impactor at 4.5 m/s

3Cs

Q3s
Preliminary Biofidelity Analysis

Q3s

head
neck
shoulder
thorax
abdomen
pelvis

indicates biofidelity improvement

3Cs
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Certification Procedures

- Adapted procedures to use Bench Seat
- Developed a Thorax with Arm Test
- Introduced Increased Mass Impactor
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Durability Concerns

- Thorax damage observed in two different dummies
Durability Concerns

- Reinforce the rib cage with spring steel or Nitinol
- Soften the plastic material
- Reduce the strain level
**Durability Concerns**

- Hip cup
- Upper femur
Durability Concerns

- Upper femur filler material not curing
- Hip cup separation
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Current Developments

Future Work
Current Developments

- Improve Q3s thorax durability
- Improve femur issues
- Incorporate 3Cs neck design into the Q3s dummy
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Future Work
Future Work

- Evaluate improvements
  - Thorax
  - Neck
  - Femur/Pelvis

- Finalize certification procedures and assess repeatability & reproducibility of responses

- Conduct sled tests for additional biofidelity assessment
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Thank You!

Questions?