Side Impact Dummy Biofidelity

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NHTSA

Overview

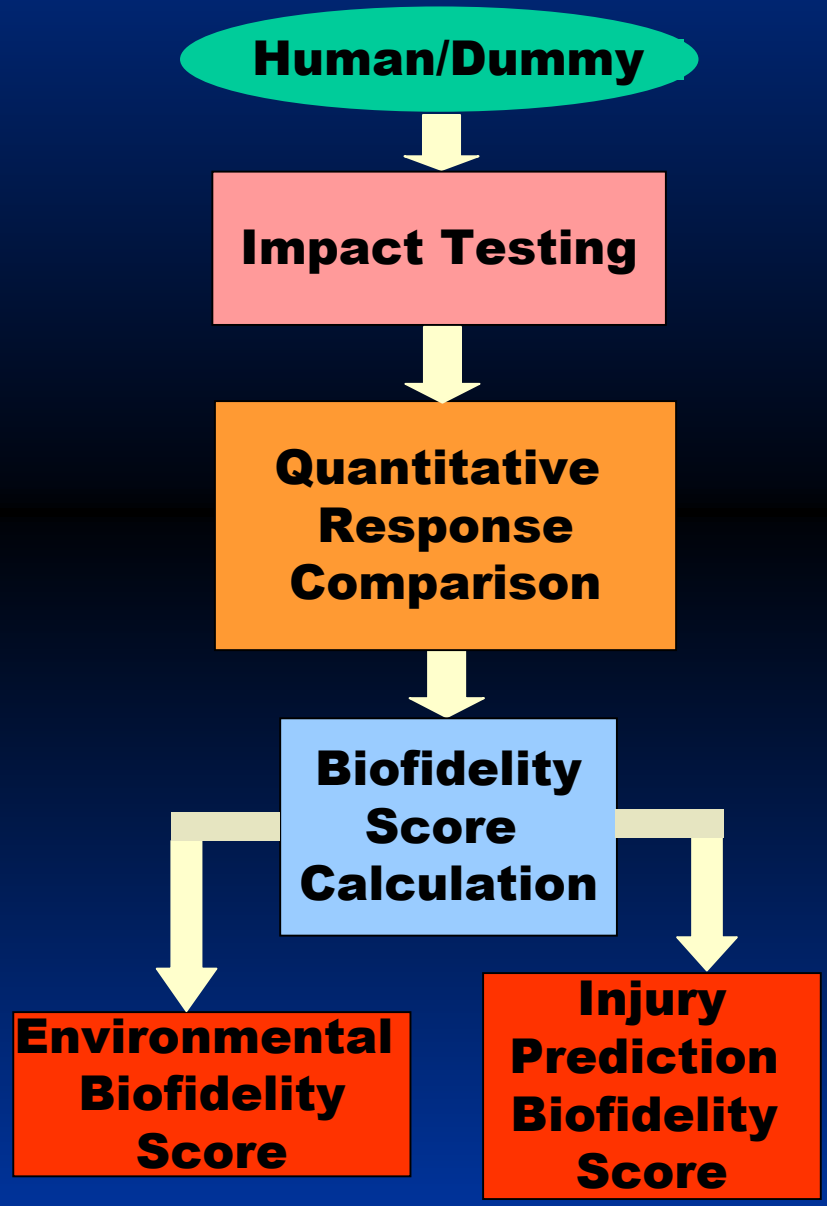
- What is Biofidelity?
- Impact Testing
- Translating Test Data to into a Biofidelity Score
- Biofidelity of various Side Impact Dummies
- Conclusions

What is Biofidelity?

- **A crash test dummy should:**
  - **Load the Crash Environment Like a Human Would**
    - a side impact dummy should impart human-like force-area-time history upon the vehicle environment
  - **Predict Human Injury Consequences**
    - a side impact dummy should reproduce the necessary internal kinematic and kinetic measurements to accurately predict injury

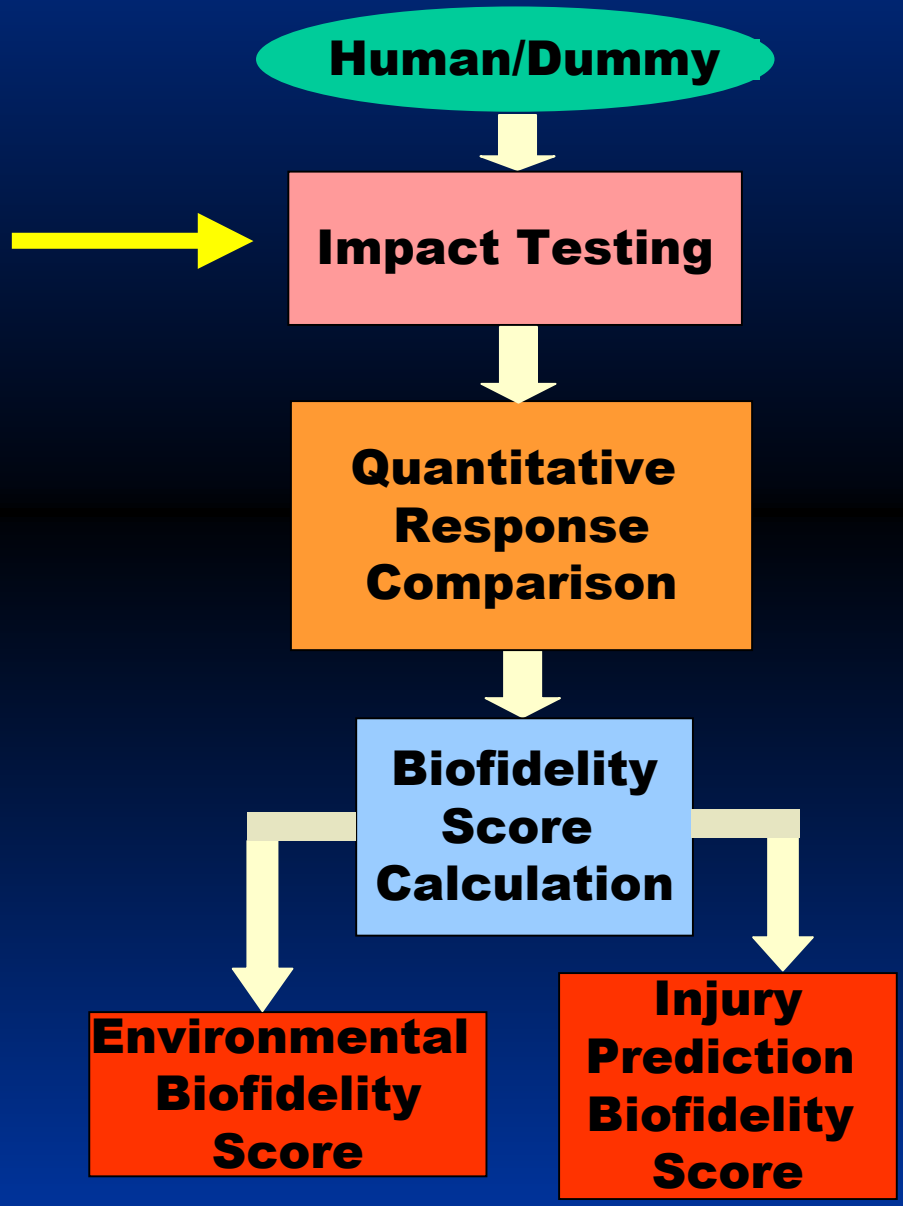
Biofidelity Evaluation Process

- Test the dummy and human surrogate in an environment similar to the crash
- Compare quantitatively the response of the human and dummy
- Combine the quantitative response comparison from each test into a meaningful score



Biofidelity Evaluation Process

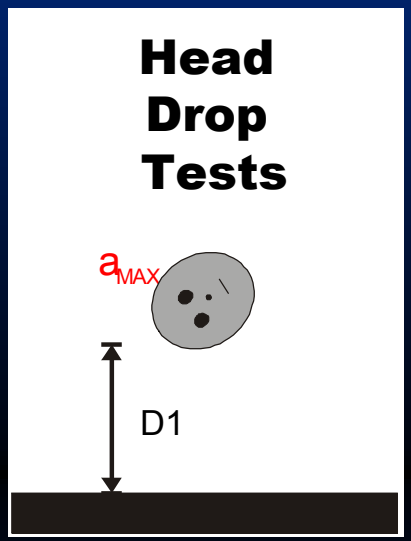
Impact Testing

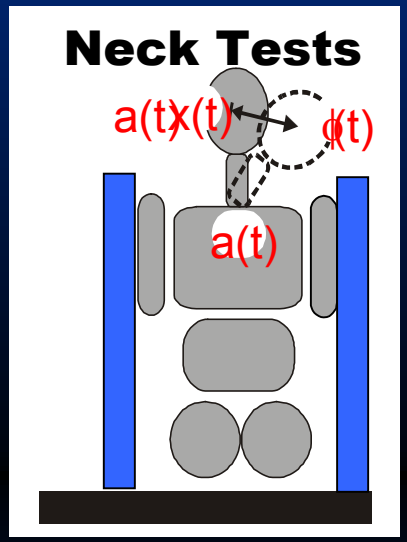


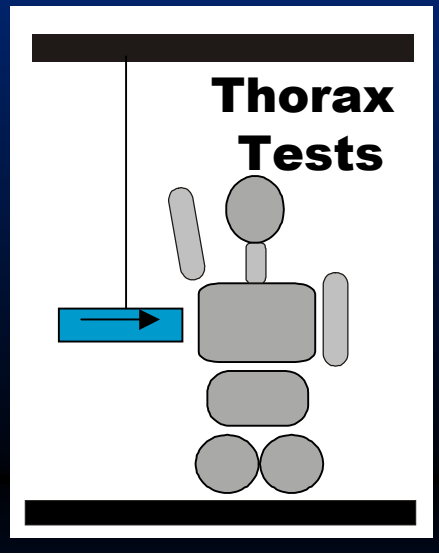
NHTSA Biofidelity Impact Tests

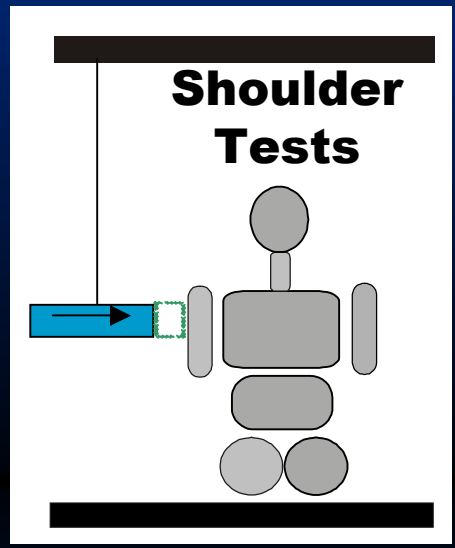
- Biofidelity tests are conducted on both dummies and human surrogates in a variety of test conditions.
- Tests include:
  - Whole-body Sled Tests to quantify the performance of the torso and pelvis as a system.
  - Pendulum tests to the thorax and shoulder.
  - Neck tests to ensure the head is correctly positioned for a head strike.
  - Head Drop tests to quantify the response of the head exposed to blunt impact.

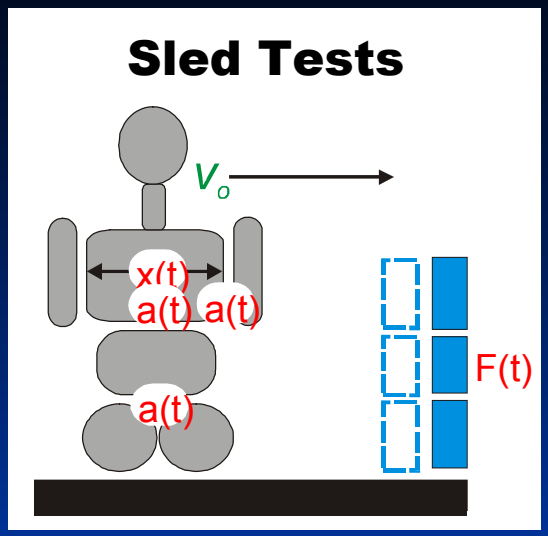
NHTSA Biofidelity Impact Tests









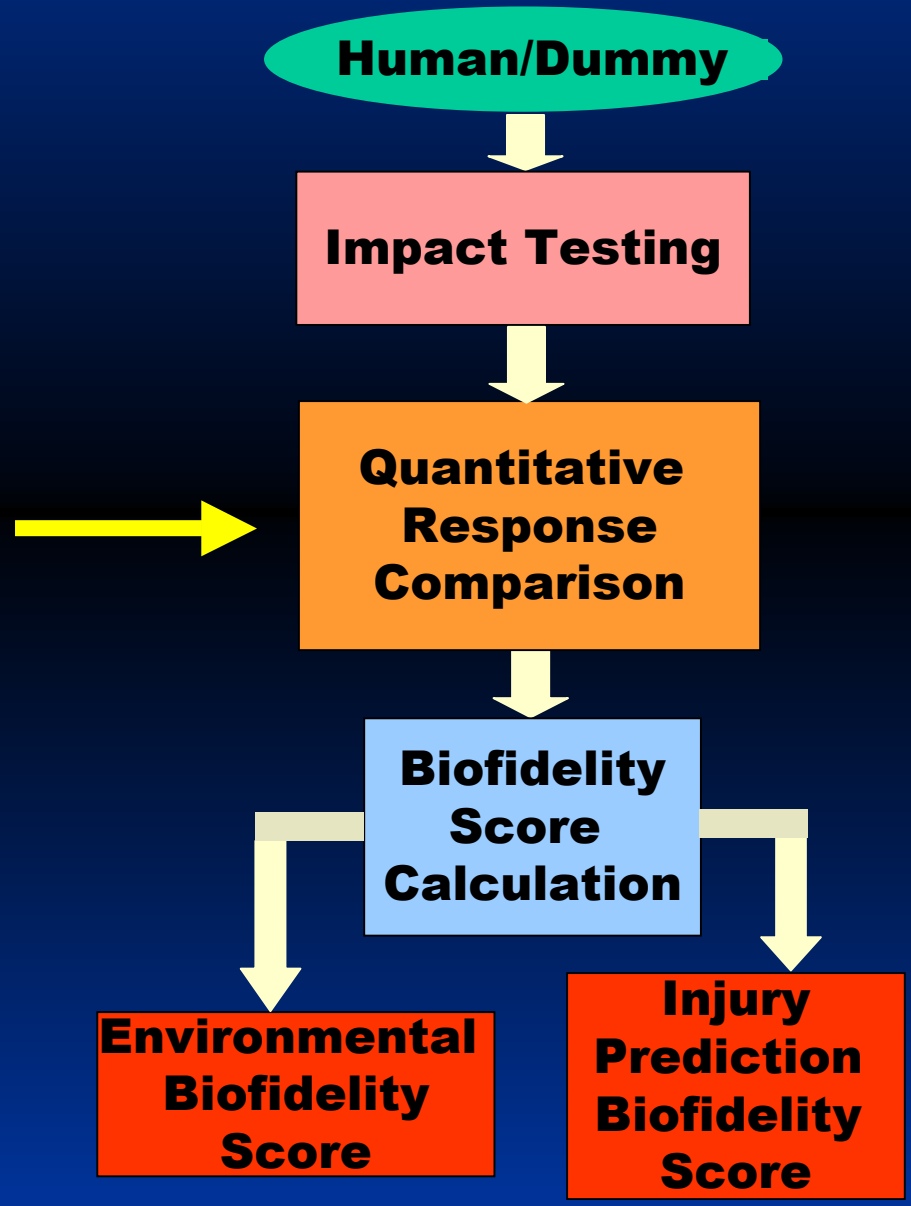


Biofidelity Evaluation Process

Quantitative

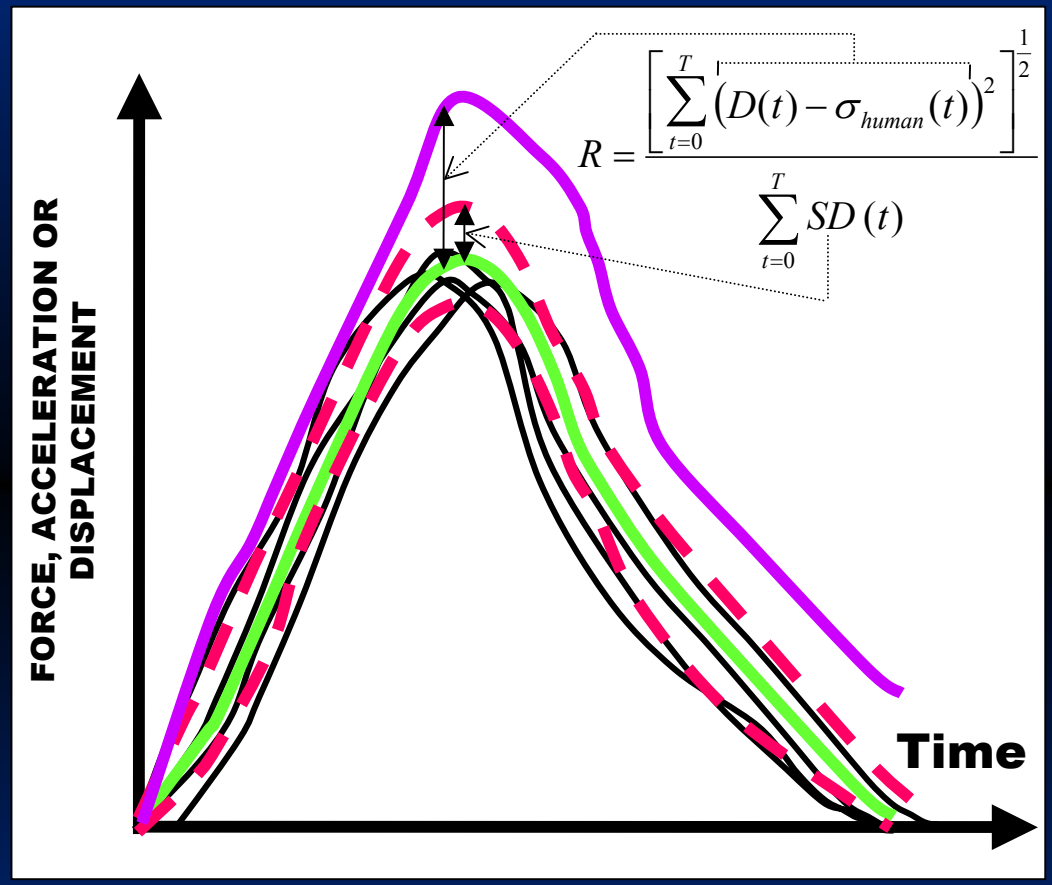
Response

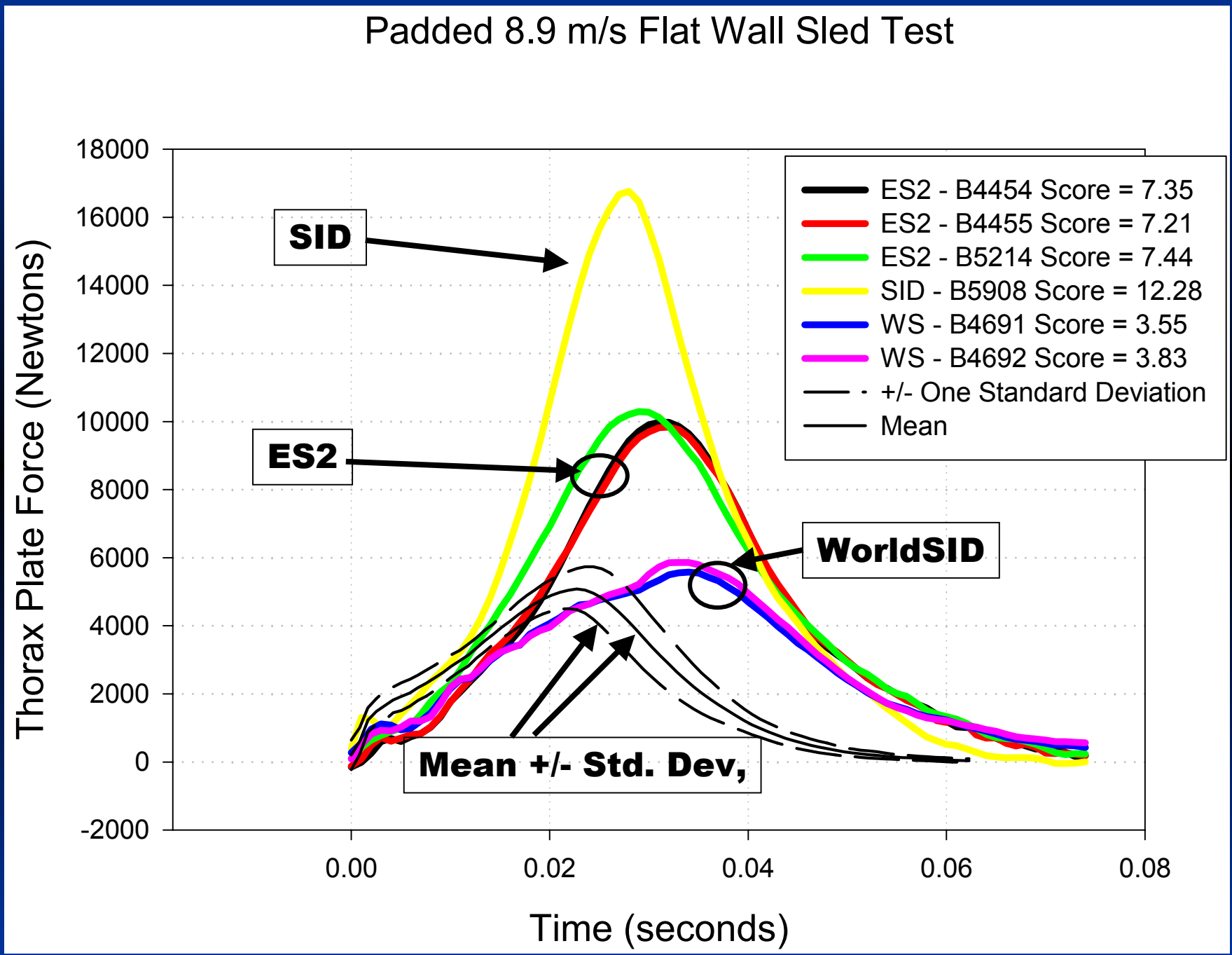
Comparison

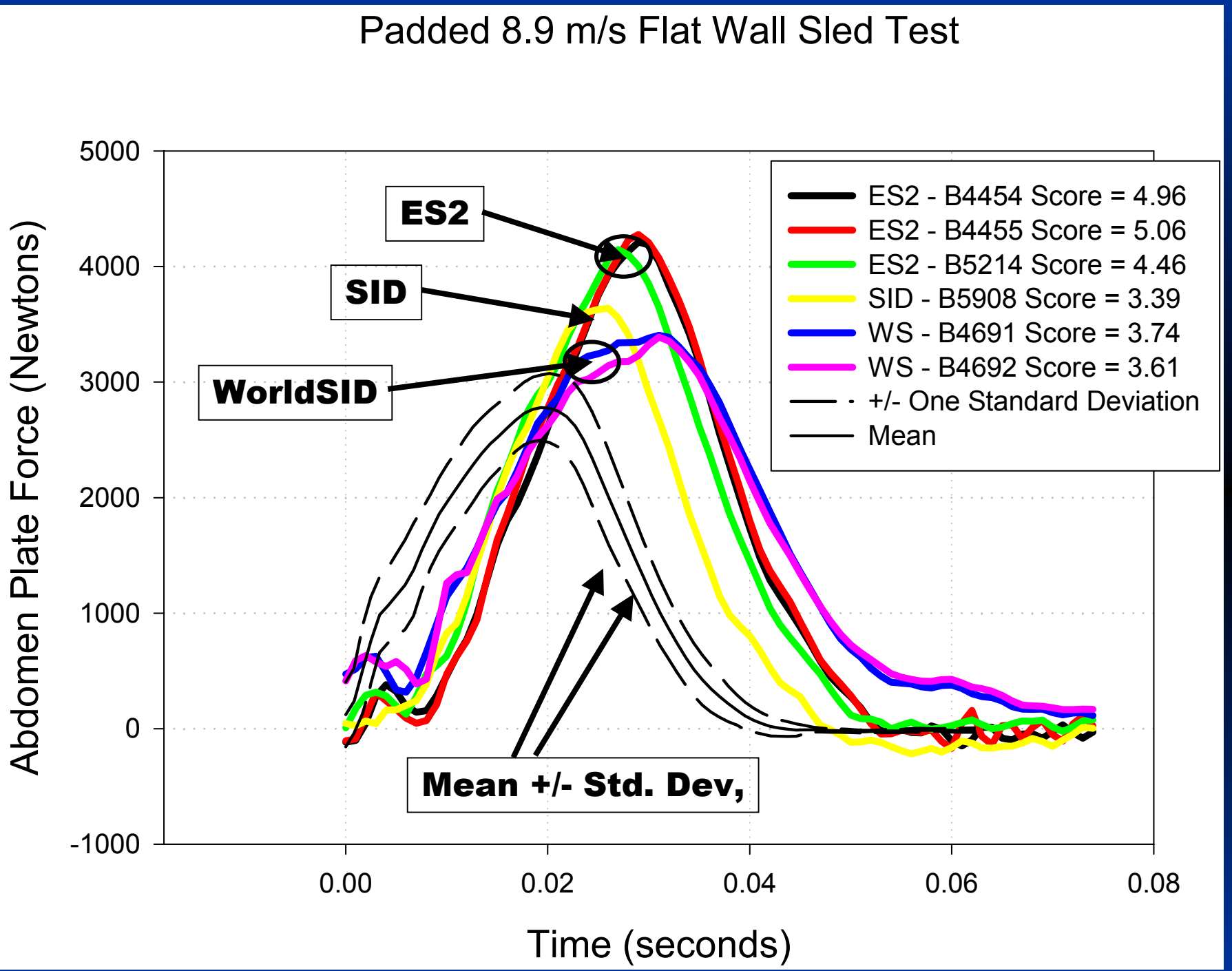


Dummy-to-Human Comparison

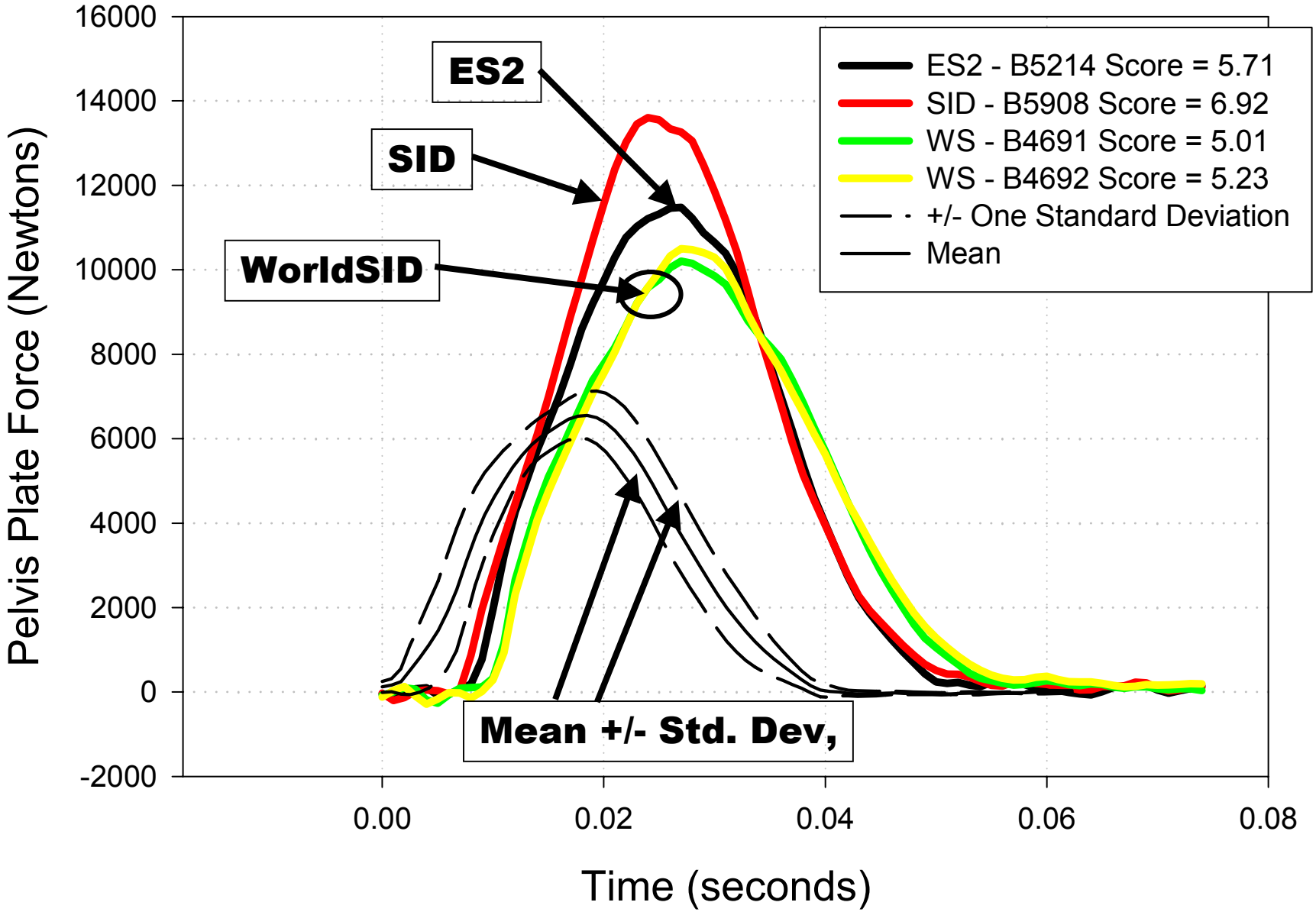
- Human surrogate and dummy response signals are overlayed.
- The dummy response (D), surrogate mean (σ), and standard deviation (SD) are then combined to quantify (R) how well the dummy matches the cadaver.




Padded 8.9 m/s Flat Wall Sled Test
Thorax Plate Force (Newtons)
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
-2000
0.00
0.02
0.04
0.06
0.08
Time (seconds)
SID
ES2
WorldSID
Mean +/- Std. Dev,
ES2 - B4454 Score = 7.35
ES2 - B4455 Score = 7.21
ES2 - B5214 Score = 7.44
SID - B5908 Score = 12.28
WS - B4691 Score = 3.55
WS - B4692 Score = 3.83
+/- One Standard Deviation
Mean


Padded 8.9 m/s Flat Wall Sled Test
Abdomen Plate Force (Newtons)
5000
4000
3000
2000
1000
0
-1000
0.00
0.02
0.04
0.06
0.08
Time (seconds)
ES2
SID
WorldSID
Mean +/- Std. Dev,
ES2 - B4454 Score = 4.96
ES2 - B4455 Score = 5.06
ES2 - B5214 Score = 4.46
SID - B5908 Score = 3.39
WS - B4691 Score = 3.74
WS - B4692 Score = 3.61
+/- One Standard Deviation
Mean

Padded 8.9 m/s Flat Wall Sled Test

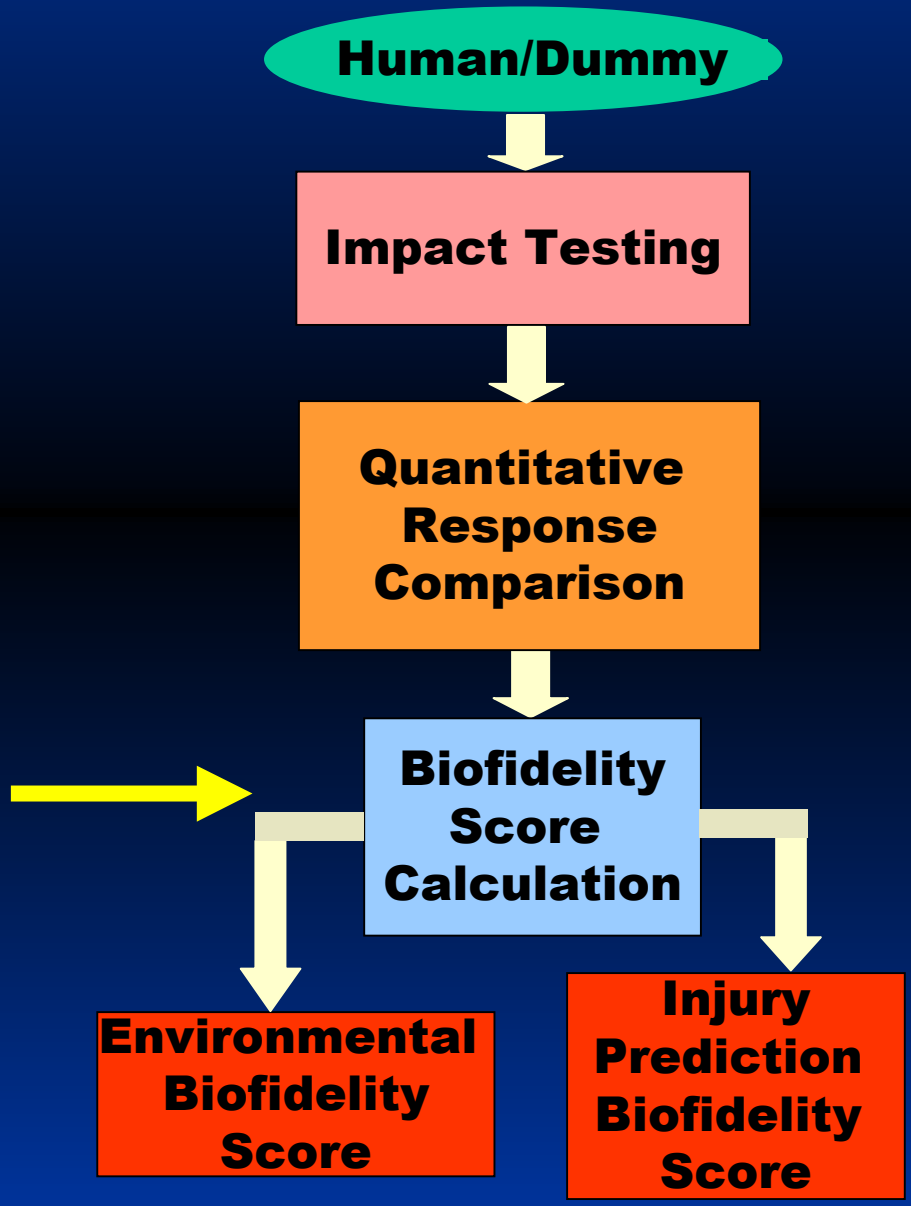


Biofidelity Evaluation Process

Biofidelity

Score

Calculation

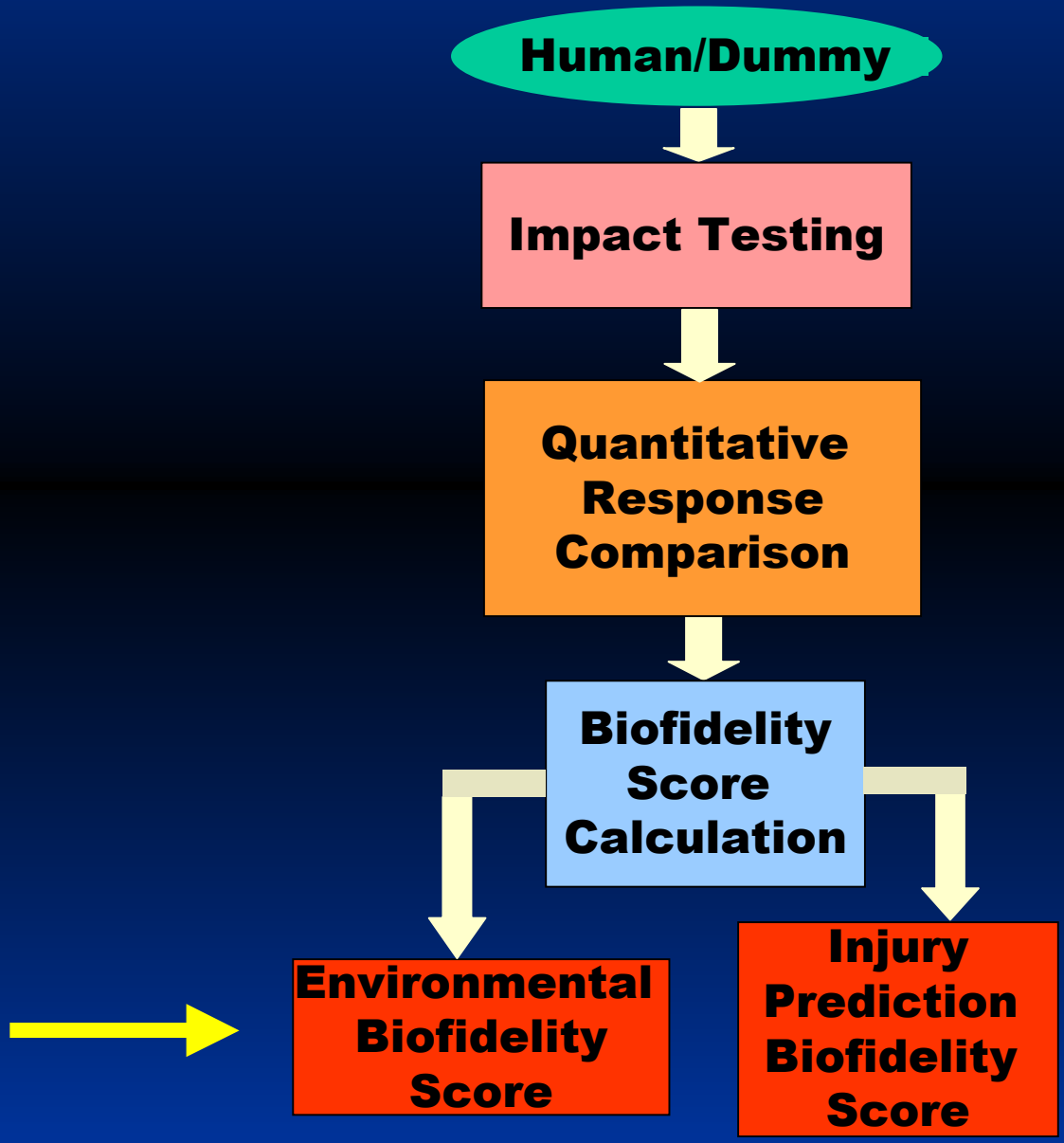


Test Condition Weights

- Each R score is weighted according to its test condition.
- The Test Condition Weights quantify the importance of the results from a particular test condition in the overall biofidelity score.
- Two factors influence the weights:
  - the number of human surrogate test subjects used to develop the corridor.
  - the degree to which a particular test condition matches the real-world crash environment.

Biofidelity Evaluation Process

Score



Biofidelity Scores

- **Two Scores are Calculated**
  - Environmental Biofidelity Rank = average of the weighted R values from Load wall and pendulum forces, as well as head/neck displacement and angle.
  - Injury Criteria Fidelity Rank = average of the weighted R values from the signals used to calculated the injury criteria for a particular body region.

Rating Dummy Biofidelity

0 <= B <= 1	Excellent
1 < B <= 2	Good
2 < B <= 3	Moderate
3 < B	Poor

Dummy Scores

	ES-2	SID/H3	WSIDp
Impact Biofidelity			
Overall	3.4	3.6	2.5
Head/neck	3.7	1.0	2.1
Shoulder	1.2	5.6	2.1
Thorax	5.4	6.3	3.1
Abdomen	3.6	3.5	2.5
Pelvis	2.6	3.6	3.5

(Smaller/Better)

Injury Criteria Fidelity			
Head	0.6	0.6	0.4
Thorax	1.1	1.1	1.1
Abdomen	3.6	NA	1.3
Pelvis	1.8	1.8	1.9

CONCLUSIONS

- **In terms of the biofidelity of the dummy-to-vehicle interaction,**
  - the SID/H3 is less biofidelic than the ES-2, and
  - the WorldSID Prototype is more biofidelic than both the SID/H3 and the ES-2.
- **In terms of the biofidelity of the measurements on the dummy required to predict injury,**
  - the head and thorax of the SID/H3, ES-2 and WorldSID Prototype were equally biofidelic,
  - the abdomen of the WorldSID Prototype is more biofidelic than the ES-2, and the SID has no abdominal injury detection capability, and
  - the pelvis of the SID/H3, ES-2 and WorldSID Prototype have roughly the same biofidelity.

Thank You