Playground Surface Testing
Background Research

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Playgrounds

High Availability

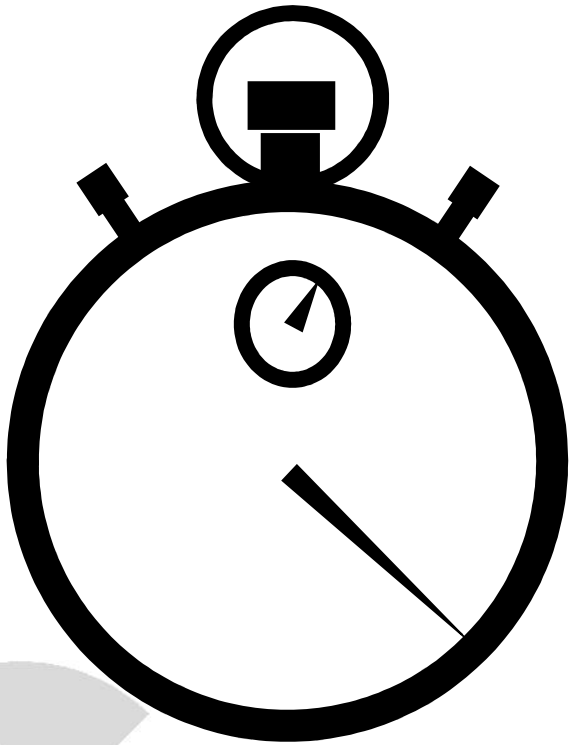
- Public
- Schools
- Home

High Risk

Injury Statistics

Injury Rates

205,850 Emergency Room admissions during 1999



Frequency

1 per 1.3 minutes

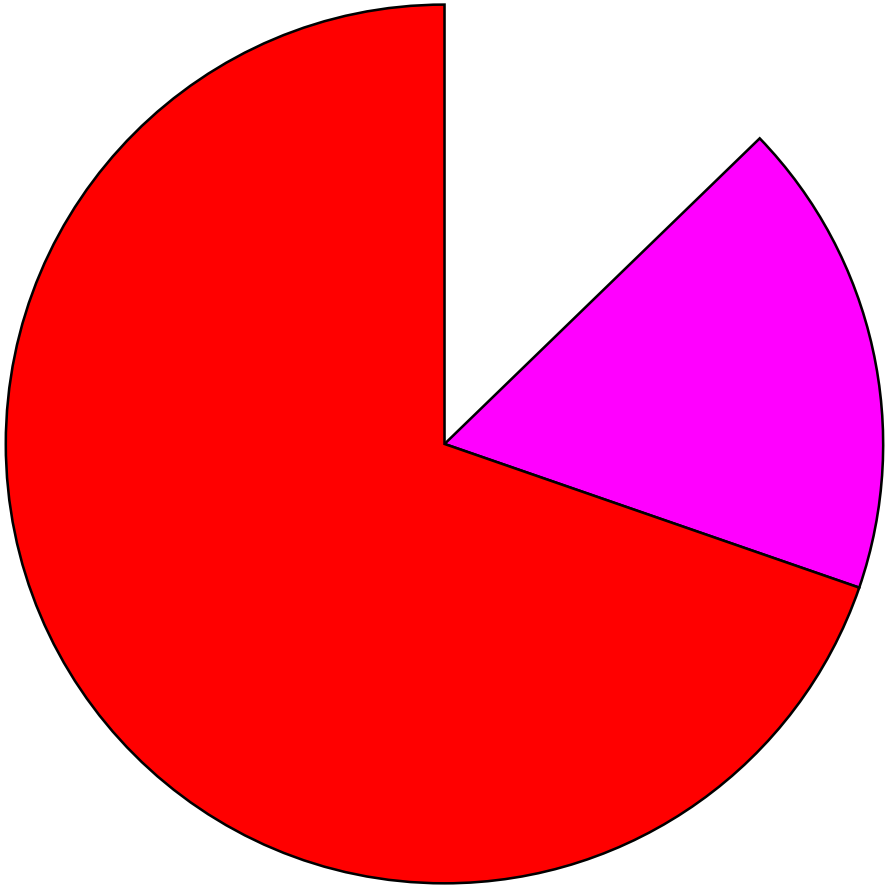
Occurrence

1 per 1333 children

Injury Statistics

Accident Type

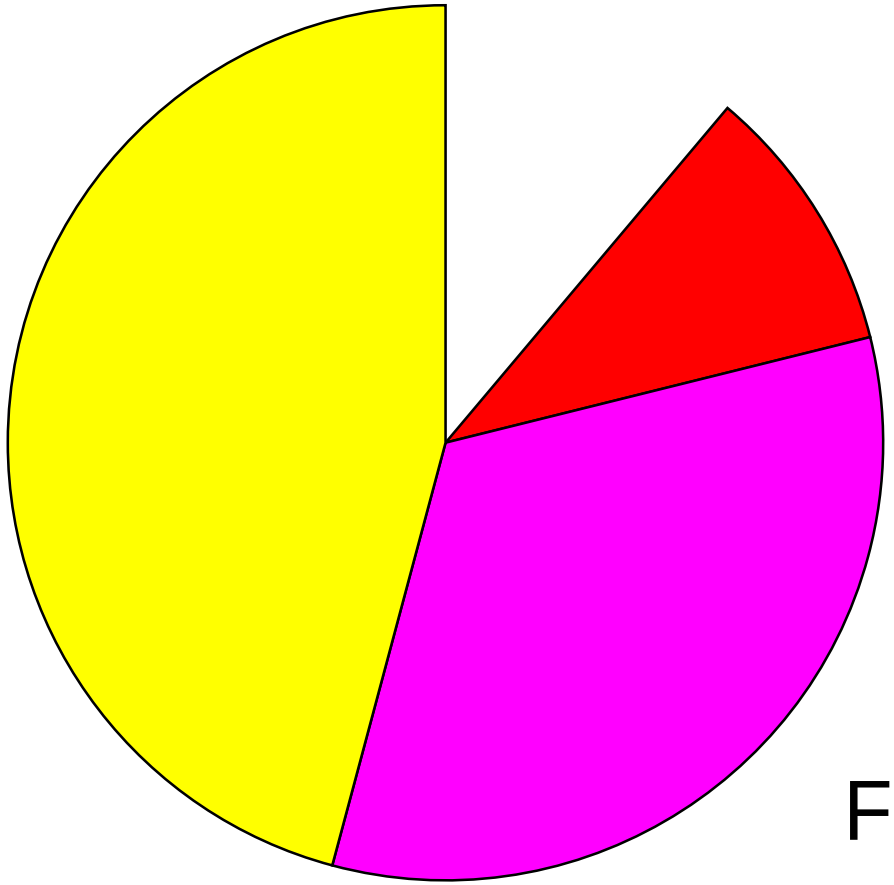
Falls
70%



Collisions
17%

Injury Statistics

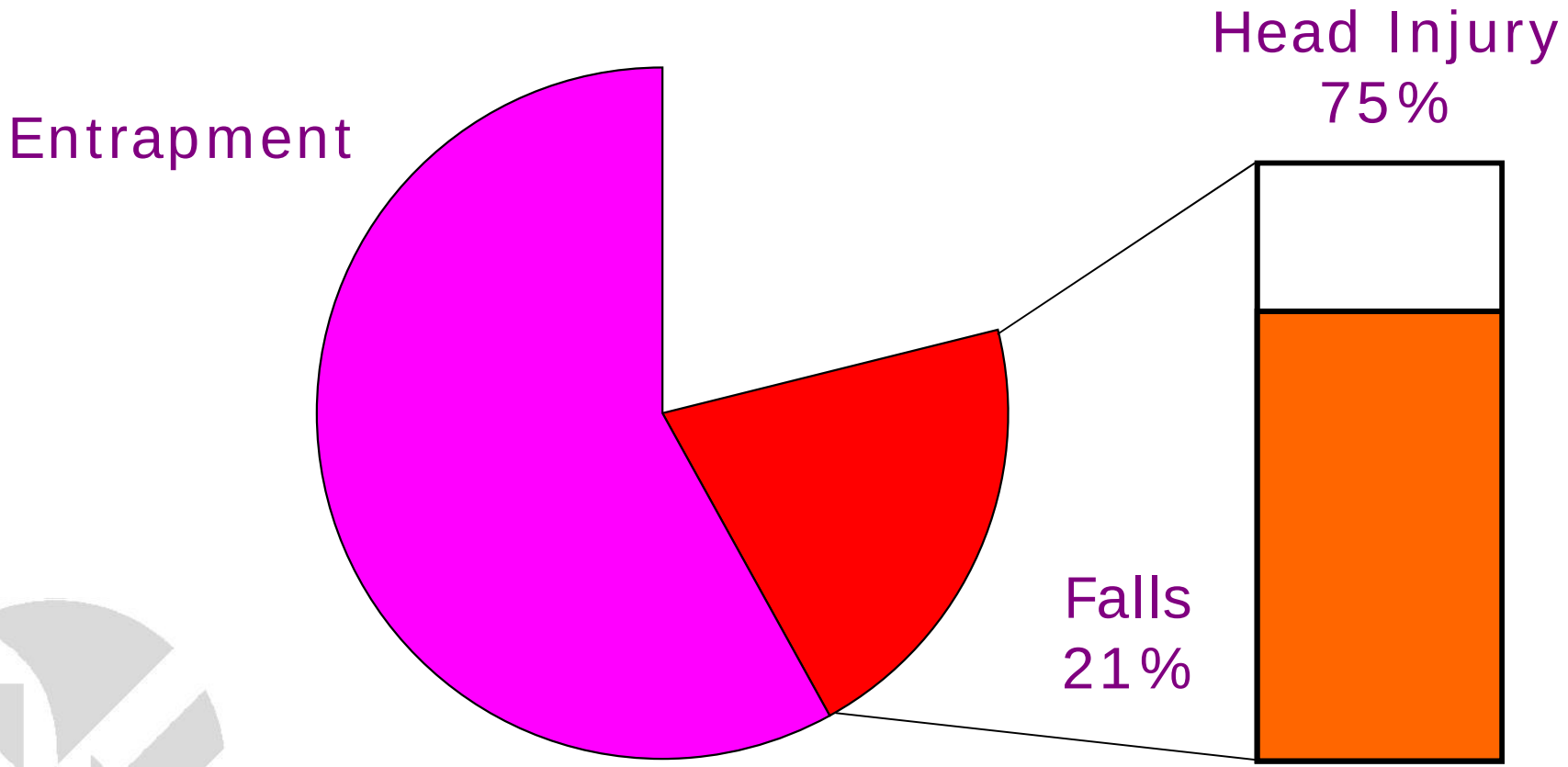
Injury Type



Injury Statistics

Fatalities

147 deaths between January 1990 and August 2000



Source: US CPSC: Tinsworth and MacDonald, 2001

Injury Statistics

Risk Factors

Equipment height

Equipment design

Parental supervision

Maintenance

Mixed use

Surfacing as a Risk Factor

Falls to the surface:

- 20% of deaths
- 70-80% of injuries

Shock Attenuating Surfaces:

- Potential for lower injury risk

Playground Safety Initiatives

CPSC Handbook
(1975)

Safety Advocates

Legislation

Equipment Design

Surfacing Standards

Playground Surfacing Materials

Loose-Fill Surfaces

- Organic
  - Bark Dust
  - Wood
  - Engineered Wood Fiber
- Inorganic
  - Sand
  - Gravel
  - Shredded foam / rubber

Playground Surfacing Materials

Unitary Surfaces

- Rubber / Urethane
- Poured-in-Place
- Tiles

Playground Surfacing

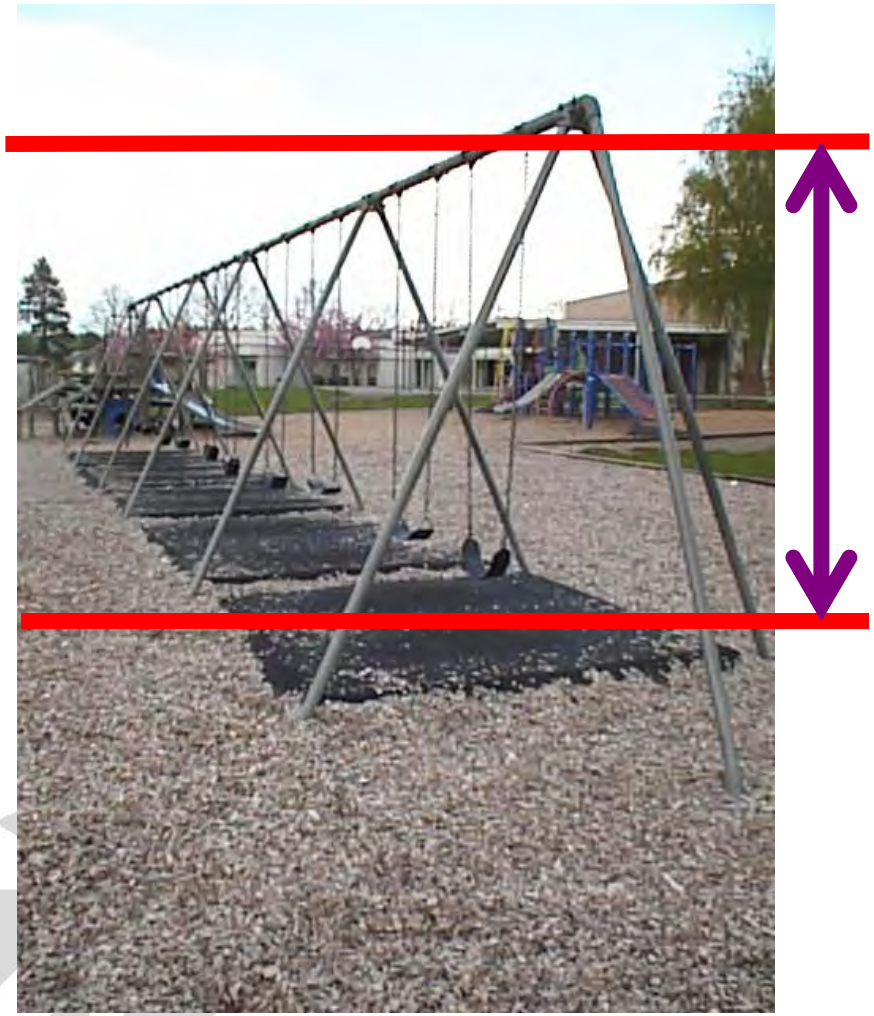
Performance Criteria

Standards

- ASTM F1292
- EN 1177, etc.

Playground Surfacing

Performance Criteria



Standards

- ASTM F1292
- EN 1177, etc.

Fall Height

Playground Surfacing

Performance Criteria

Standards

- ASTM F1292
- EN 1177, etc.

Fall Height

Test Method

- Instrumented headform
- Triaxial Accelerometer

Playground Surfacing

Performance Criteria

Standards

- ASTM F1292
- EN 1177, etc.

Fall Height

Test Method

- Instrumented headform
- Triaxial Accelerometer

Critical Fall Height

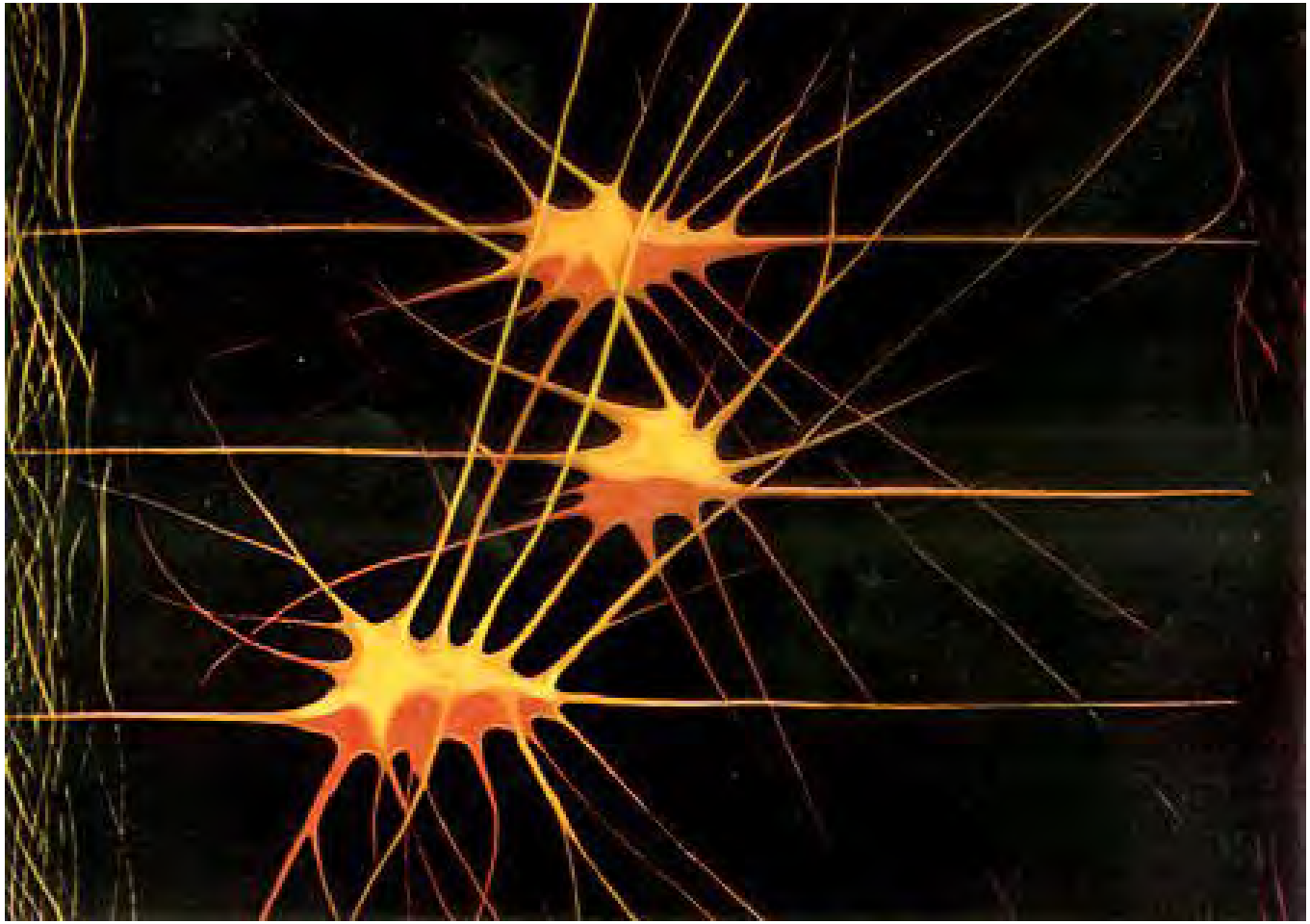
Performance Criteria

Historical efforts to base performance criteria on (head) injury risk data

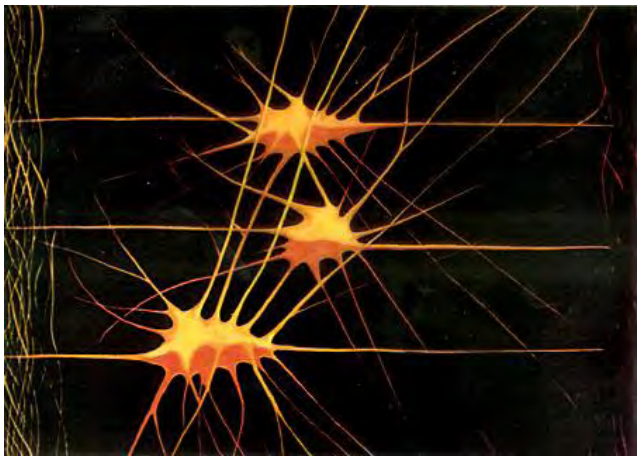
g-max

Head Injury Criterion

Brain Injury Mechanisms



Diffuse Axonal Injury



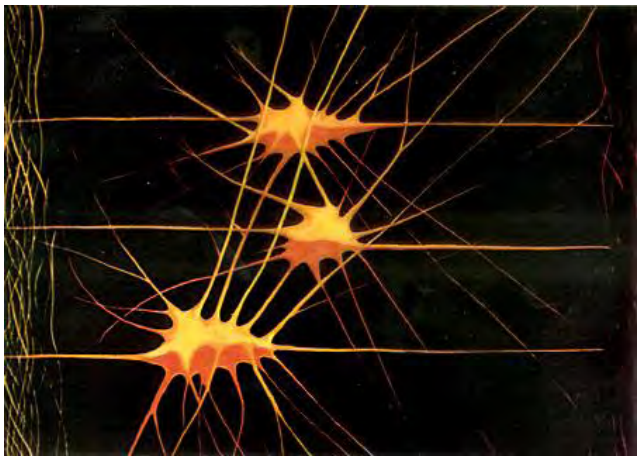
Normal Axons

Traumatized Axons

Metabolic Cascade:

- Ca and K ion release
- Disruption of neural function
- Compensation
- Increase energy expenditure
- Metabolic distress
- Increased vulnerability

Mild Traumatic Brain Injury



Normal Axons

Traumatized Axons

Long Term Consequences:

- Second Concussion Syndrome
- Cumulative Effects

Brain Injury Mechanisms

Abbreviated Injury Scale

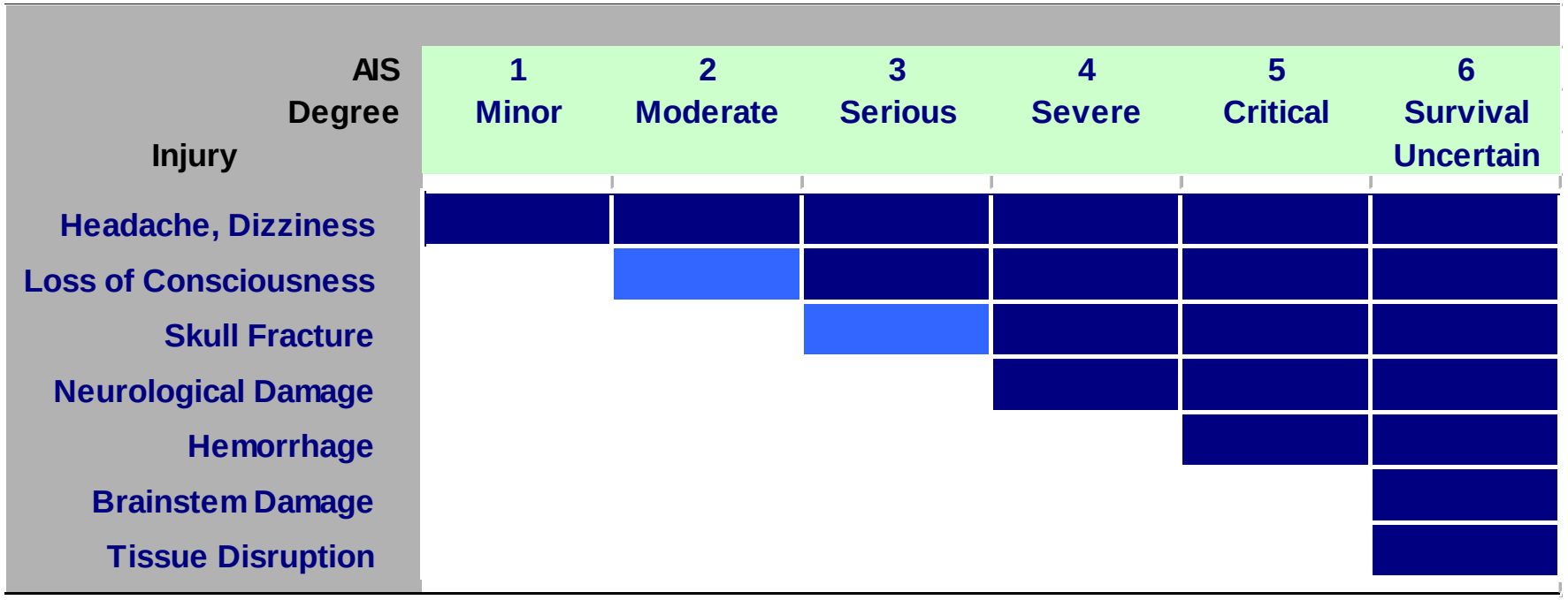
Injury
Headache, Dizziness
Loss of Consciousness
Skull Fracture
Neurological Damage
Hemorrhage
Brainstem Damage
Tissue Disruption

Brain Injury Mechanisms

Abbreviated Injury Scale

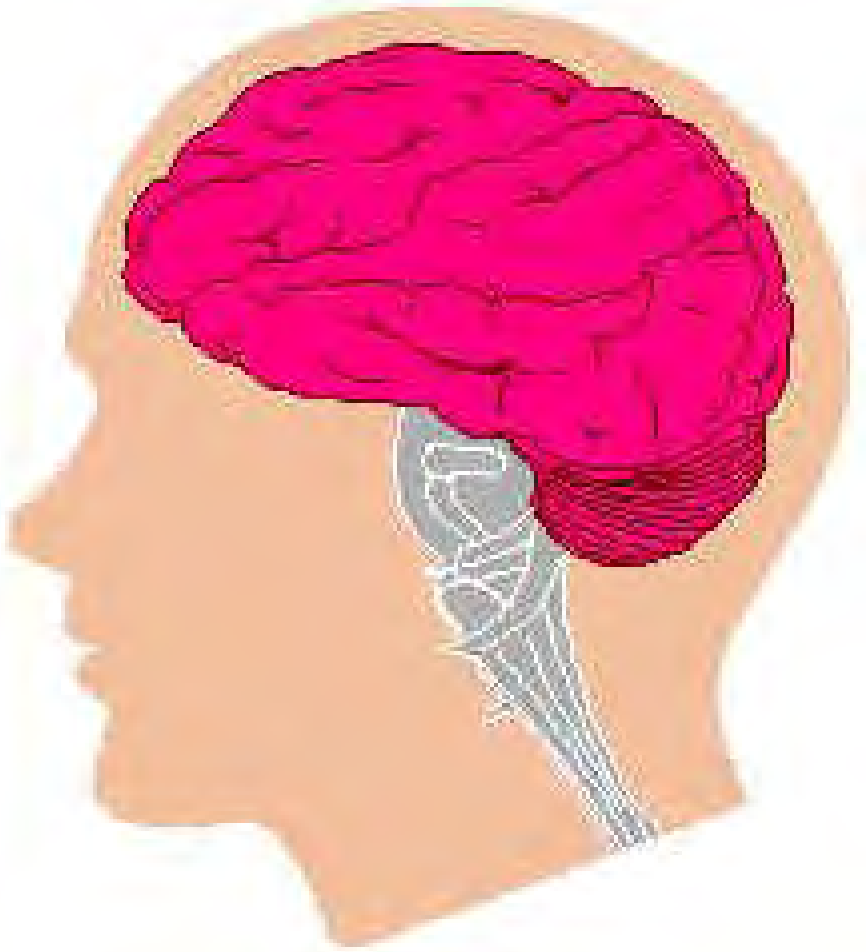
Injury	AIS Degree	1 Minor	2 Moderate	3 Serious	4 Severe	5 Critical	6 Survival Uncertain
Headache, Dizziness							
Loss of Consciousness							
Skull Fracture							
Neurological Damage							
Hemorrhage							
Brainstem Damage							
Tissue Disruption							

Abbreviated Injury Scale

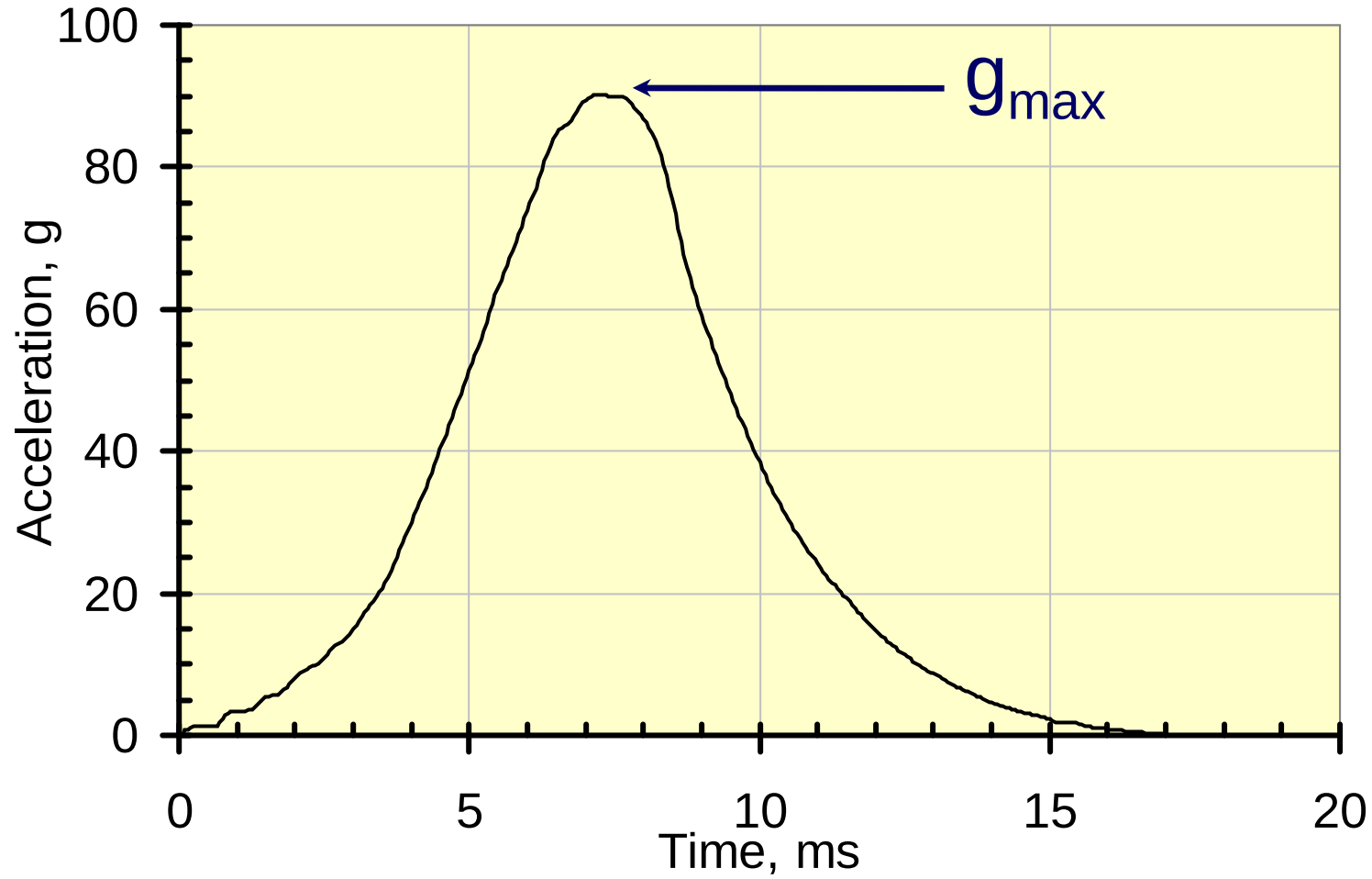


Impact Tolerance of the Brain

- Cadaver studies
- Animal studies
- Human volunteers
  - Automotive Industry
  - Aerospace Industry
  - Military

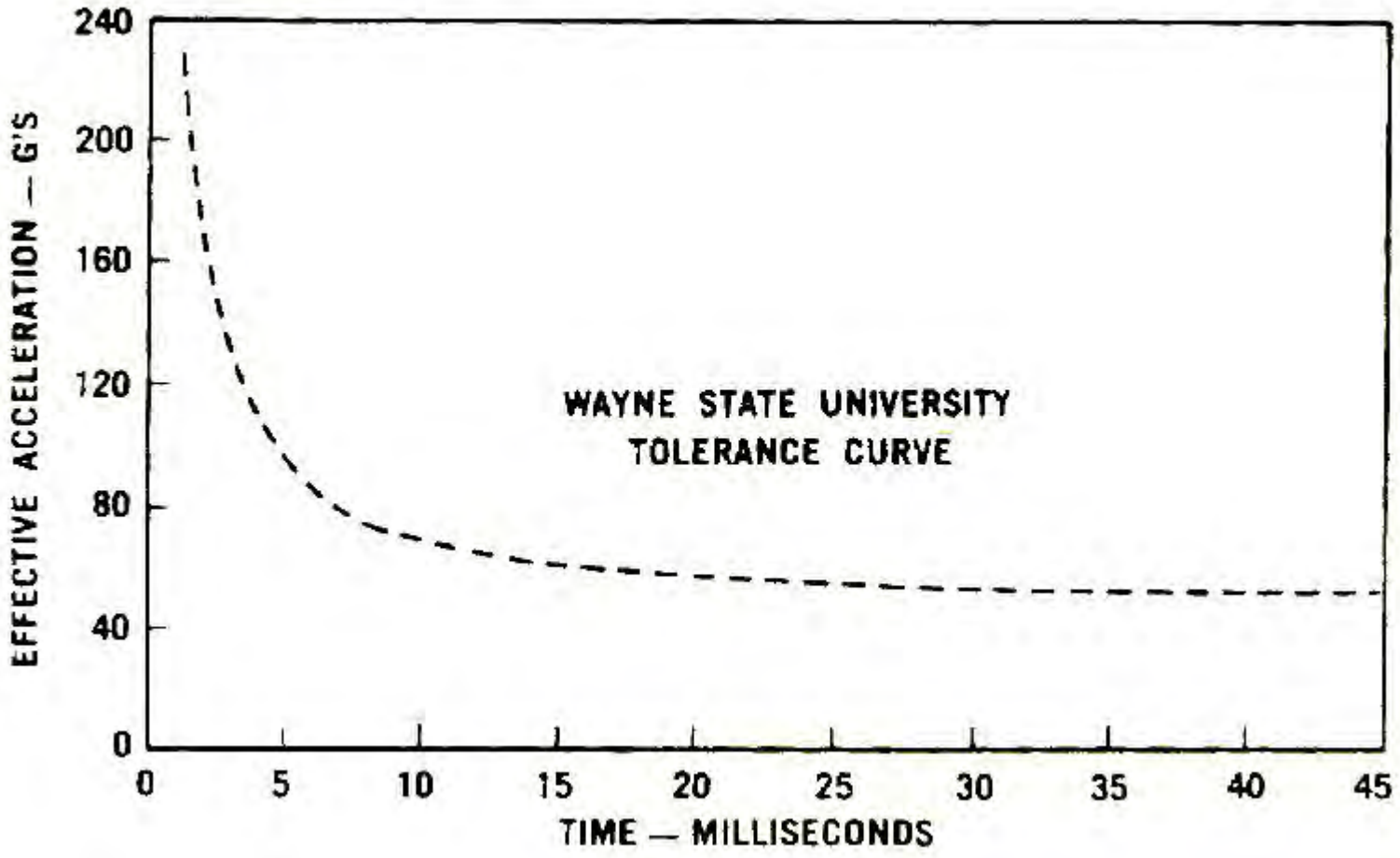


Acceleration

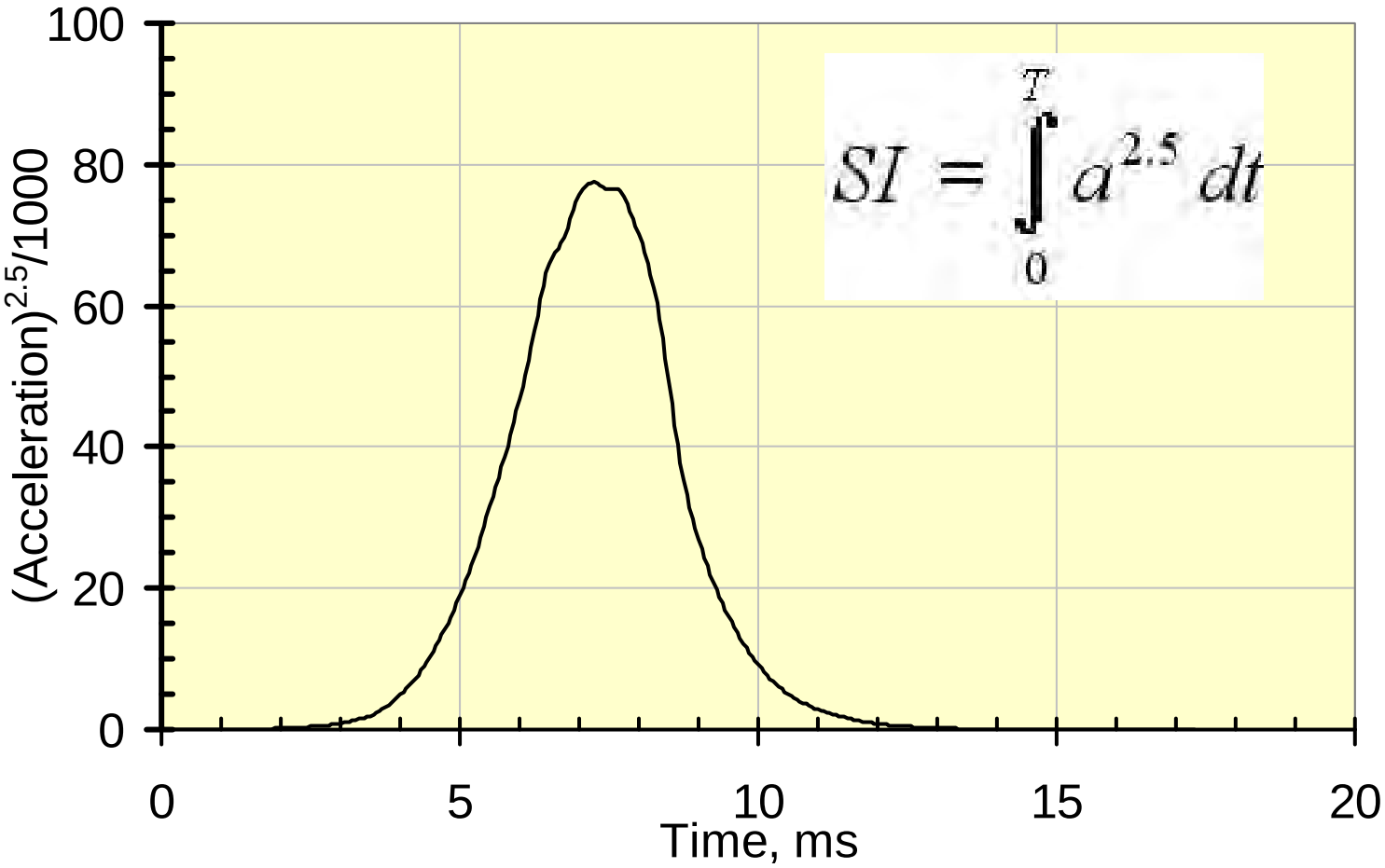


Impact Tolerance of the Brain

Wayne State Curve



Gadd Severity Index



Impact Tolerance of the Brain

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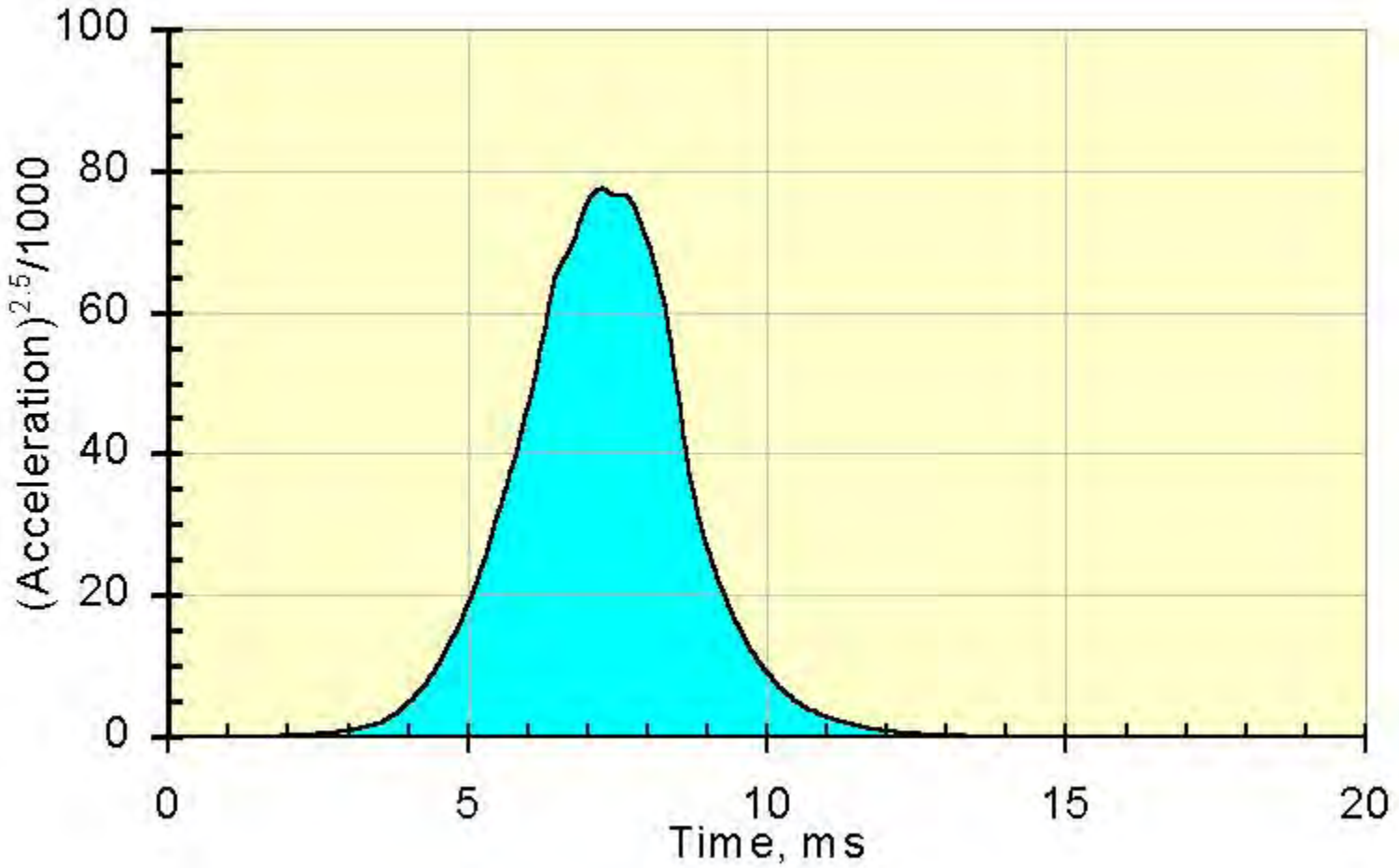
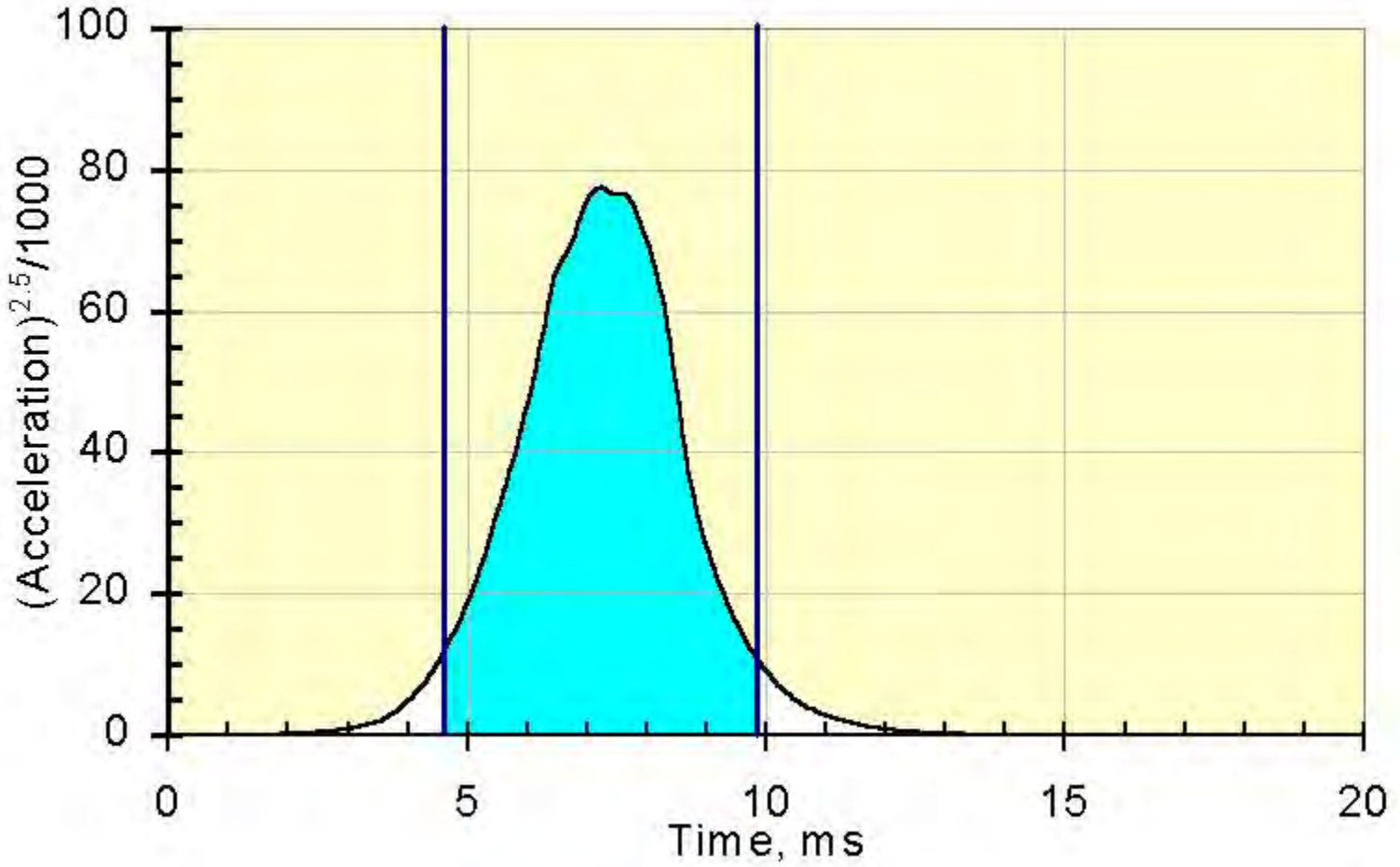


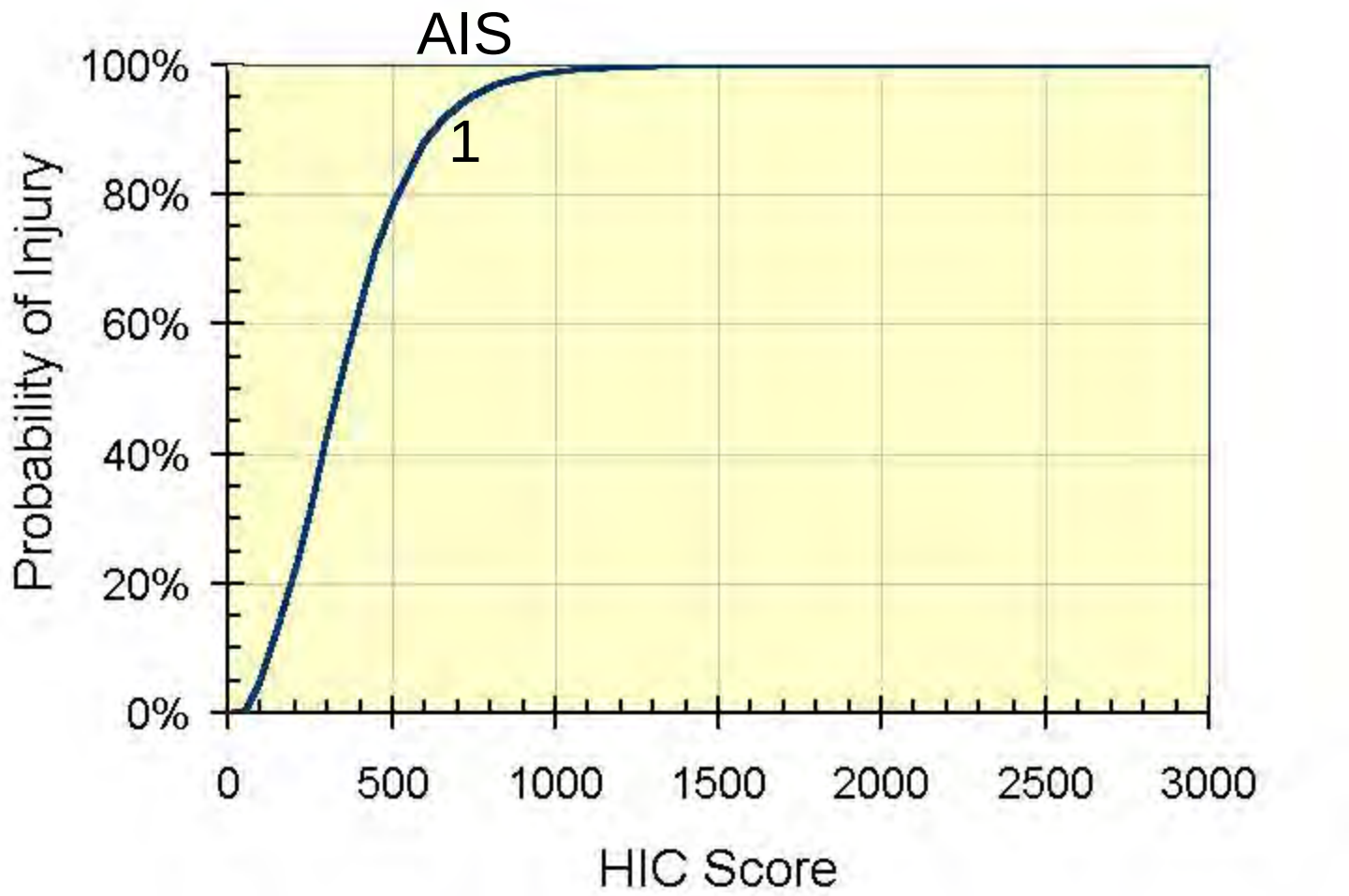
Impact Tolerance of the Brain

Head Injury Criterion



Impact Tolerance of the Brain

Prasad-Mertz Curves



Impact Tolerance of the Brain

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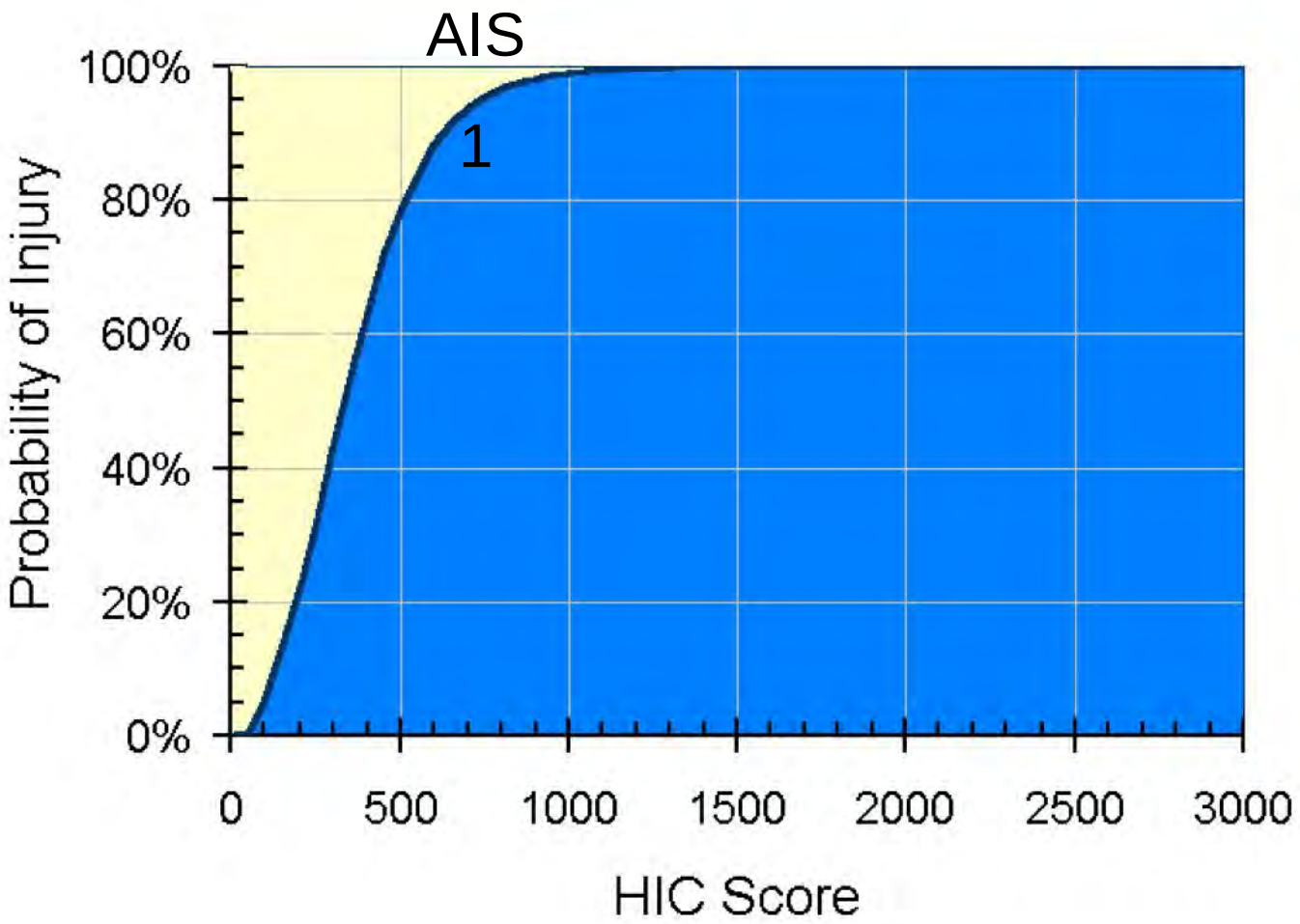

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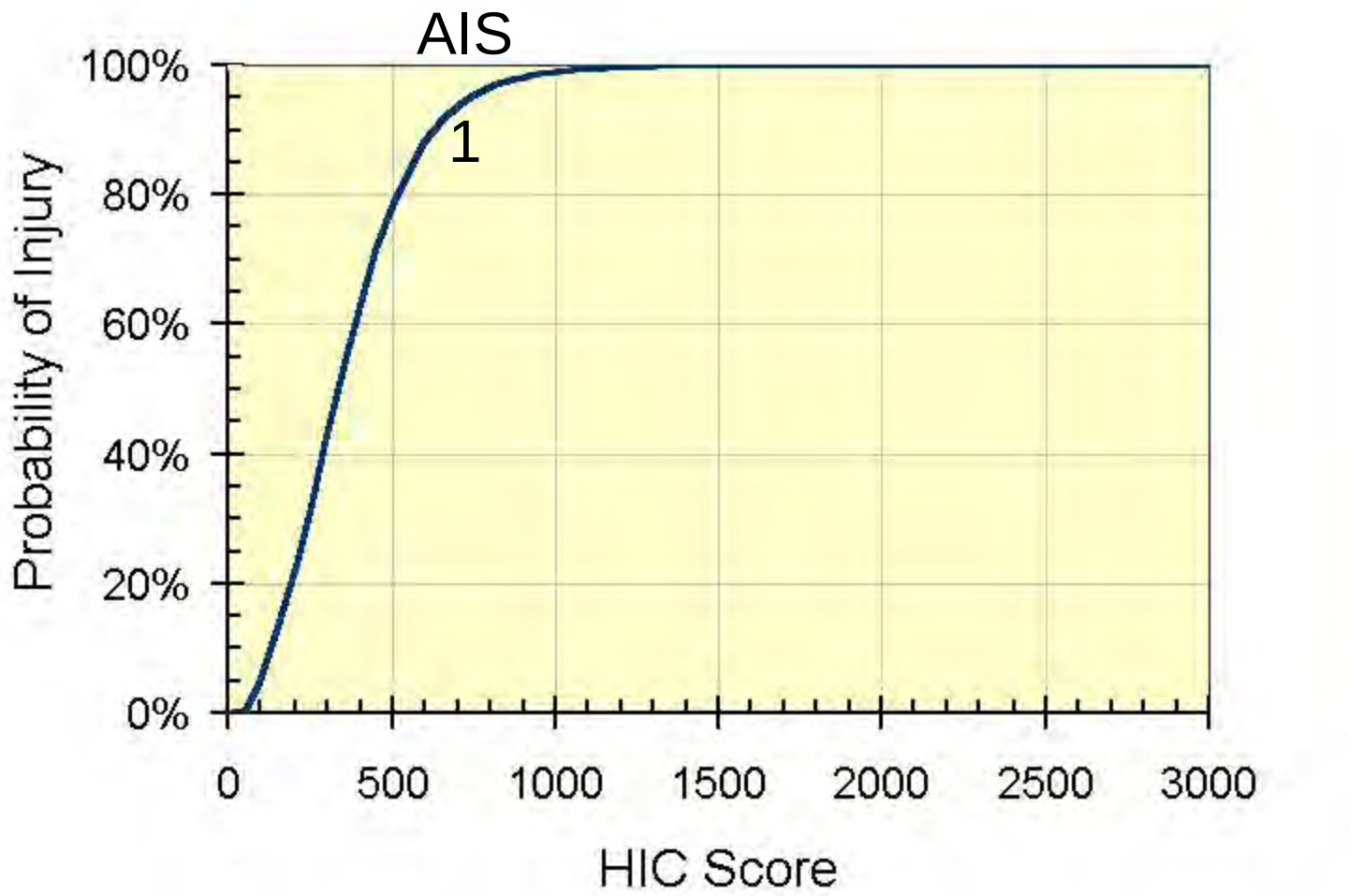

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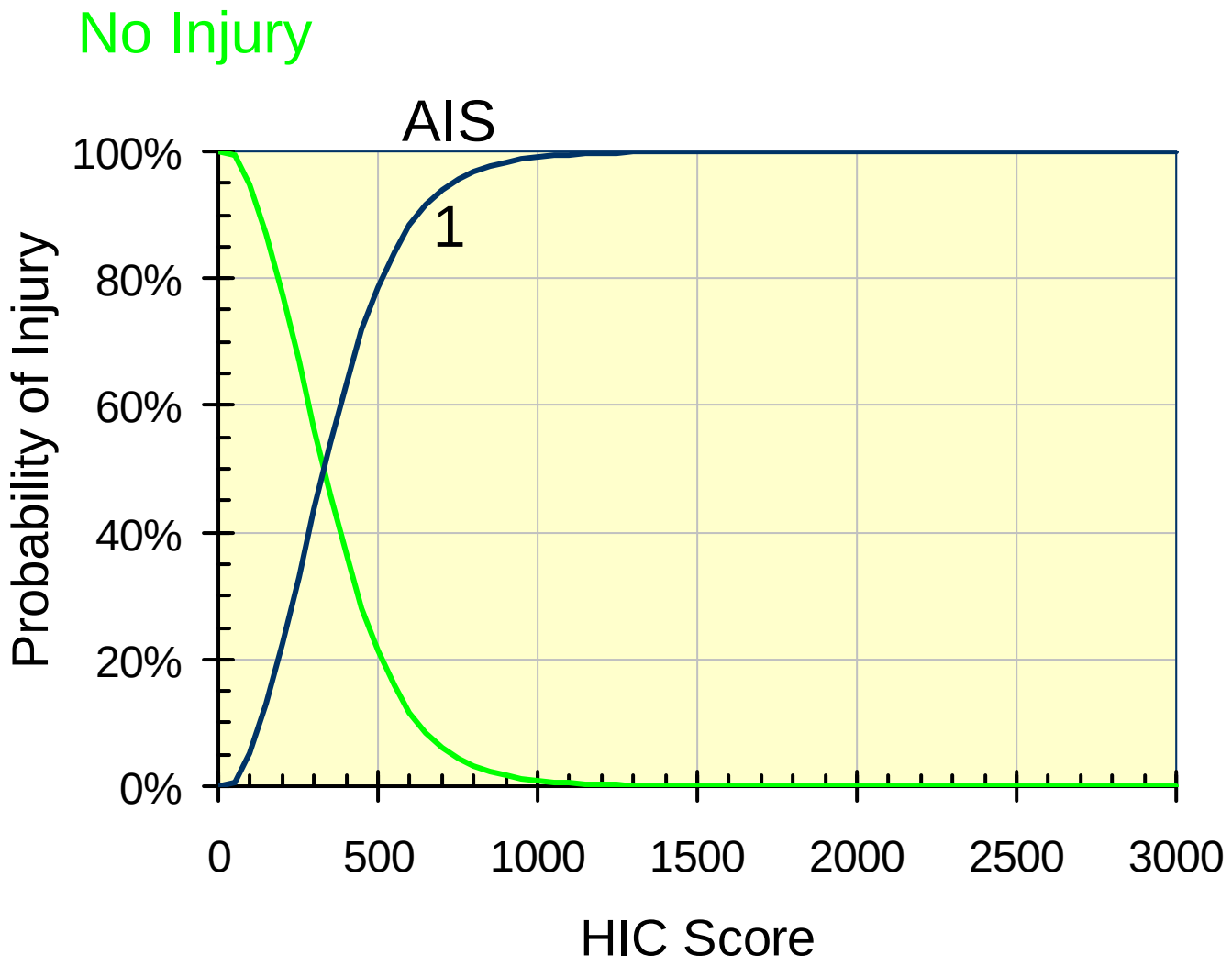

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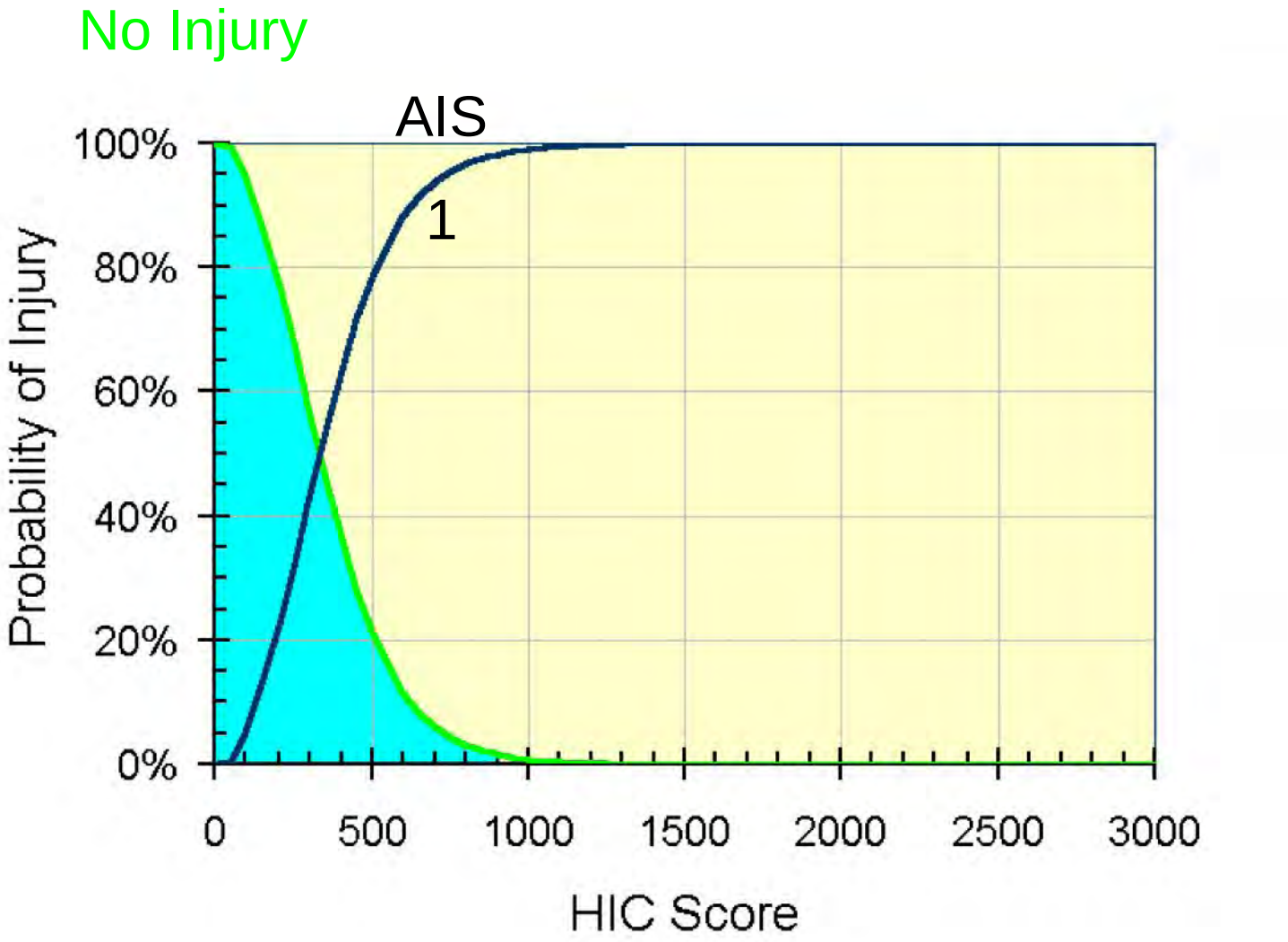

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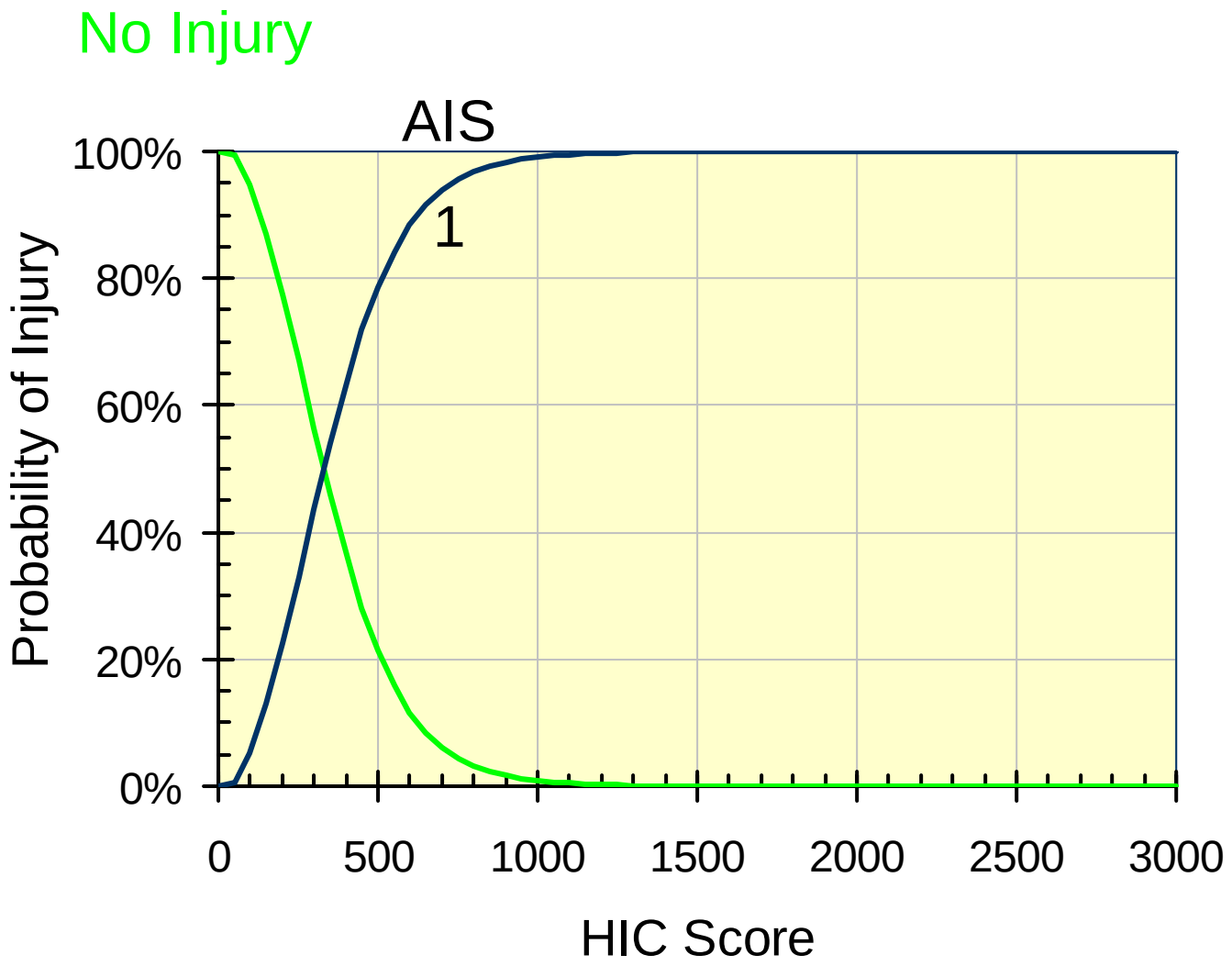

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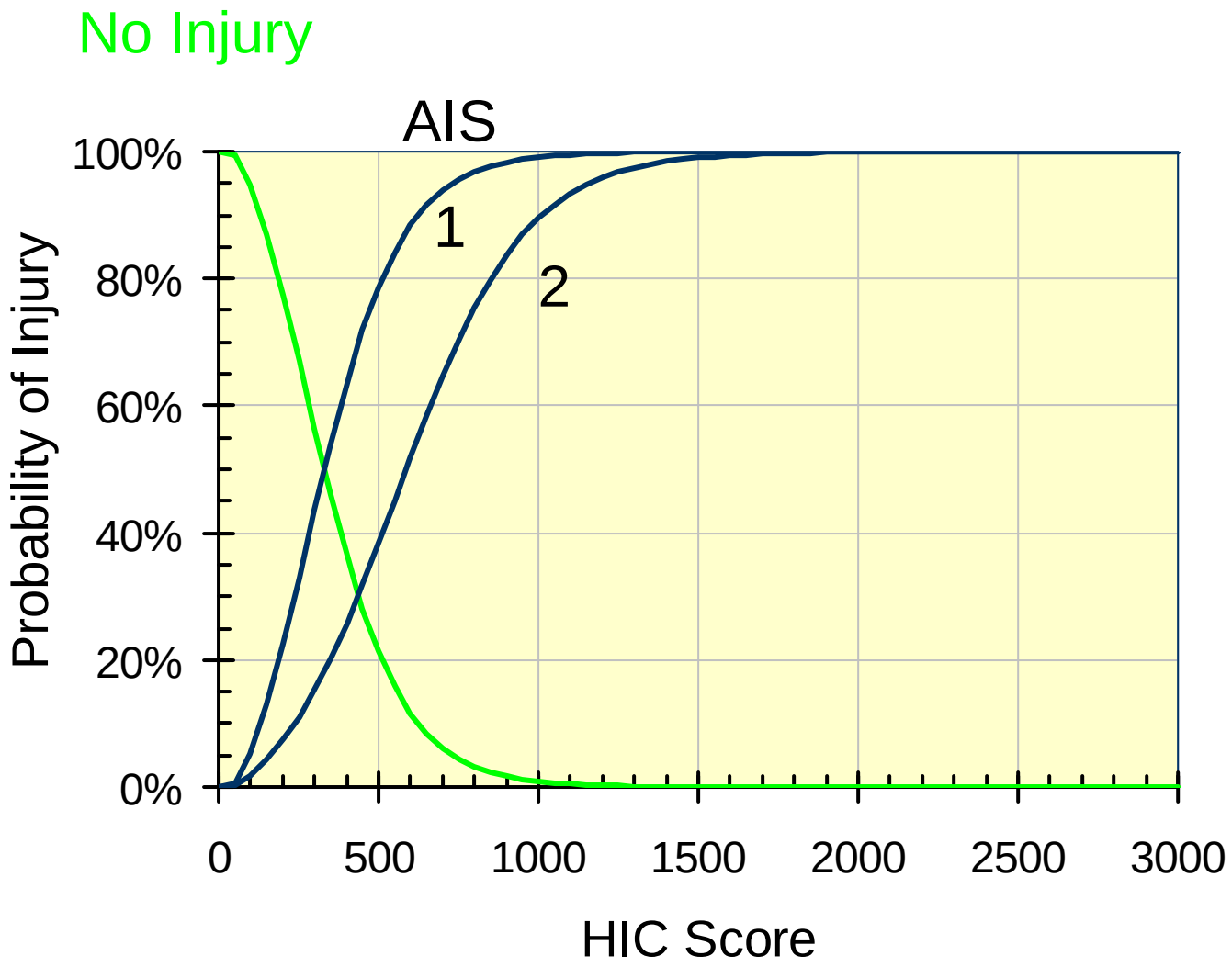

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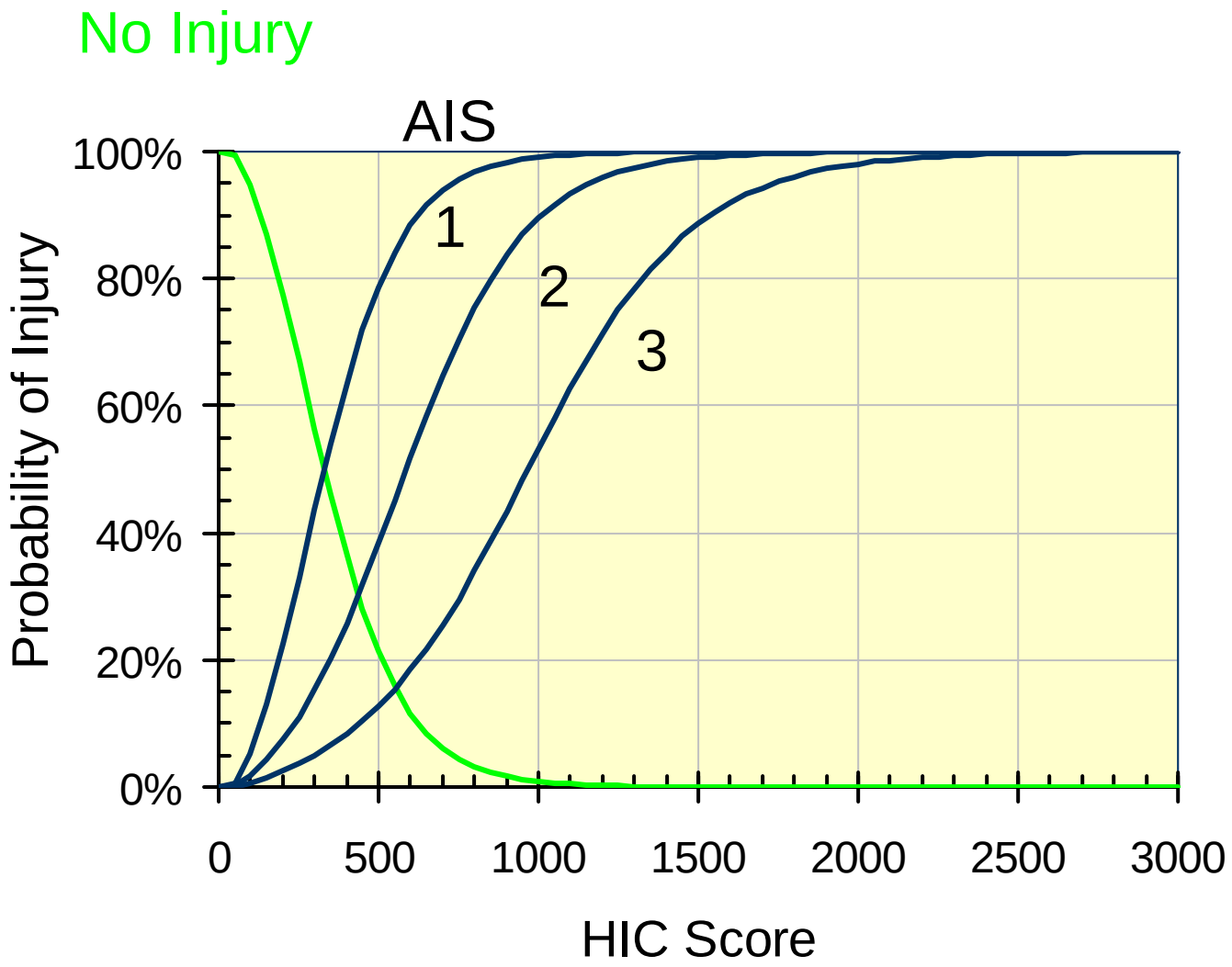

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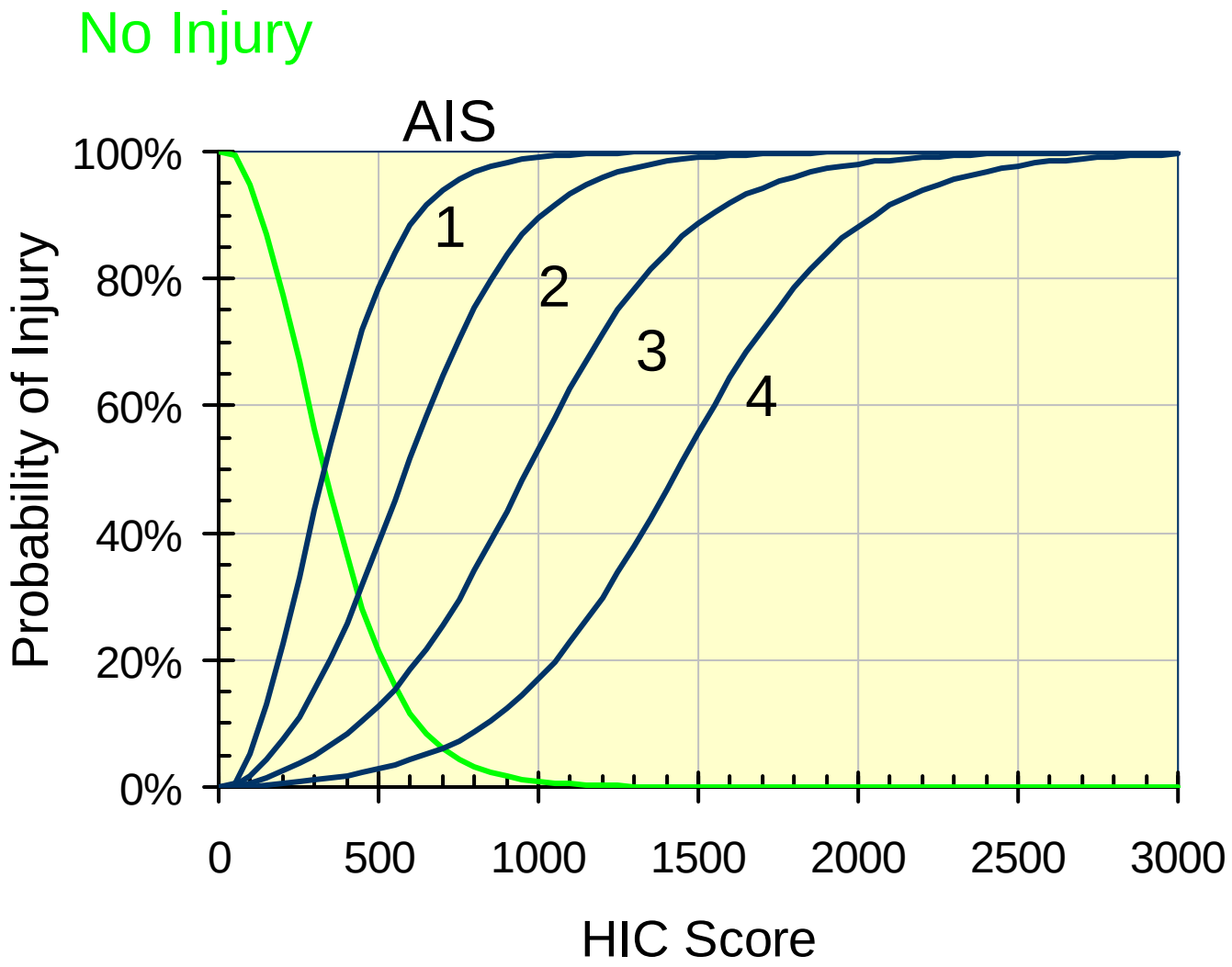

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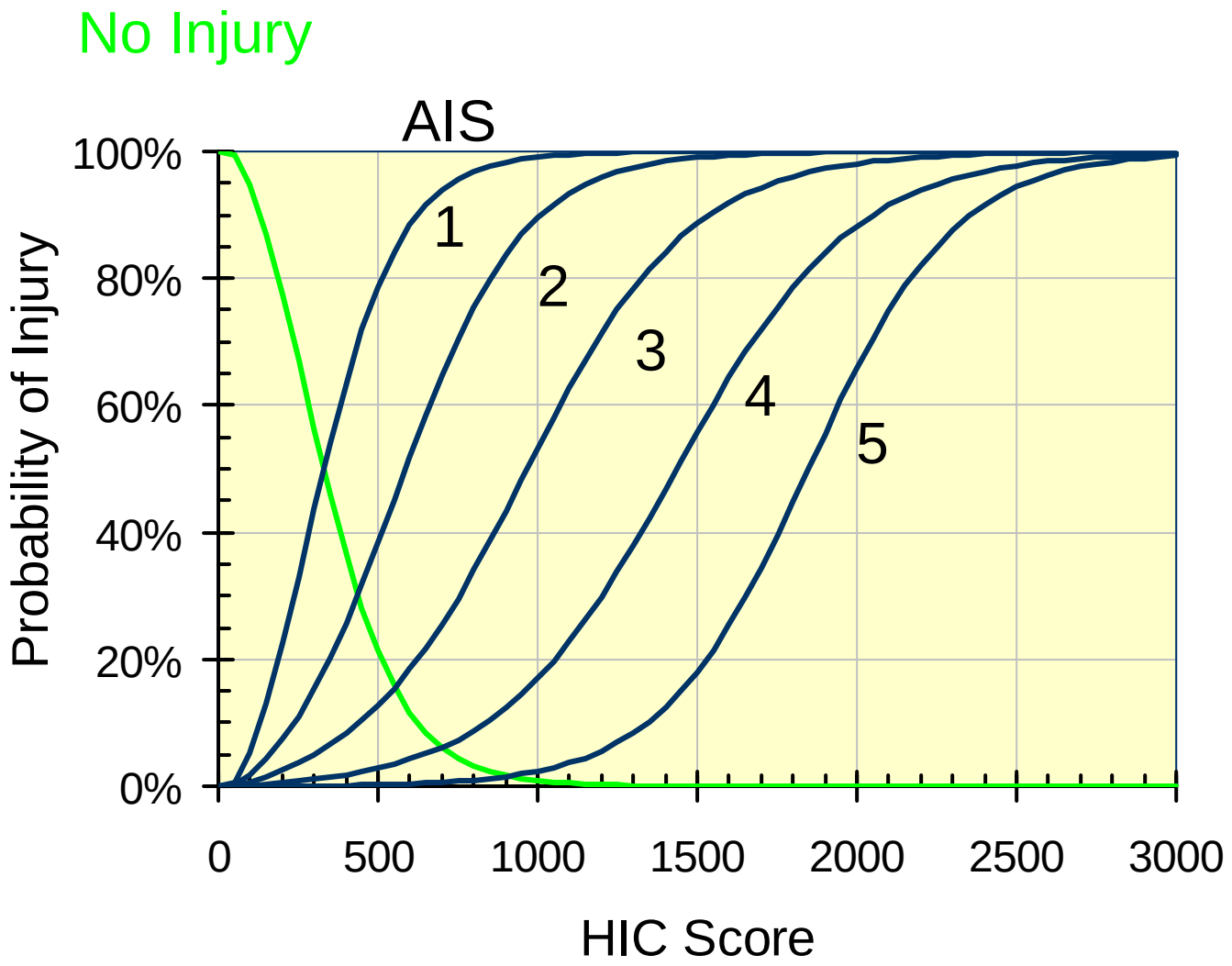
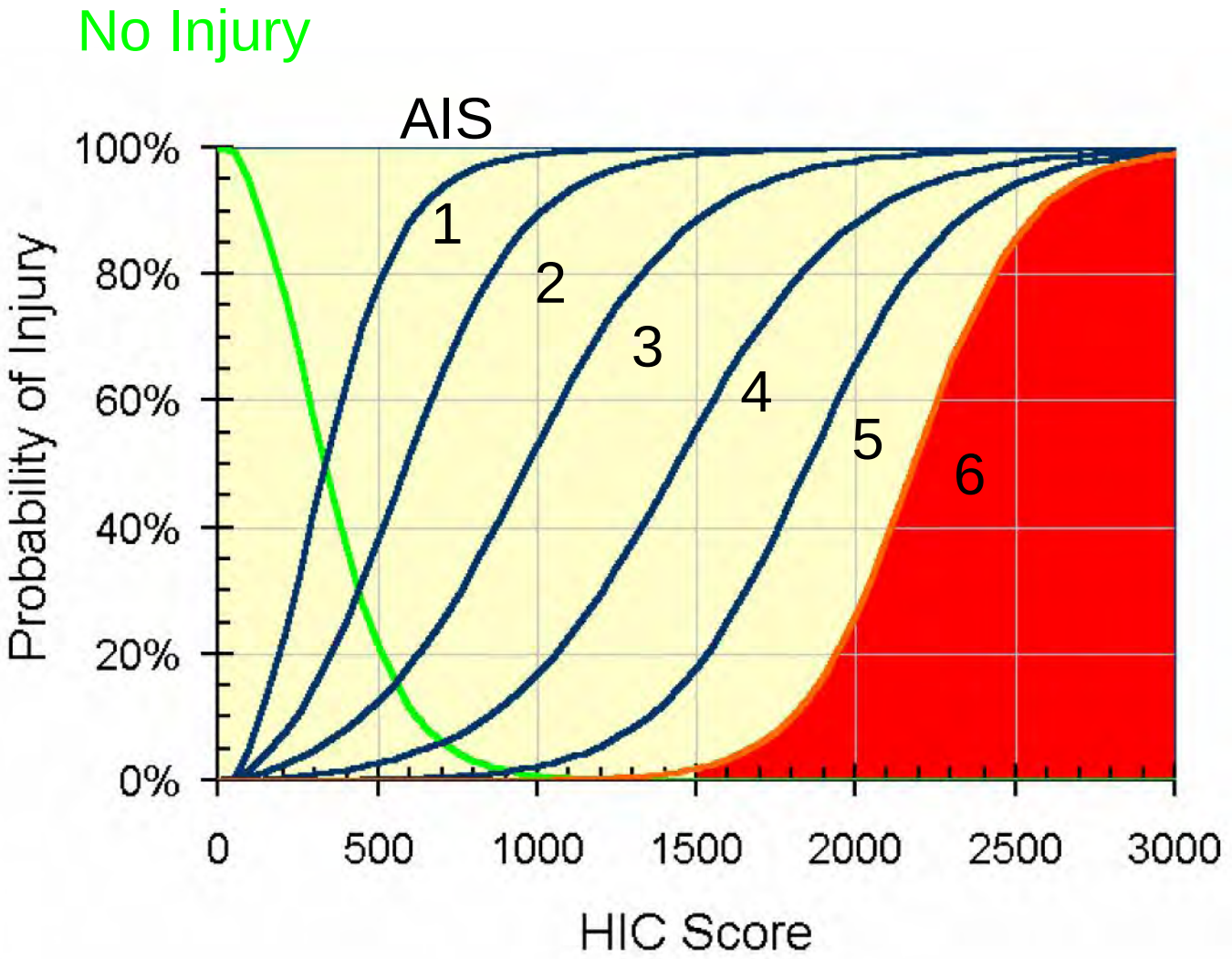


Impact Tolerance of the Brain

Prasad-Mertz Curves



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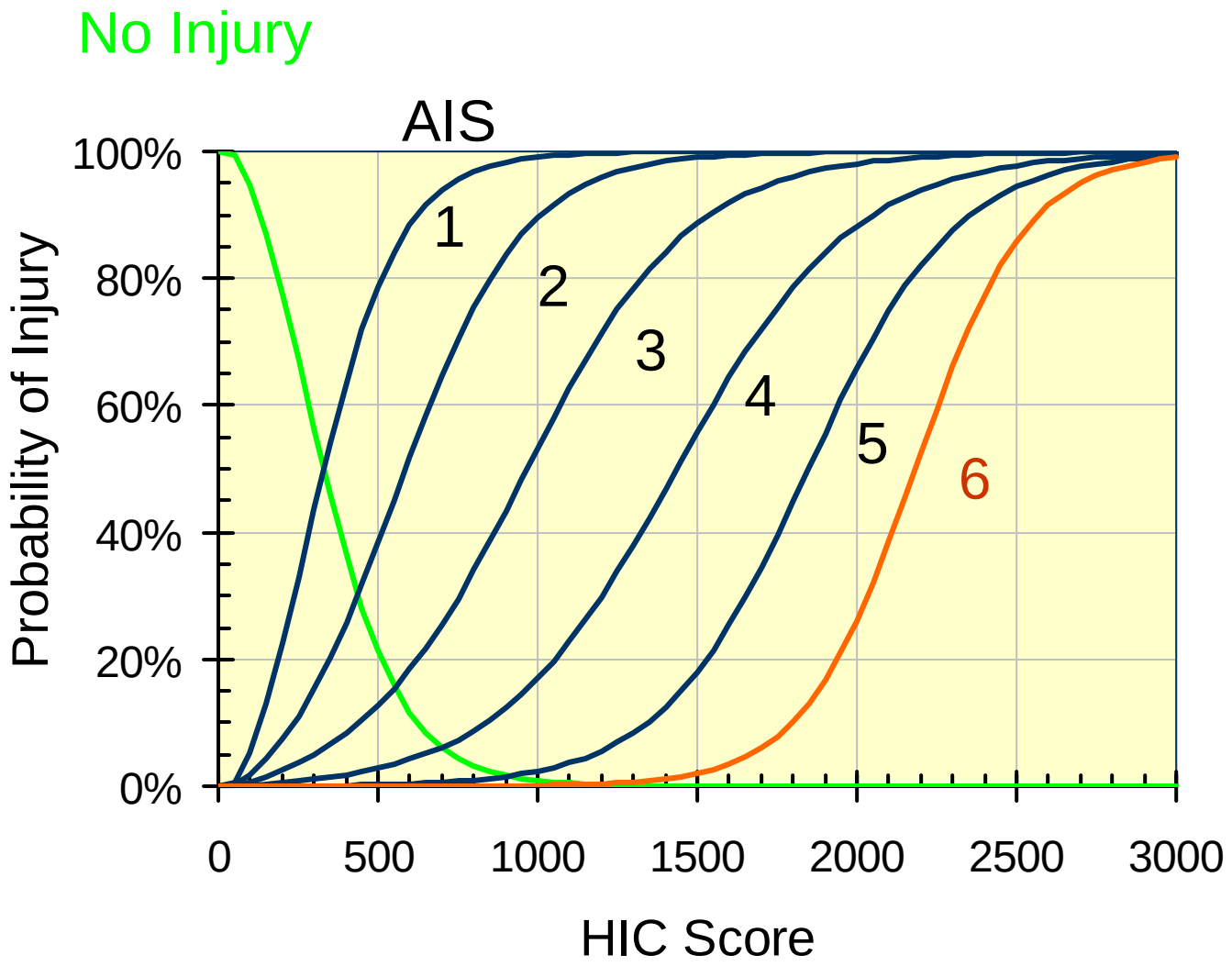

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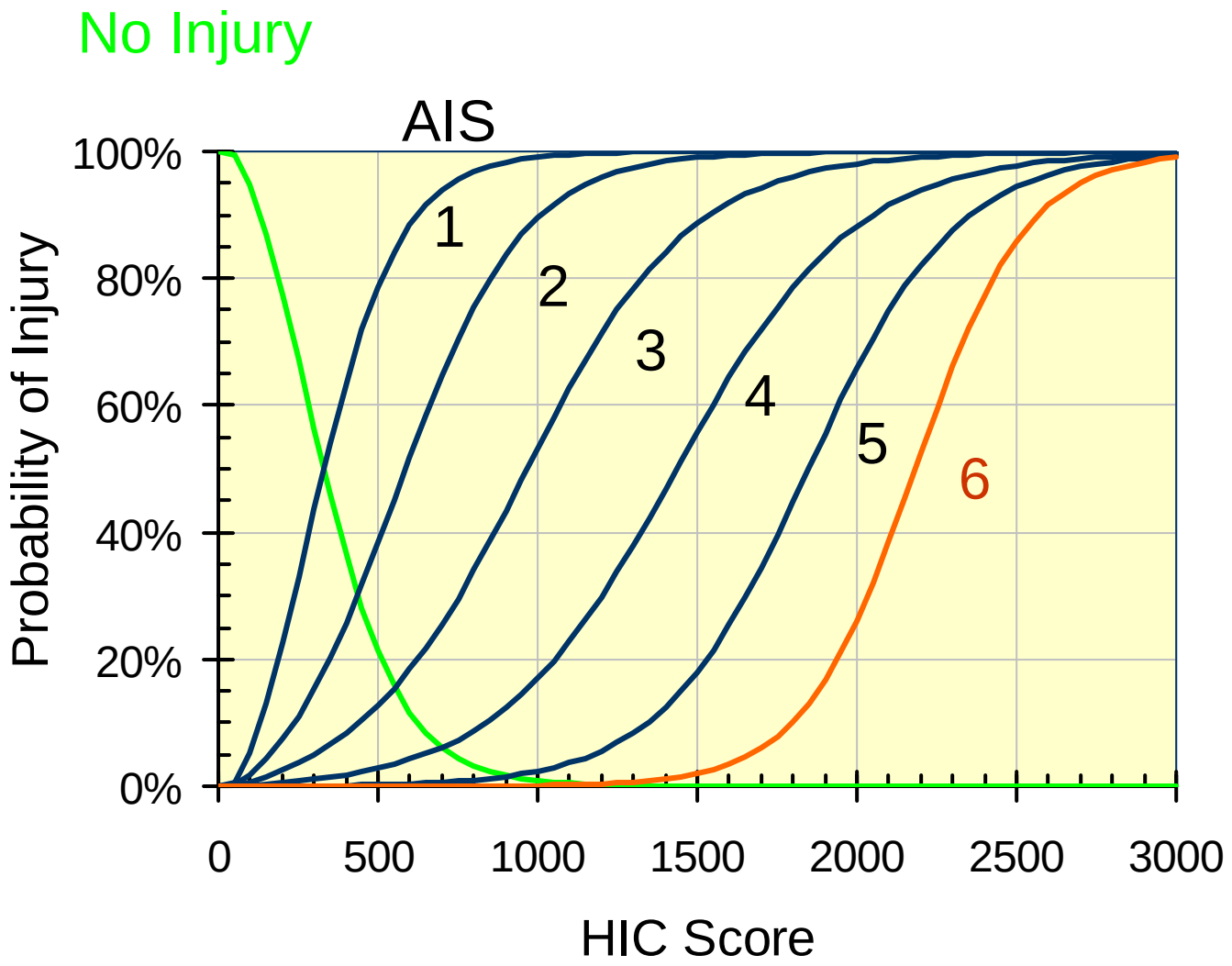

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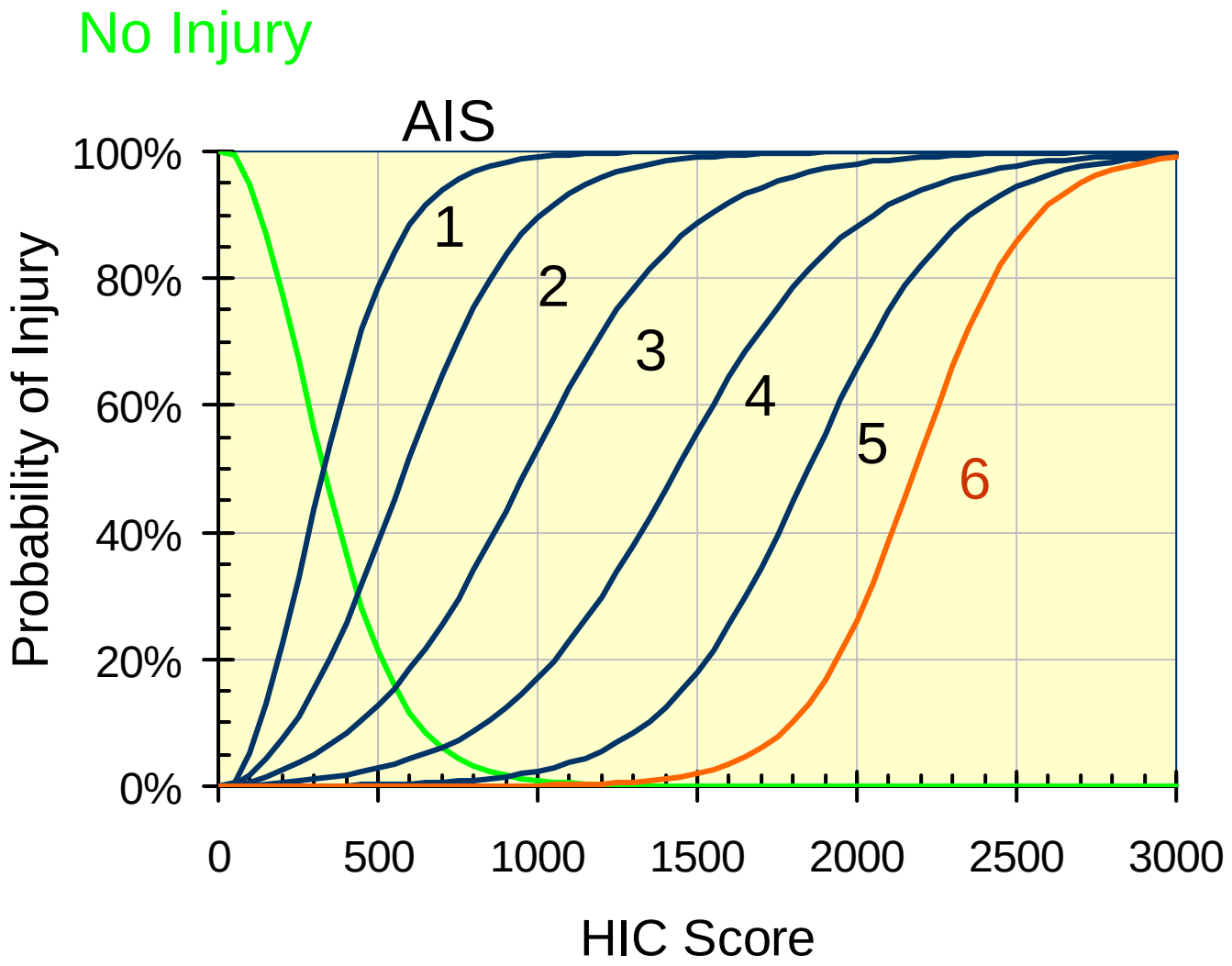
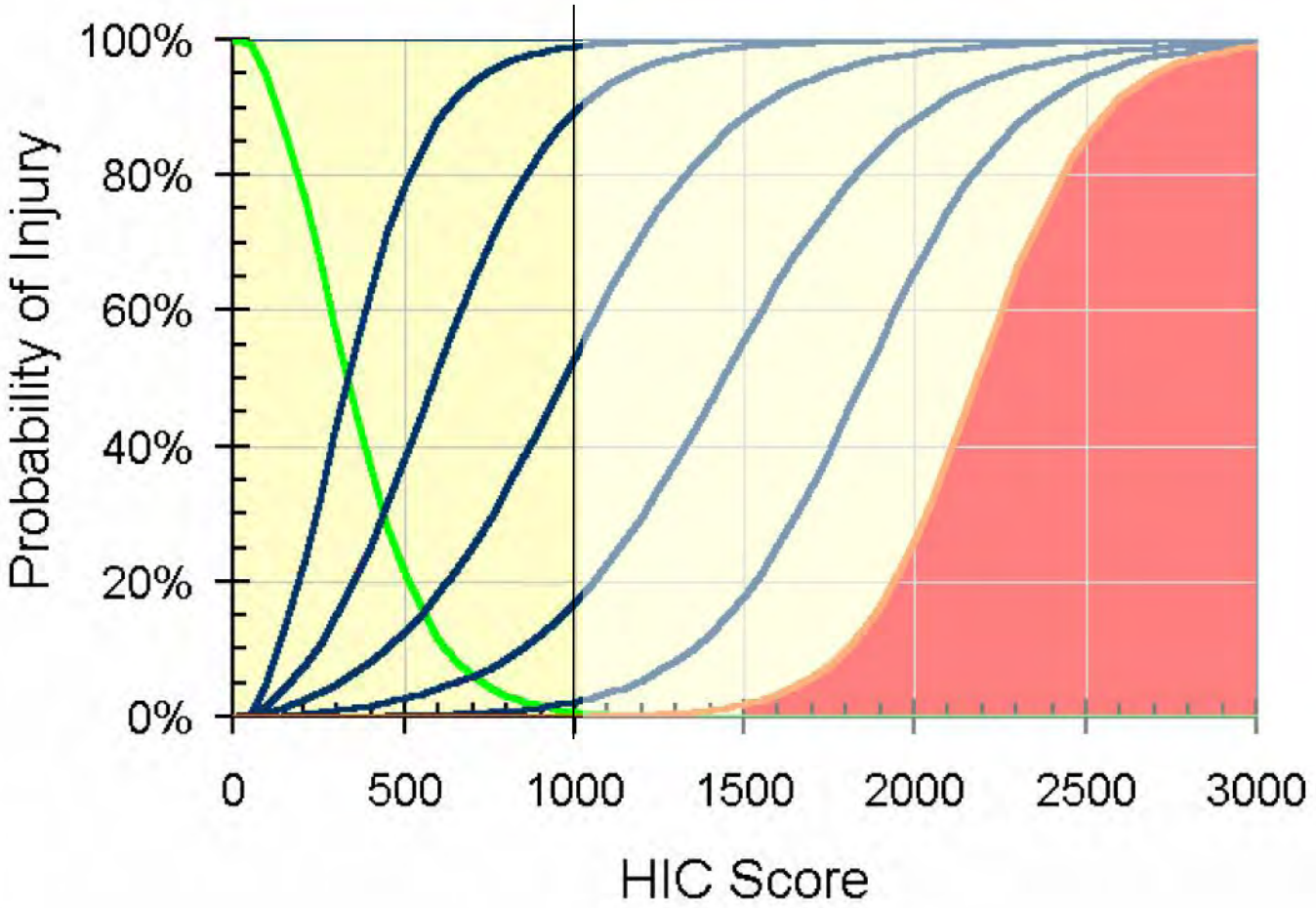


Prasad-Mertz Curves

HIC = 1000



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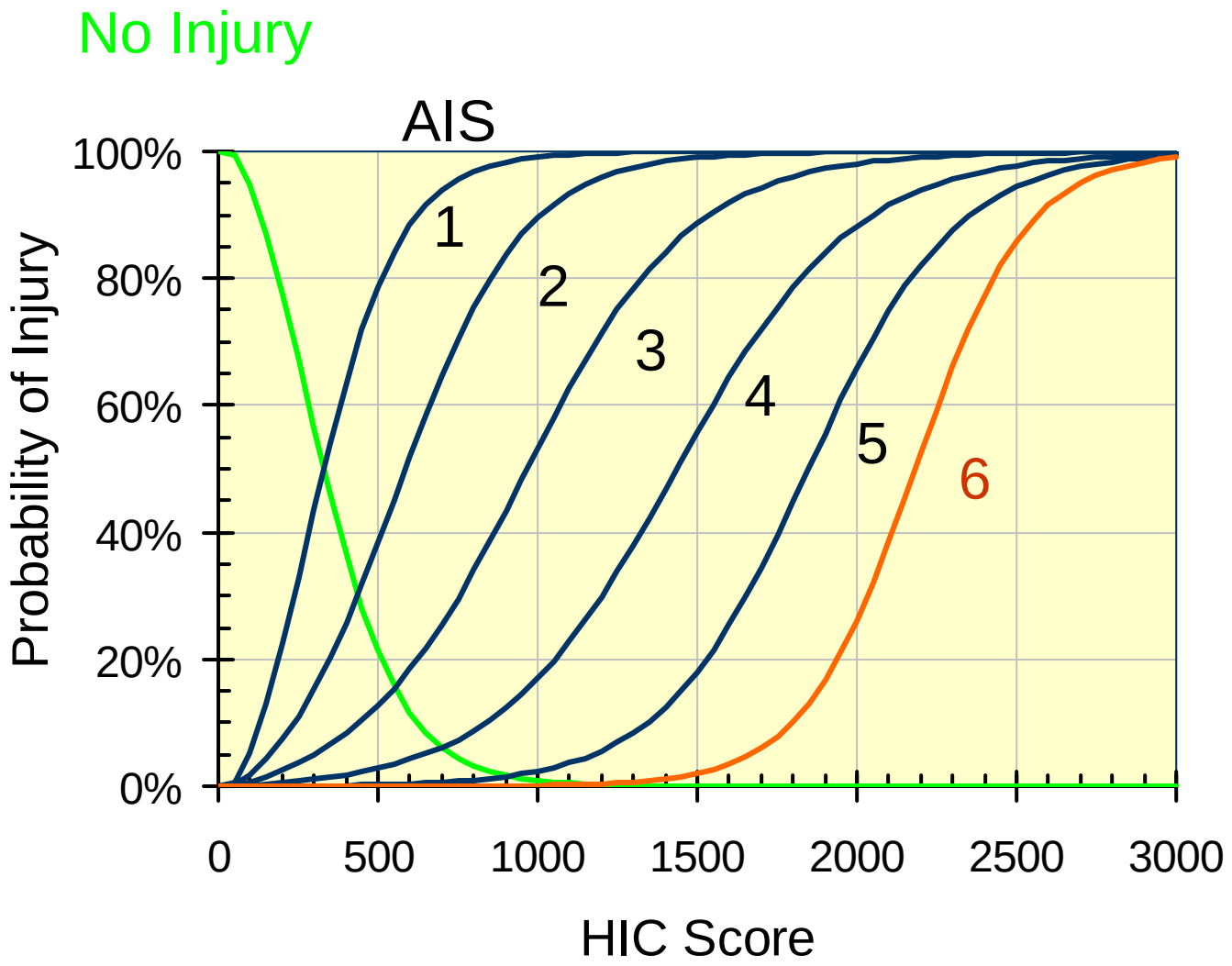
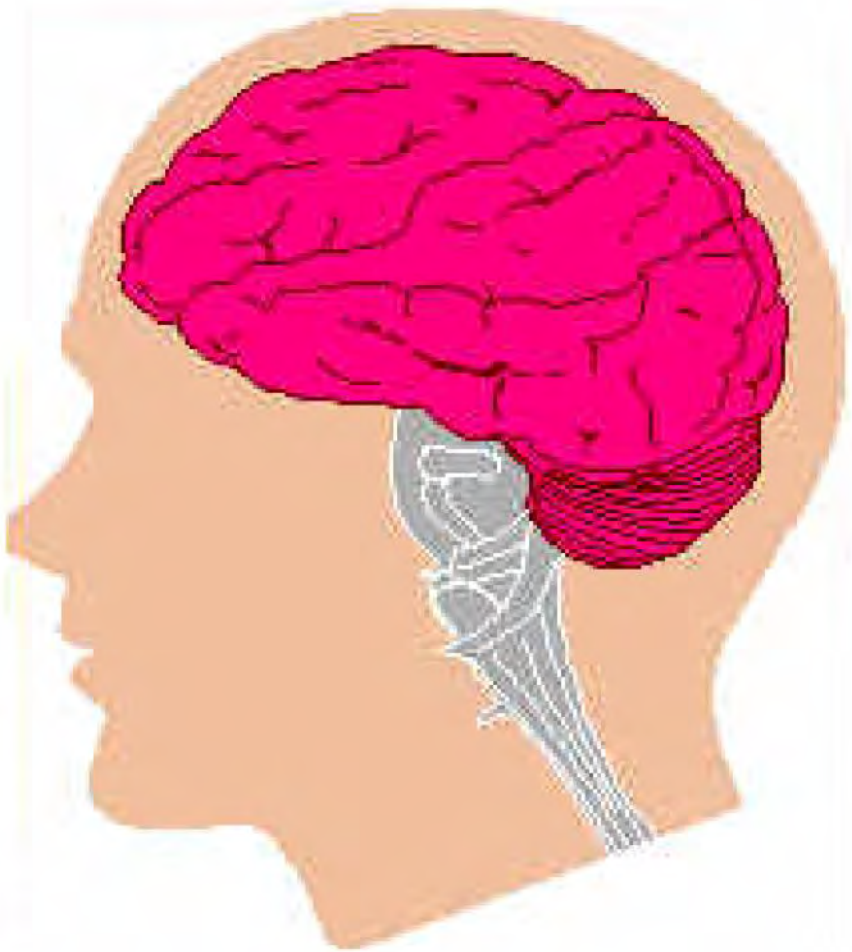


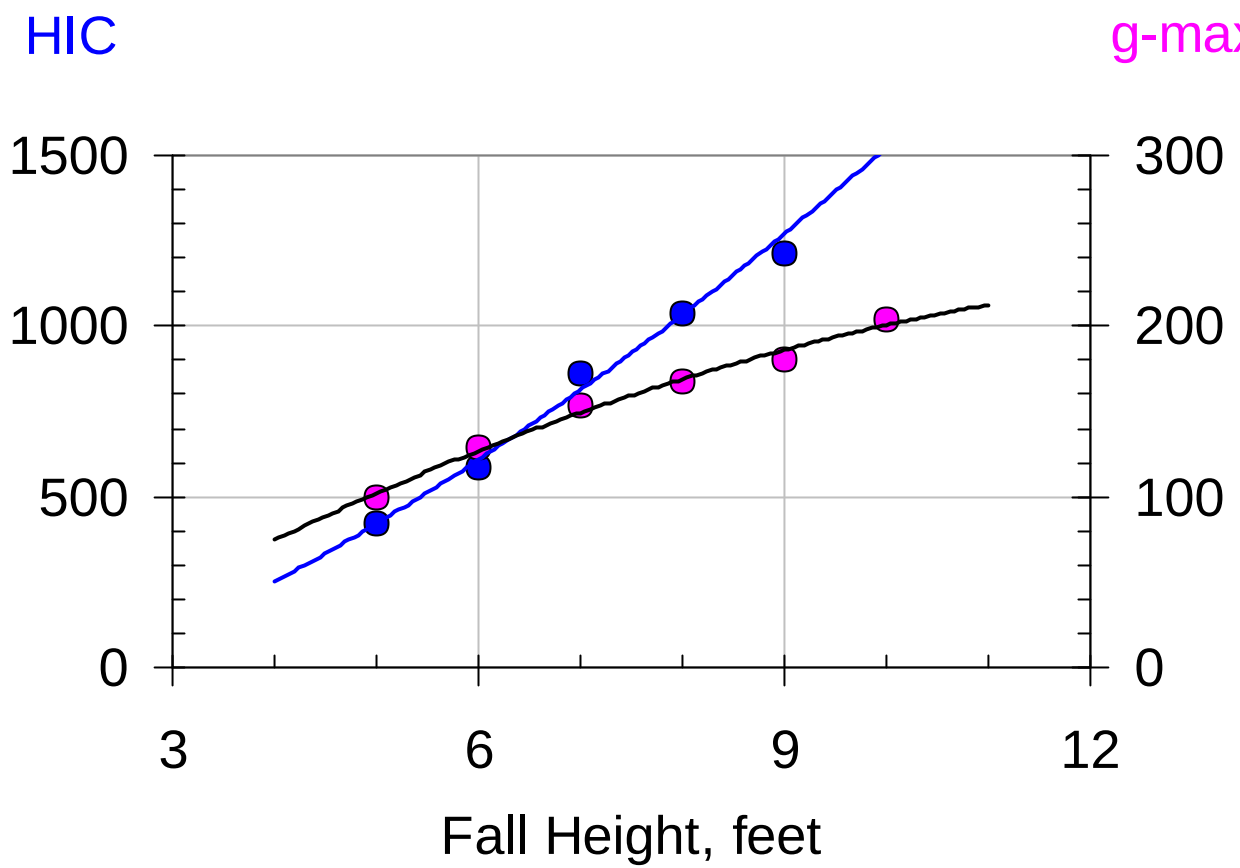
Are Impact Tests Good Surrogates?



- Mass
- Energetics
- Geometry
- Flexibility

Playground Surfacing

Critical Fall Height



Playground Surfacing

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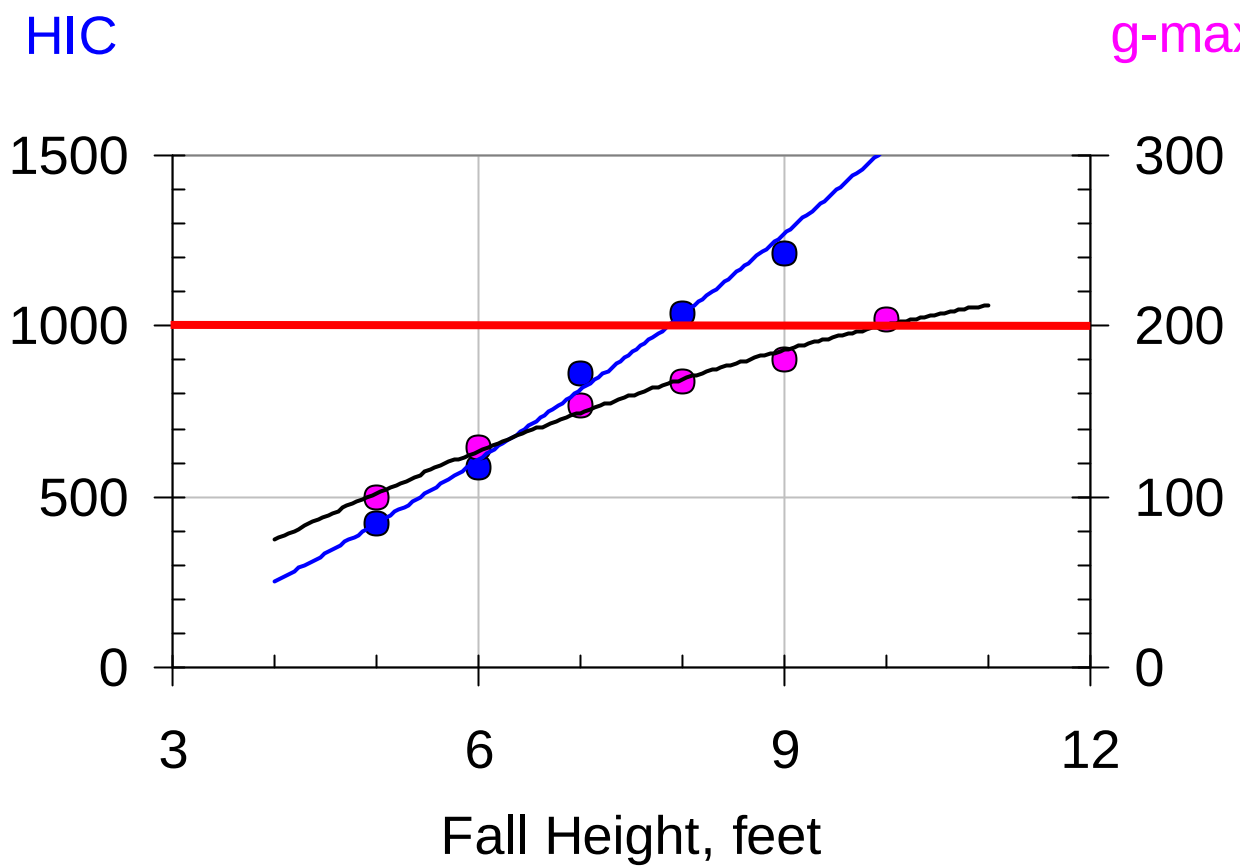

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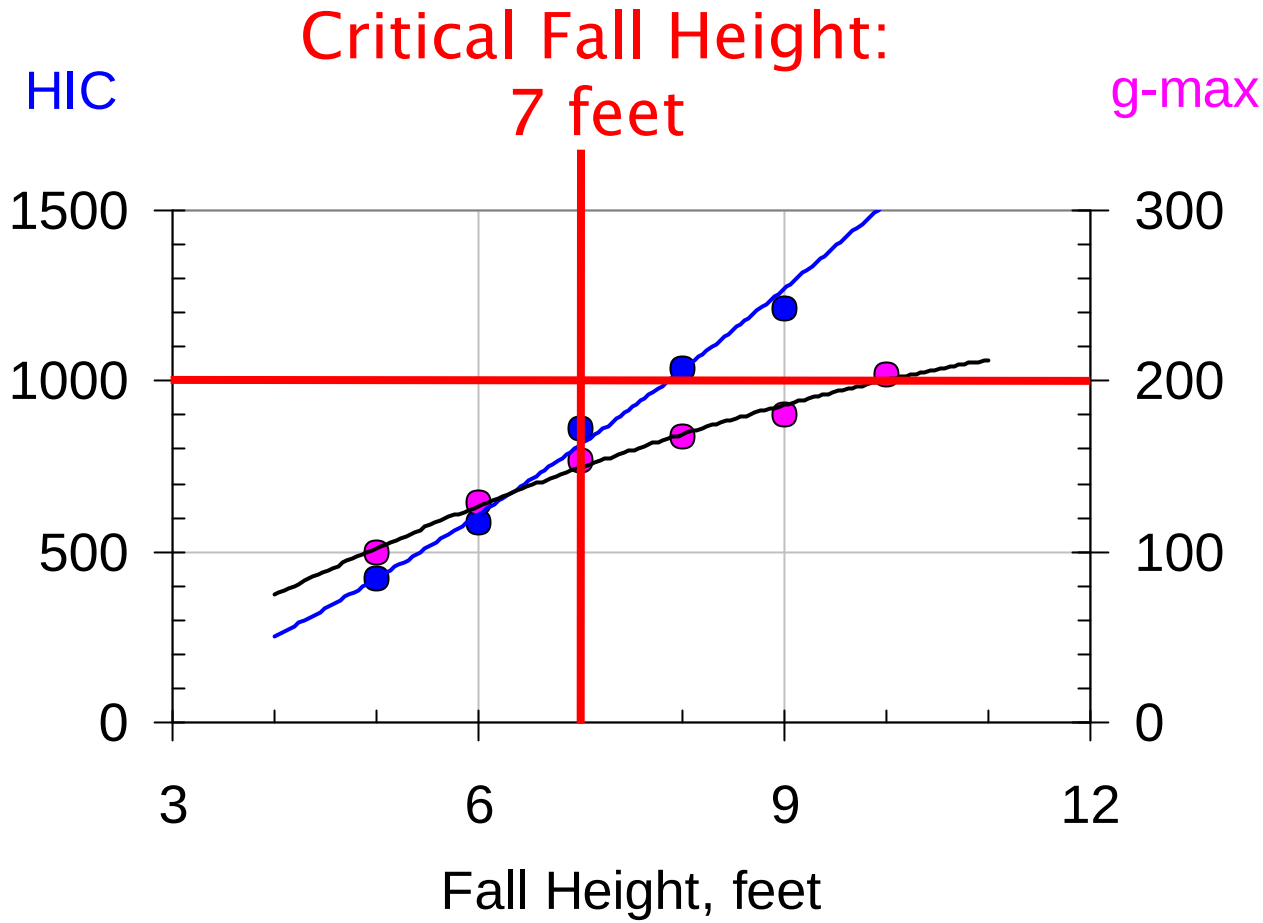


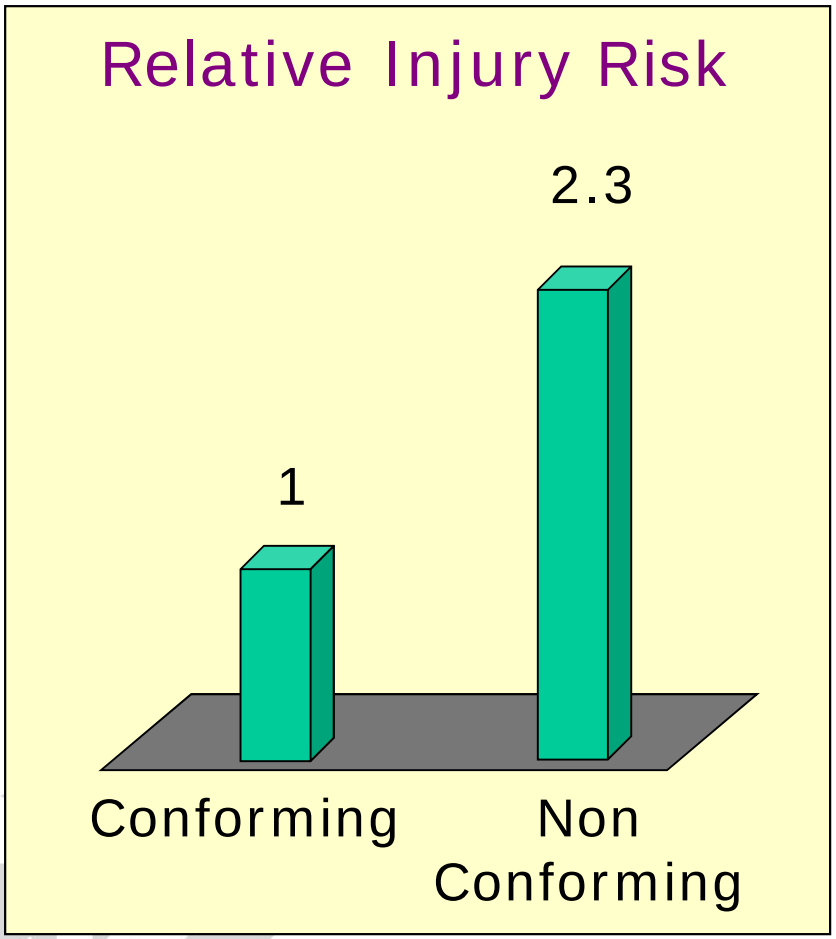
Playground Surfacing Materials

Shock Attenuation Performance

25 cm uncompressed depth

15 cm thickness

Benefits of Shock Attenuation

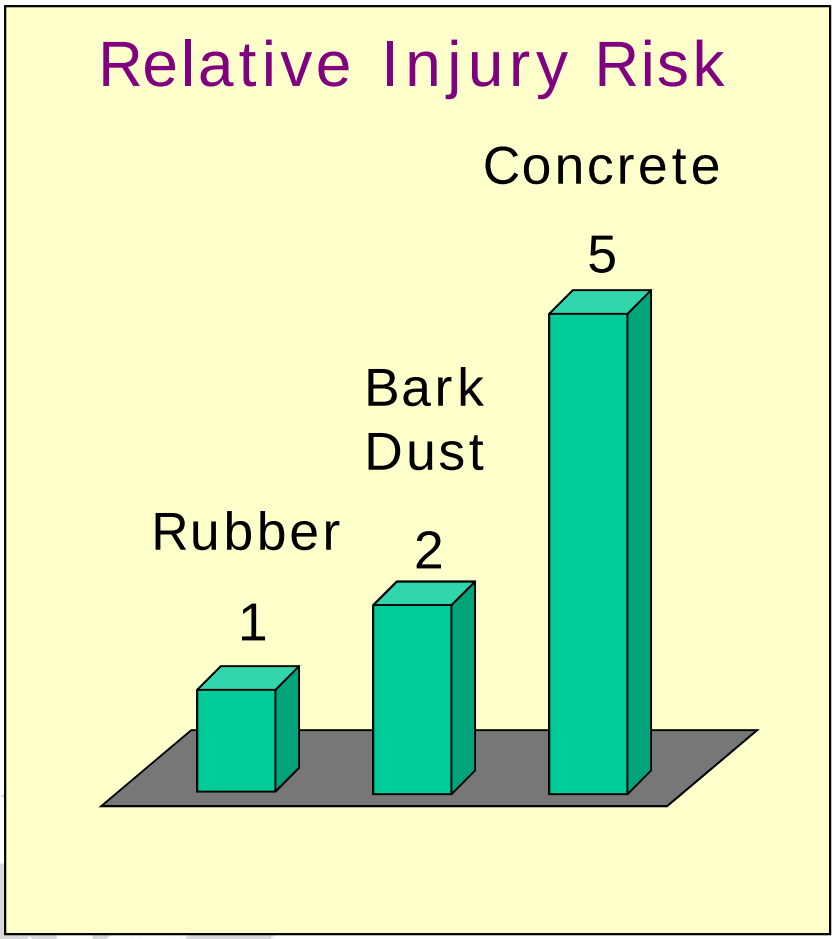


Chalmers et al, 1996

Non-conforming surfaces

- 2.3 times greater injury risk

Benefits of Shock Attenuation



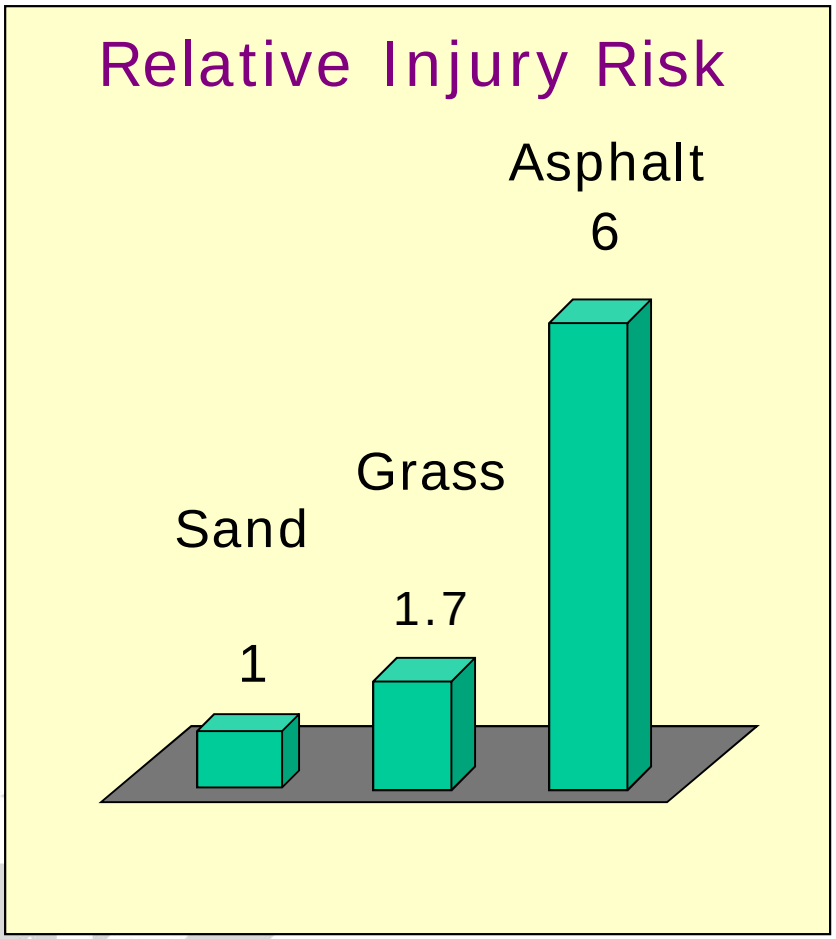
Mott et al, 1997

Non-conforming surfaces

- 2.3 times greater injury risk

Surfacing Materials

Benefits of Shock Attenuation



Sosin et al, 1993; Laforest et al, 2000

Non-conforming surfaces

- 2.3 times greater injury risk

Surfacing Materials

Severe head injuries

Impact Test Issues

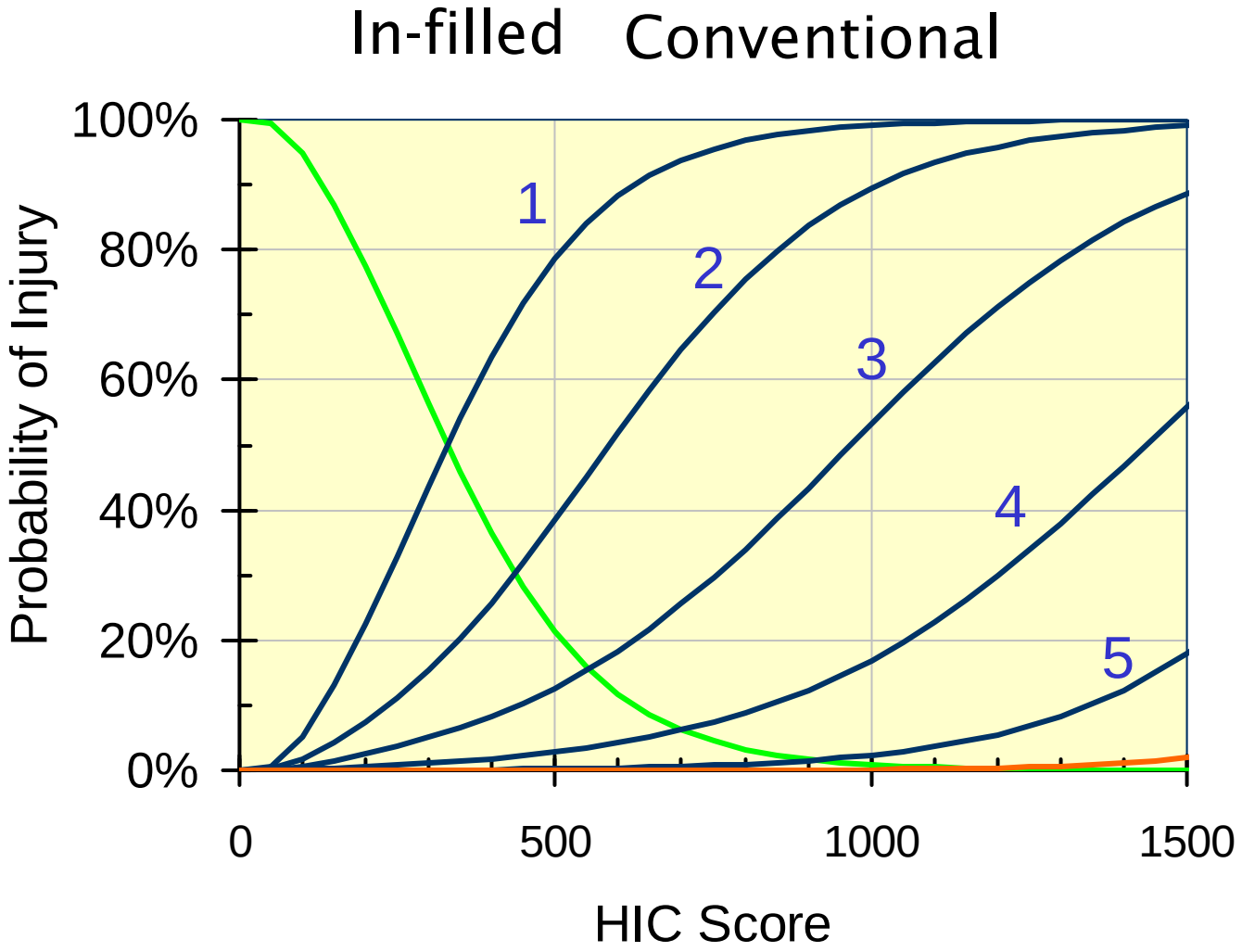
Positives:

- Good faith attempt to evaluate injury risk
- Documented effectiveness
- Bias of risk estimates

Are Impact Tests A Good Surrogate

“True” HIC Estimation

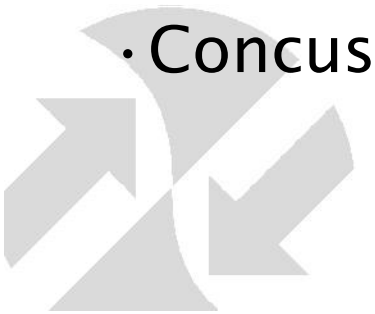
Adjusted HIC scores



Impact Test Issues

Limitations:

- Data
  - Quantity
  - Applicability
  - Validity
- Method
  - Biofidelity
  - Reproducibility and repeatability
- Concussion
  - Head injury focus



"Concussus"

"to shake violently"

BIOMECHANICA