Body Changes With Aging

University of Michigan Program for
Injury Research and Education

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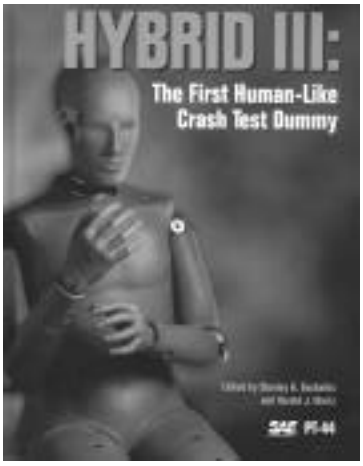
Automotive Safety

- Vehicles are safer than they have ever been.
- Laboratory testing using idealized occupants and standardized crashes has led to great improvements in safety.
- The body is relatively stable during early and middle adulthood - not so during early childhood or advanced age.



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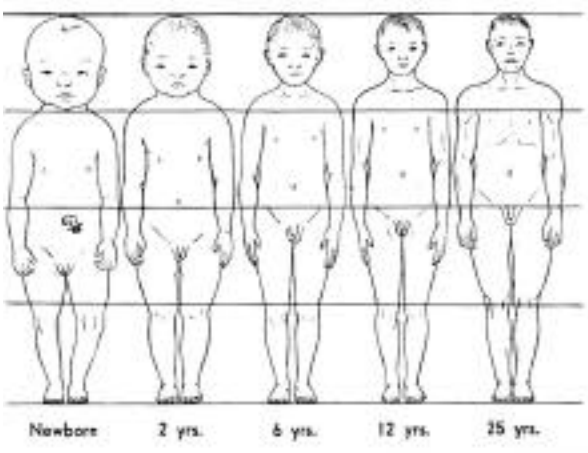
Child ≠ Small Adult



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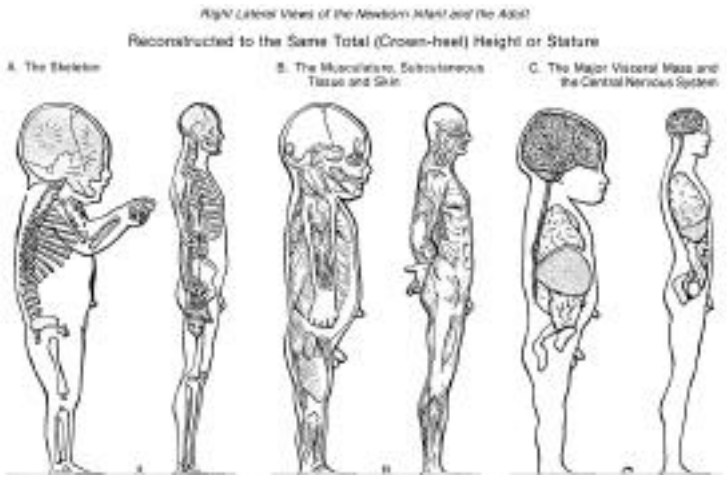
A Child's Neck is Under-developed



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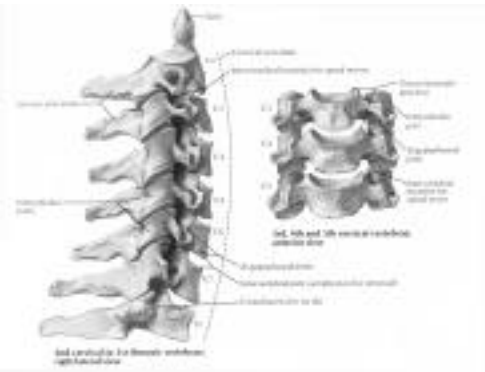
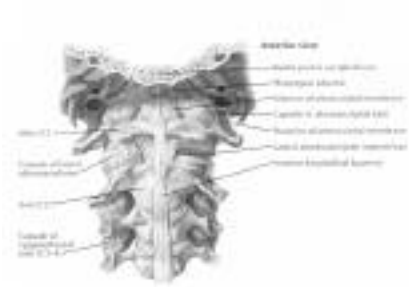
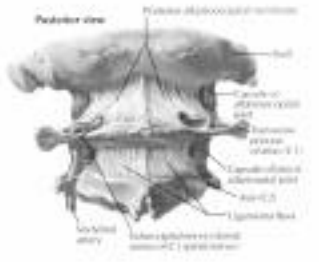
Upper vertebrae joints are more horizontal in children:

Less resistance to translation



The Head Bone is Connected to the Neck Bone...





- Partial rupture of ligaments between bottom of skull and first vertebrae presents as bleeding in lower skull.
- Total rupture of these ligaments results in rupture of the spinal cord, a fatal injury.

A child's ligaments are loose to accommodate growth:

- **An infant's neck column can stretch up to 2 inches with traction.**
- **If stretched more than 1/4 inch, spinal cord rupture may occur.**

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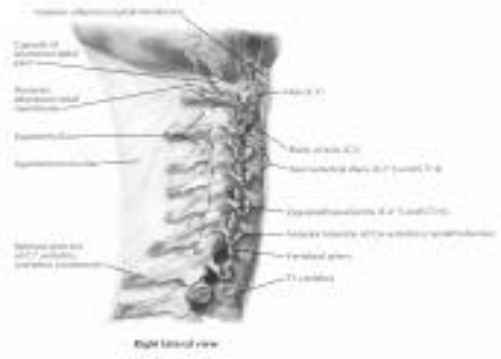
The Head Bone is Connected to the Neck Bone...



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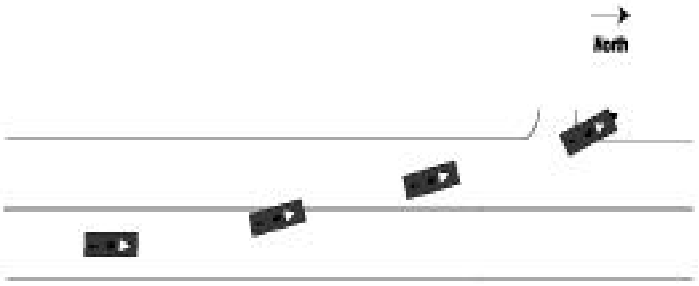
Crash Scenario



- 1994 Ford Tempo vs tree
- Driver of V1 fell asleep, V1 crosses the center line and strikes a tree on the left side of the road
- Driver and center rear passenger are the only occupants of case vehicle
- Daylight with clear weather
- Dry asphalt roadway

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Crash Scene

Path of Case Vehicle

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Case Vehicle - 1994 Ford Tempo

Crush Profile

CDC: 12-FYEW-3

47 cm of direct damage

PDOF: 360 degrees

77 cm of maximum crush

Impact Severity:

38 mph total delta V

all longitudinal

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Case Vehicle - 1994 Ford Tempo

Center-rear passenger

18-month-old female

32 in tall, 28 lb

In forward-facing child safety seat secured by manual vehicle lap belt

Photos Prior to Removal of Seat from Vehicle by Police **41-01**

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Case Vehicle - 1994 Ford Tempo

Child Safety Seat

Century 3000 STE convertible child safety seat

Manufactured 12/99

CSS being used in forward-facing mode

Shoulder harness set for use in rear-facing position

Tether equipped but not used

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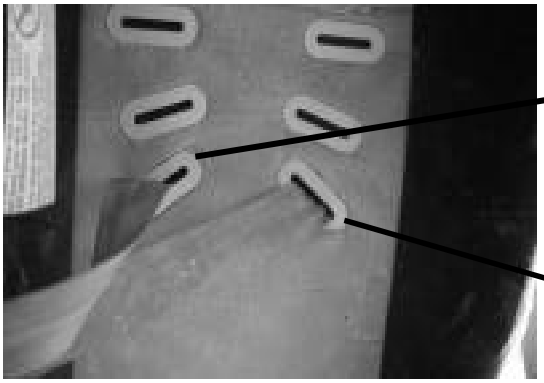
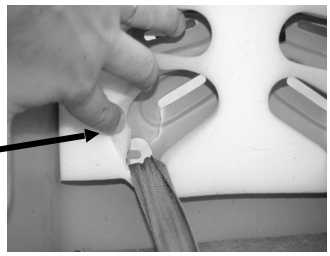
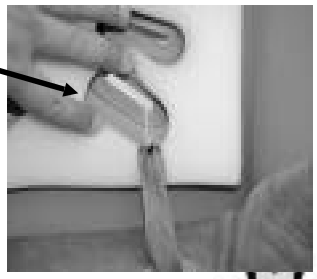
Case Vehicle - 1994 Ford Tempo

Child Safety Seat Harness Slots







Front View

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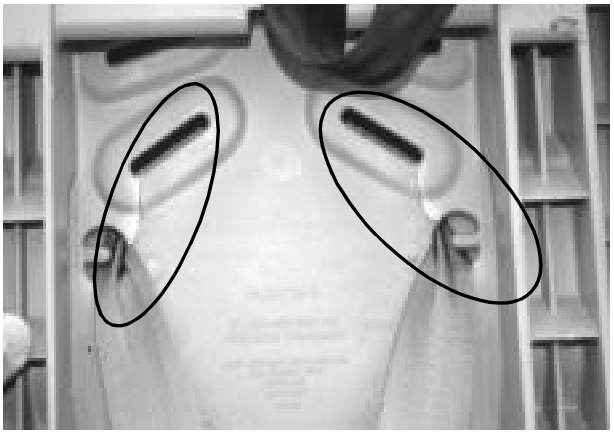
Case Vehicle - 1994 Ford Tempo

Child Safety Seat Harness Slots



Rear View

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Center hit, 12 o'clock PDOF

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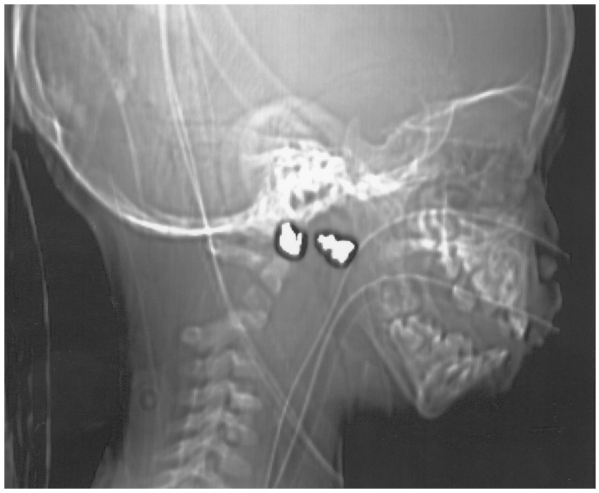

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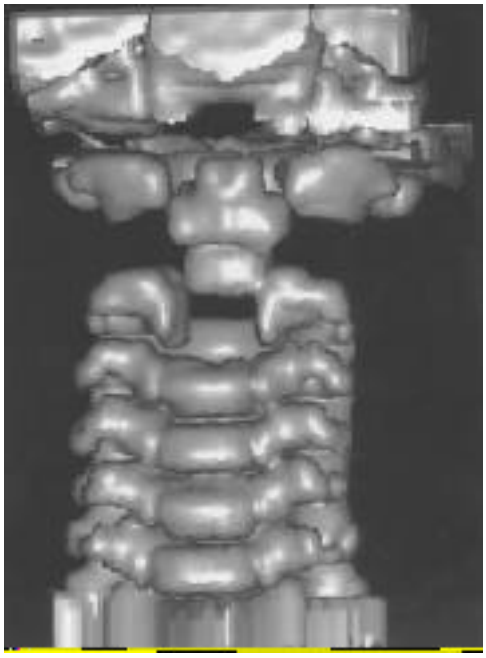

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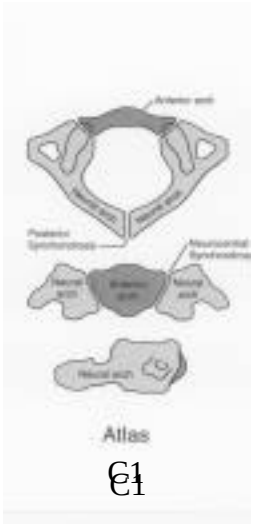

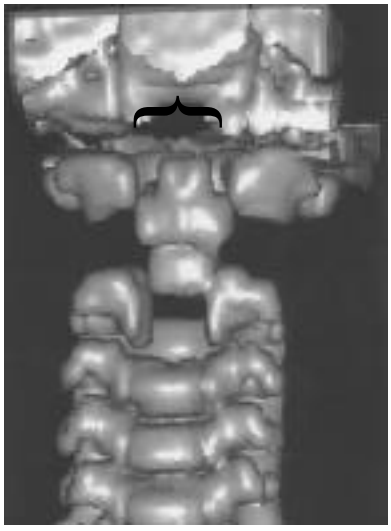

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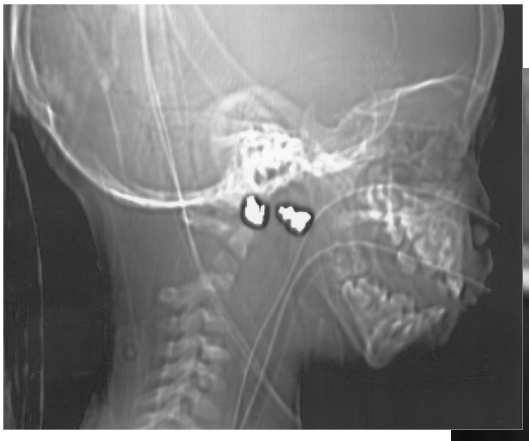

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Result: Quadriplegia

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Summary

- 18 month old, 28 lb female, front facing in CSS with improper belt placement.
- A small child's neck is not yet fully developed and less able to withstand deforming forces.
- A heavy head and weak neck structure make small children extremely vulnerable in a frontal car crash.
- Preserving the normal structural integrity, alignment and spacing of the structures from the skull base down to the chest is critical to avoid injury to the spinal cord.

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Observations

- The optimal solution would be to provide firm support behind the child's head, neck and spine in a rearward-facing child seat - ***already done for infants***.
- Spreading the crash forces in this manner prevents excessive flexion, extension and traction movements that are may result in permanent neurological disability or death.

SWEDEN - children kept rear-facing until age 3.

There is little anatomic and tissue information available regarding young children--Can imaging technology help??

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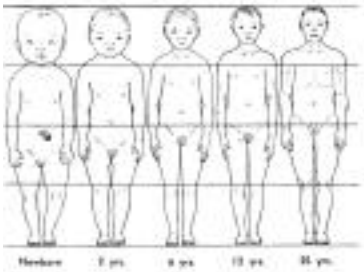
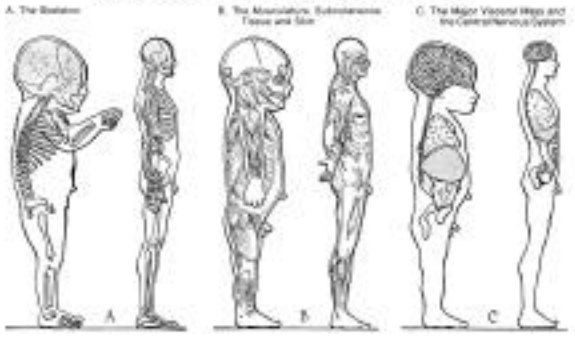
Child ≠ Small Adult





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Not all adults are the same.

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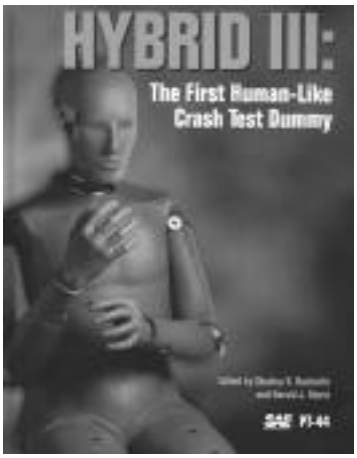
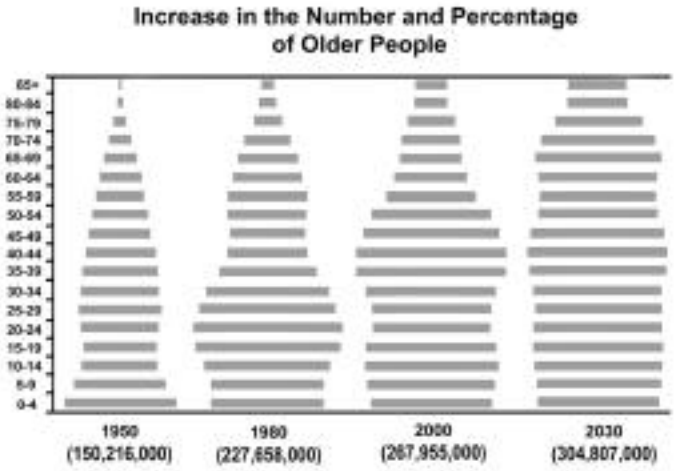


Aging of Population



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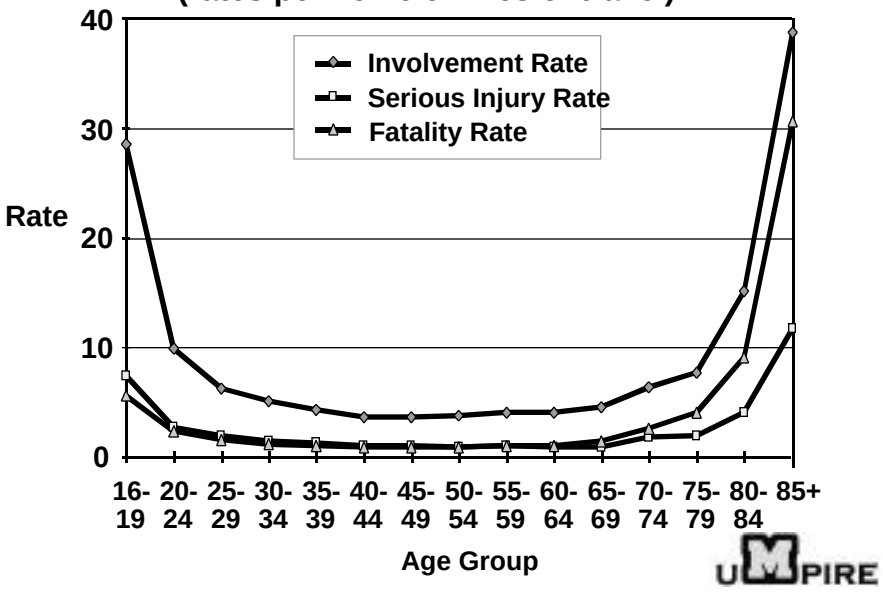

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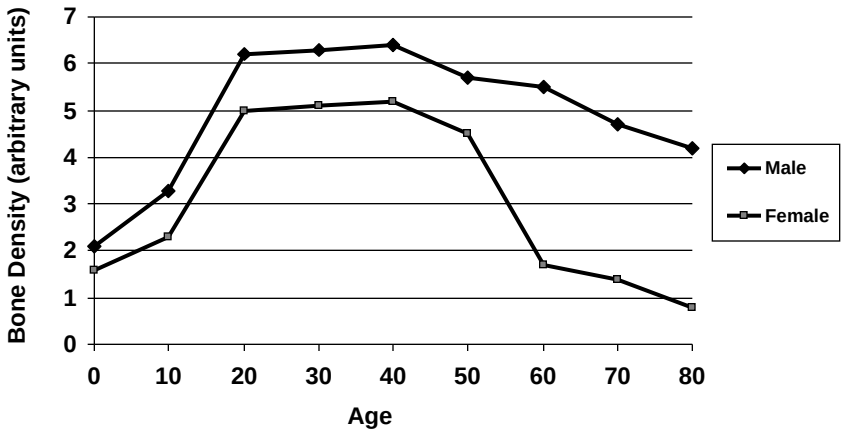
Life Span Changes in Bone Density



Kraenzlin et al: In Principles of Geriatric Medicine and Gerontology 2d ed. McGraw-Hill, 1990

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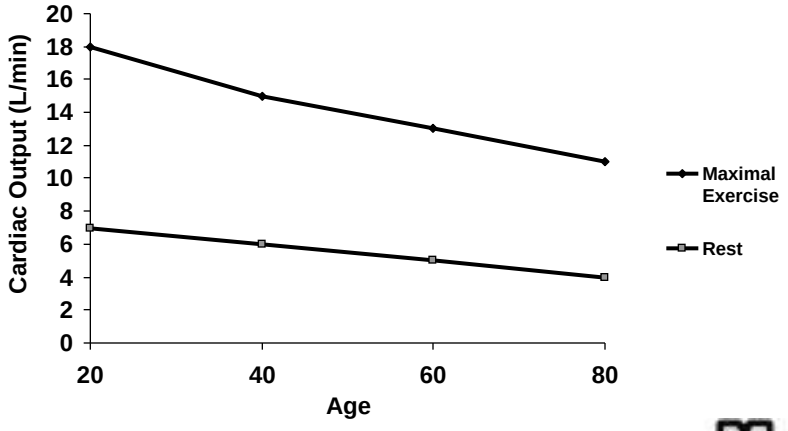
Effect of Aging on Cardiac Output



M Branfronbrener, Circulation 12:557, 1955
Julius, et al: Influence of age, Circulation 36:222, 1967

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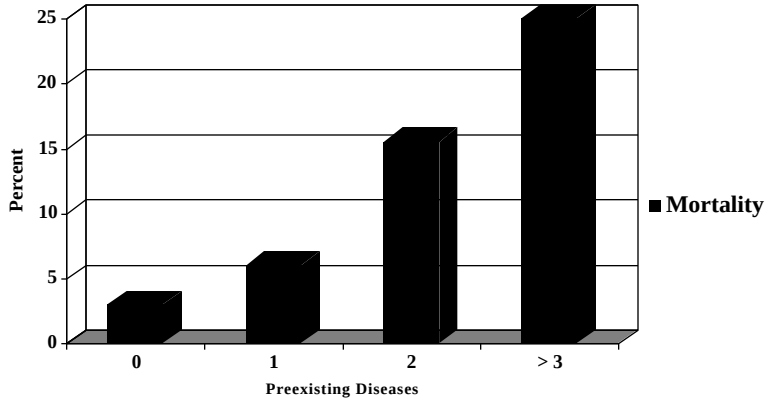
Preexisting Diseases and Outcomes



Milzman, et al: Pre-existing Diseases in Trauma Patients.
J Trauma 32-236, 1992

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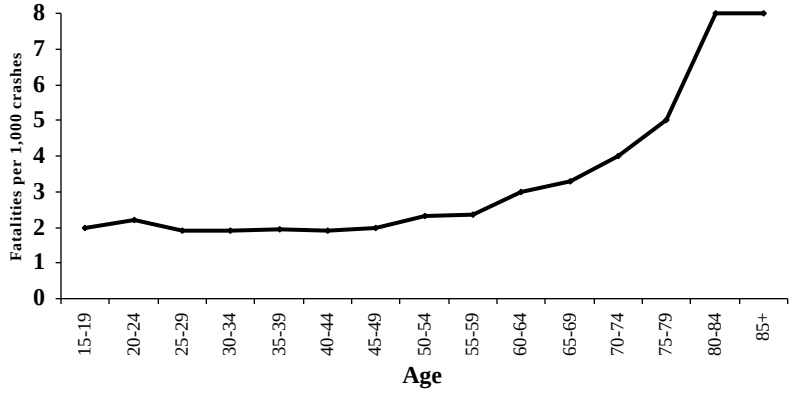
Age Fragility Relationship



Source TRB report "Transportation in an Aging Society" 1988

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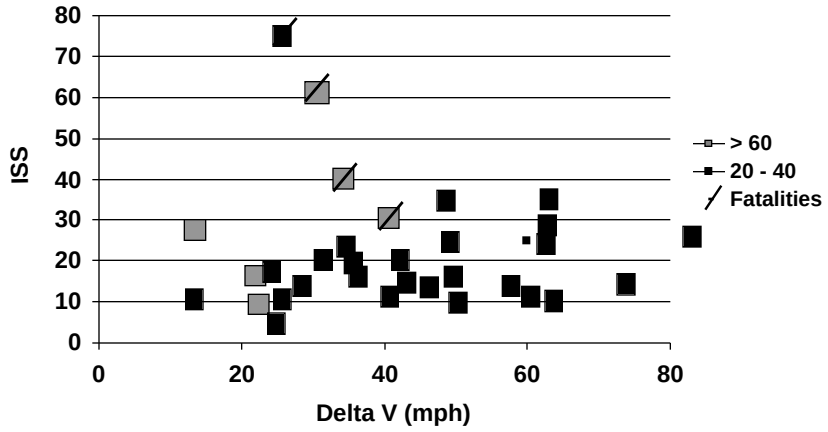
ISS Scores
UM CIREN 1997 - 1998



University of Michigan CIREN Center, 1997 - 1998

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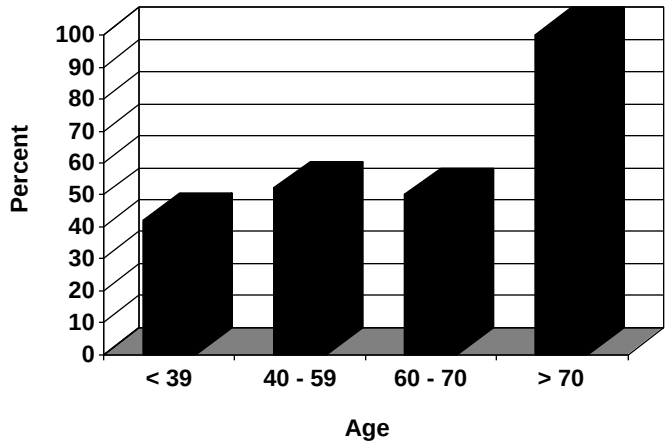
Age Incidence of Rib Fractures
UM CIREN 1997 - 1998



University of Michigan CIREN Center, 1997 - 1998

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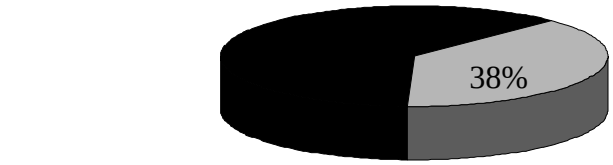
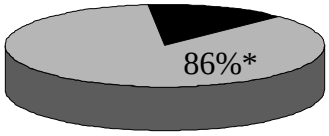
Injury Patterns in Elderly Fatalities
CIREN (Maryland, NJ, Michigan)



Head Injury



Chest Injury
(all with rib fractures)

***Chest Injury a major cause of death in 71% of fatality cases**

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Elderly Fatalities CIREN 1997-1998

18 of 21 fatalities had Chest Injuries (86%)

All 18 had rib fractures

- 8-rib fractures
- 5-heart injuries
- 2-major vessel only
- 1-heart and major vessel
- 1-lung and major vessel
- 1-lung

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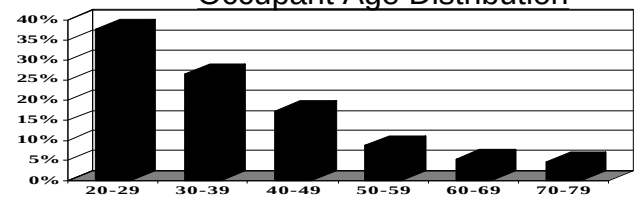
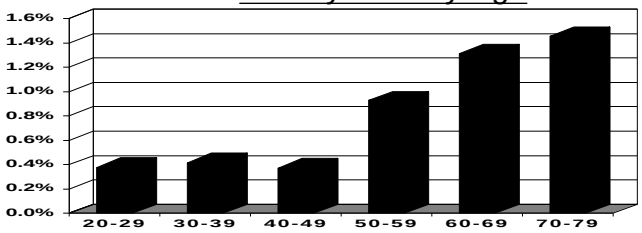
Frontal Crash NASS 1993-1996

Occupant Age Distribution



Fatality Rate by Age



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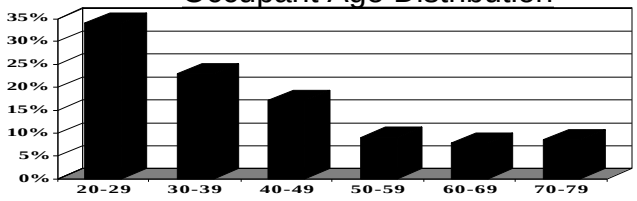
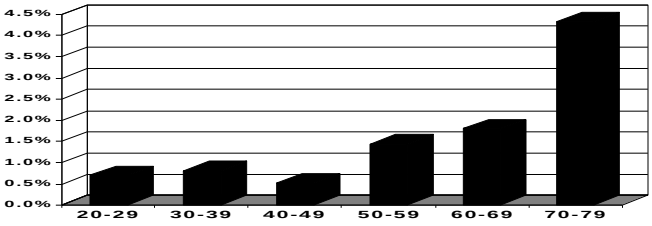
Side Crash Cases NASS 1993-1996

Occupant Age Distribution



Fatality Rate by Age



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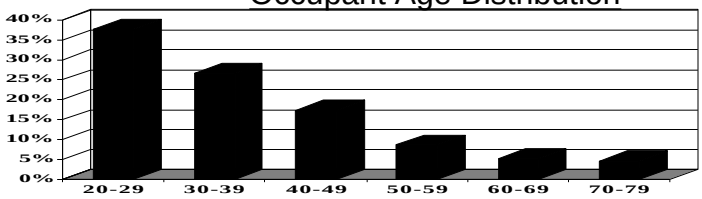
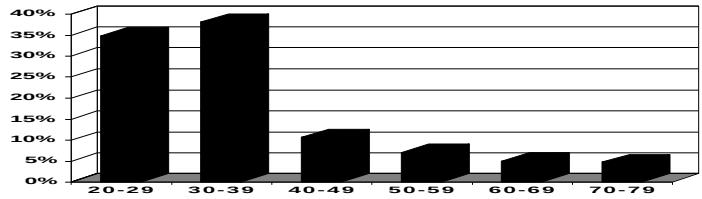
Frontal Crash NASS 1993-1996

Occupant Age Distribution



Femur Fracture Rate by Age



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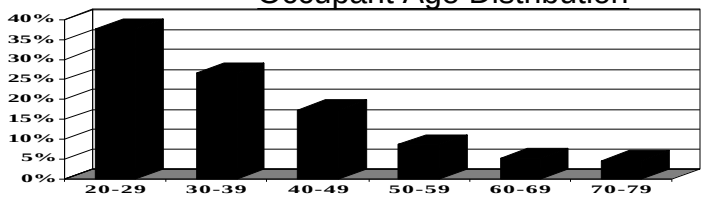
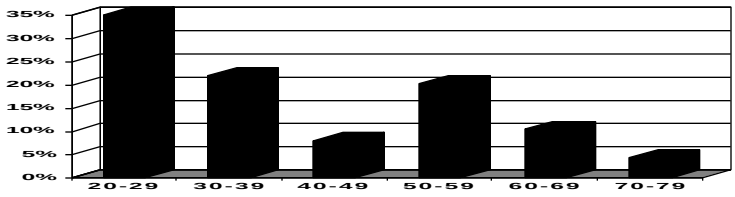
Frontal Crash NASS 1993-1996

Occupant Age Distribution



Tibia Fracture Rate by Age



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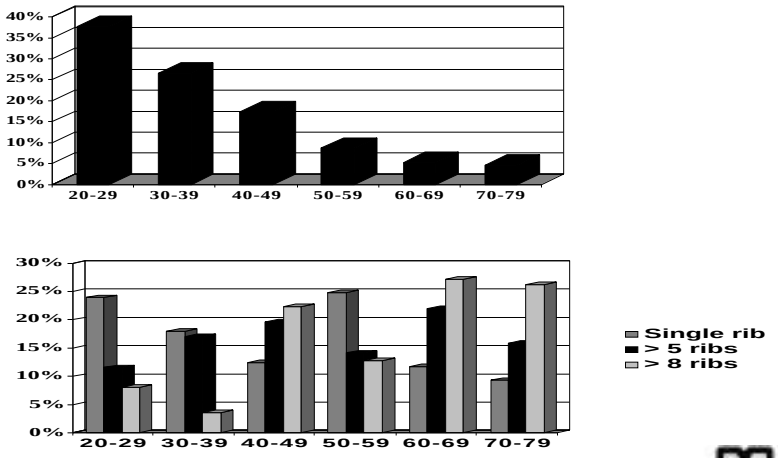
Age Distribution of Rib Fracture Patterns
Frontal Crashes NASS 1993-1996



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Odds Ratio for Rib Fractures
Elderly vs. Young
NASS 1993-1996

	FRONT	SIDE
Single rib	3.4	4
2-3 ribs	3.8	7
> 5 ribs	13	20

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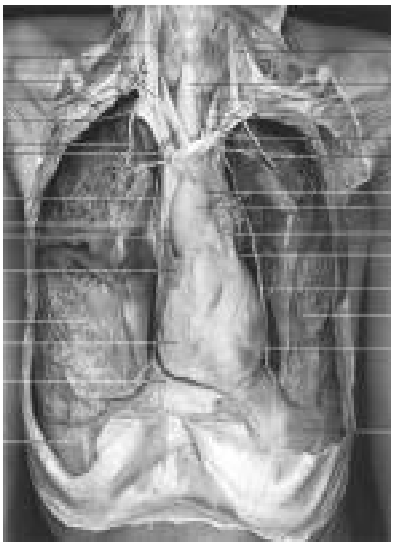
Why??



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Decreased
Cortical Bone
Bone Density
Muscle

Increased
AP diameter
Cartilage ossification

ADULT

ELDERLY

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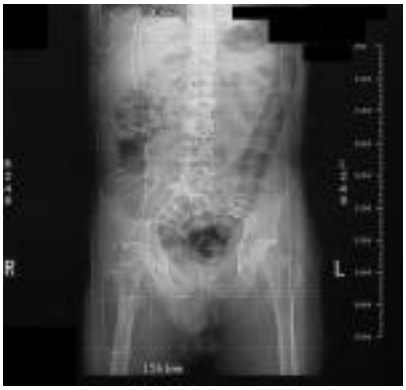
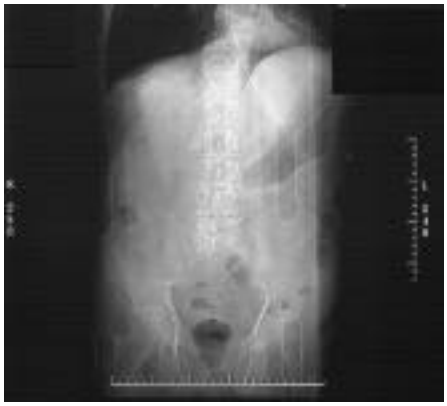
7A/B

- **Male, 183 cm, 86 kg**
- **Age = 38 years**



- **Male, 183 cm, 80 kg**
- **Age = 79 years**



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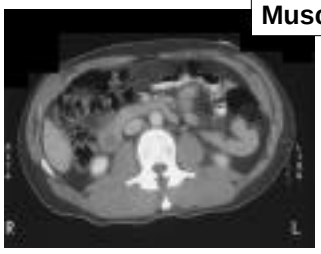

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Bone Geometry
Muscle Mass/Quality

UMPIRE

7A/B

- **Male, 183 cm, 86 kg**
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- **Male, 183 cm, 80 kg**
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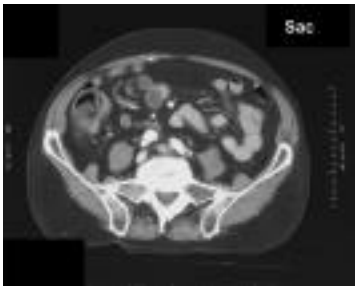

Bone Density
Muscle Mass/Quality
Fat Mass/Distribution

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4 A/B

- **Female, 168 cm, 50 kg**
- **Age = 18 years**

- **Female, 165 cm, 49 kg**
- **Age = 72 years**

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4 A/B

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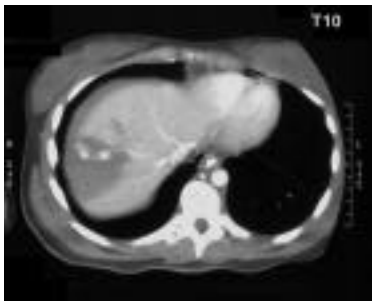

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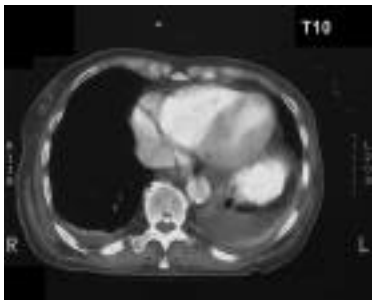

Bone Density/Quality
Muscle Mass/Quality

UMPIRE

4 A/B

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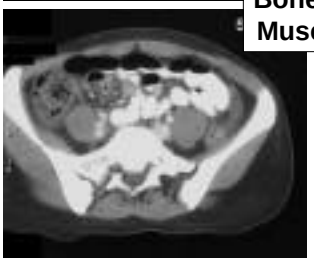

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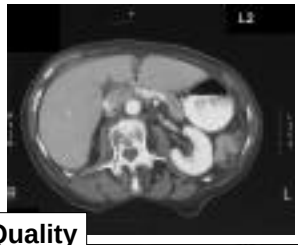


Bone Density/Quality
Muscle Mass/Quality

UMPIRE

3A/B

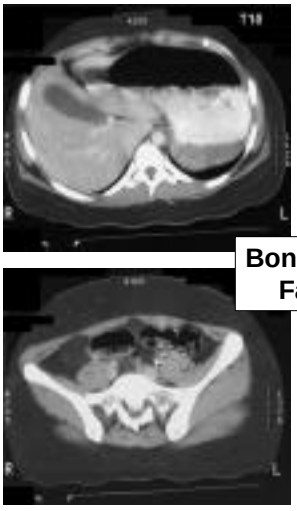
- Female, 165 cm, 77 kg
- Age = 27 years

- Female, 165 cm, 78 kg
- Age = 78 years

Body Habitus

3A/B

- Female, 165 cm, 77 kg
- Age = 27 years



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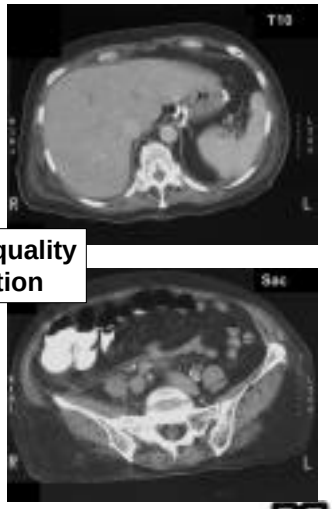

Bone density/quality
Fat distribution

The Body Changes With Aging

- These changes affect the body's tolerance to injurious forces.
- People at the extremes of age are particularly vulnerable to injury.
- Little is known about changes in anthropometry and body composition with aging.
- Little is known about the response of very young or very old tissues to high energy trauma.
- Development and validation of dummies representative of individuals at the extremes of age is difficult?

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How many different dummies can be built and validated?

- CIREN subjects are volunteer real-life crash dummies - (living ones at that!).
- Changes in body dimensions and composition with aging affect injury tolerance.
- Injury data is being collected by computer (CT) - Body dimension and composition data also.

Can this data be used as a surrogate for tissue properties and for the determination of body injury tolerance?
If so, what needs to be done?

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