

Biomechanical Factors to Consider for Optimum Helmet Efficiency

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What is biomechanics?

...the science that examines the internal and external forces acting on a human body and the effects produced by these forces...

James Hay, 1973

Impact biomechanics

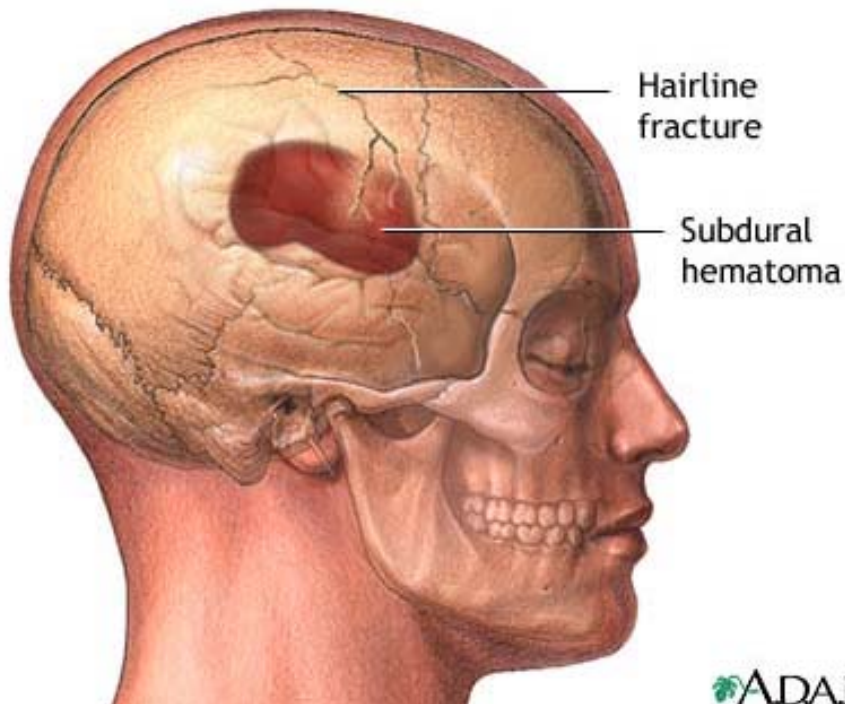
- Study of mechanisms by which injuries occur
- Human response to impact loading
- Human tolerance to injury

Biomechanics of head injury

In recreation - mostly caused during dynamic loading - an impact to the head that results in acceleration of the head as well as local effects

A head impact

- Can cause the underlying skull to deform and fracture
- Skull fractures remote from the impact site can also occur
- Can result in brain injury



Brain injury

- Can occur even if the skull does not bend or fracture
- Brain injury occurs if it is distorted, stretched or compressed, or torn away from the interior of the skull

Contact injuries

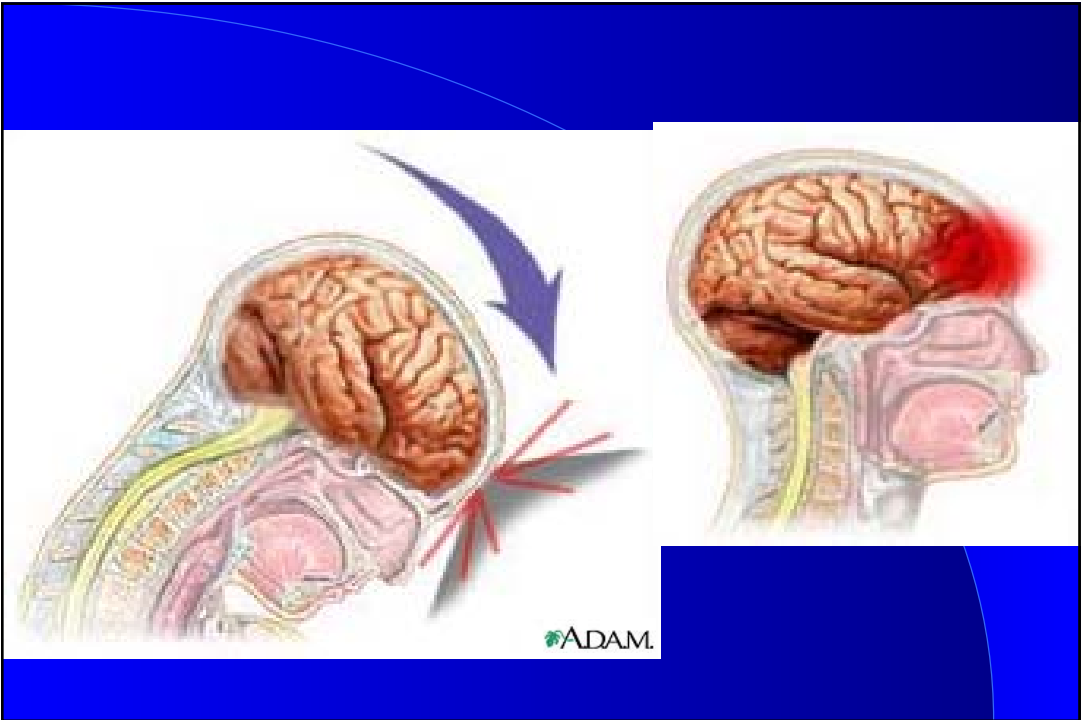
Skull deformation injuries

Local: Skull fracture (linear, depressed)
Extradural hematoma
Coup contusions

Remote: Vault and basilar fractures

Shock wave injuries

Contrecoup contusion
Intracerebral hematoma



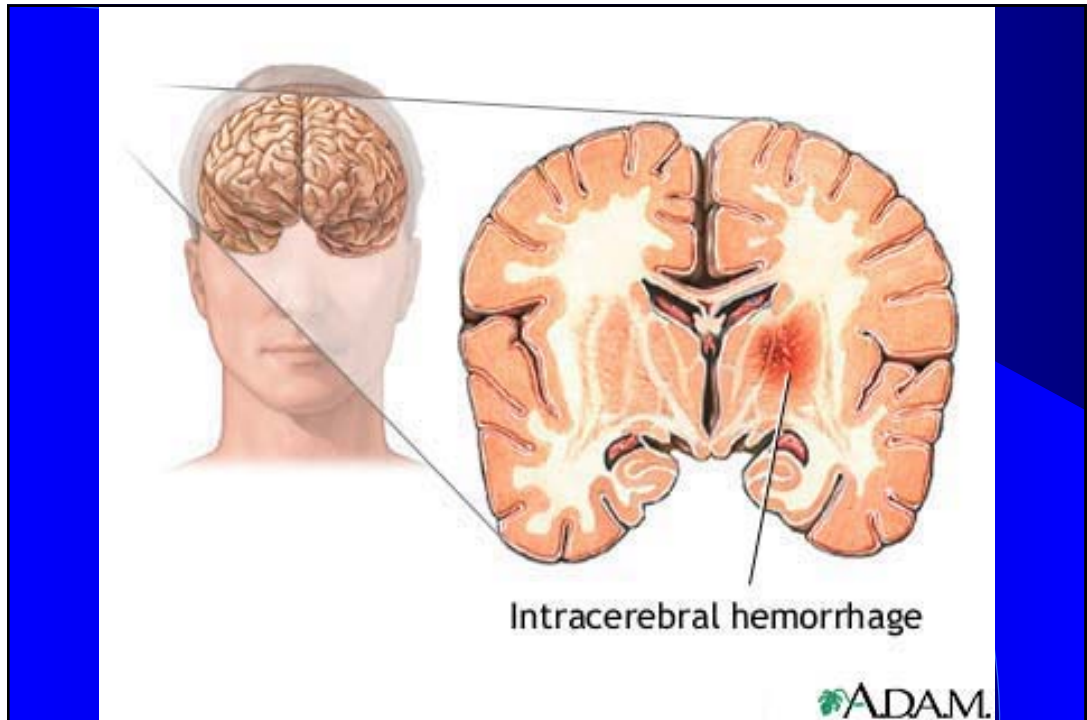
Acceleration injuries

Surface strains

- Subdural hematoma
- Contrecoup contusion
- Intermediate coup contusion

Deep strains

- Concussion syndromes
- Diffuse axonal injury



Factors affecting head injury

- Impact velocity
- Mass, shape and surface hardness of impacting object
- Physiological variations

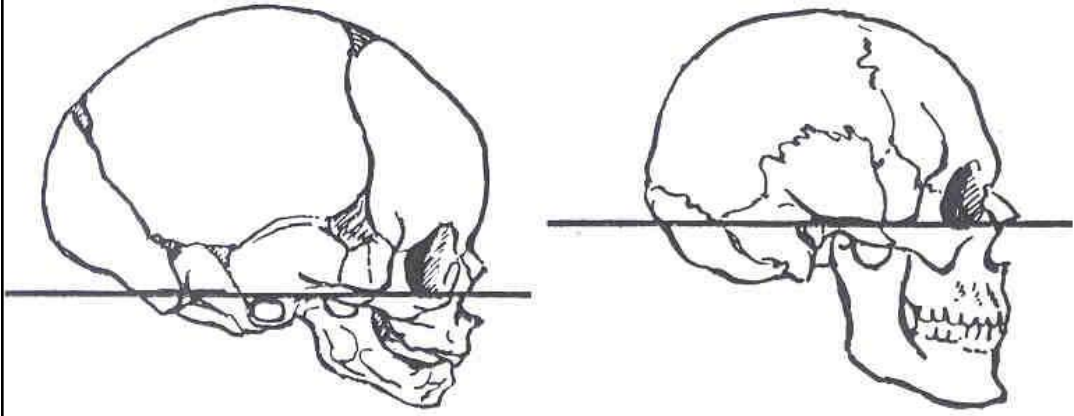
Impact velocity



Hazards



Physiological considerations



And helmet use!



What is a helmet?

A piece of protective or defensive armour for the head worn by soldiers, policeman, fireman, divers, etc..

Collins Dictionary

...by road users



other road users



...in sport



**...in other
recreational
activities**



...variety of styles



Helmet function

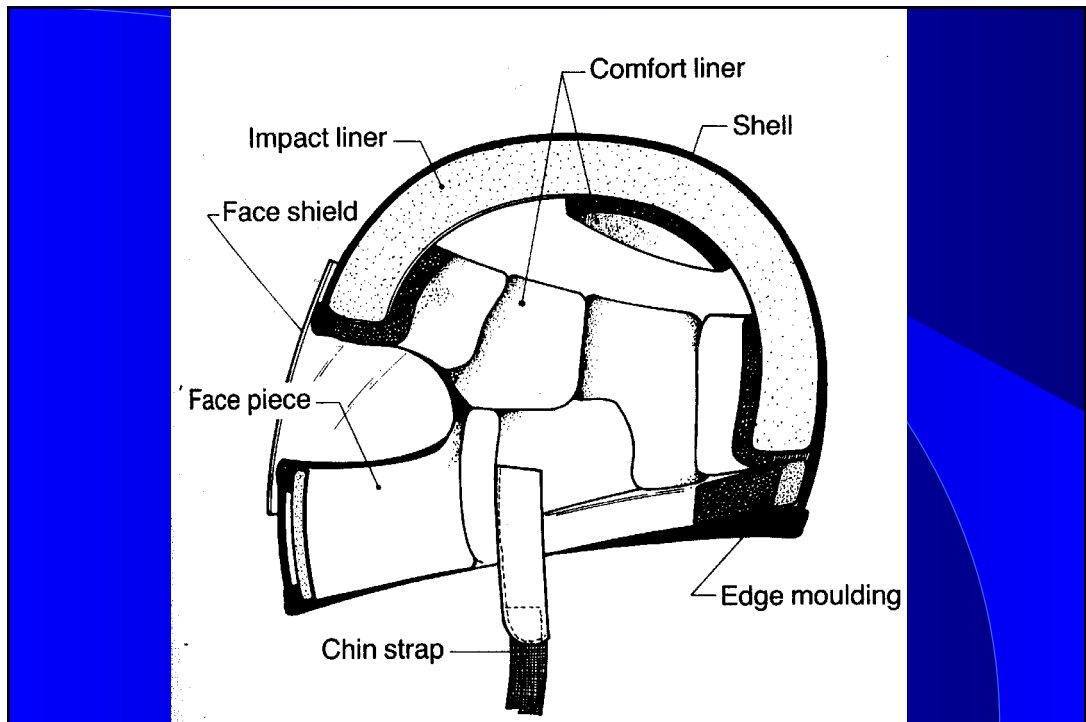
- Protect the head during an impact or blow to the head
- Reduce risk and severity of head injuries
- Protect in range of tolerable impact conditions
- Not interfere with safe performance

Do helmets work?

- Yes!
- Motorcycle helmets reduce risk of severe head injury by one third
- Bicycle helmets decrease risk of head and brain injury by 70-88%
- In all activities helmets reduce risk of head injuries

A helmet...

- Cushions the blow to the head
- Spreads the impact over a larger area
- Reduces the force of the impact on the head
- Reduces its acceleration and skull bending



To be effective

- Must be worn and secured
- Remain in place during impact
- Cover area of head impacted
- Provide adequate protection during the impact

Helmet Standards

- A means to ensure helmets provide a reasonable level of impact protection.
- Specify minimum performance requirements

Labelling Requirements

- Permanent
- Name of manufacturer
- Date of manufacture
- Standard designation
- Helmet size and warnings

Physical Requirements

- Durable materials
- Smooth shell surface
- No projections
- Peripheral vision

Impact requirements

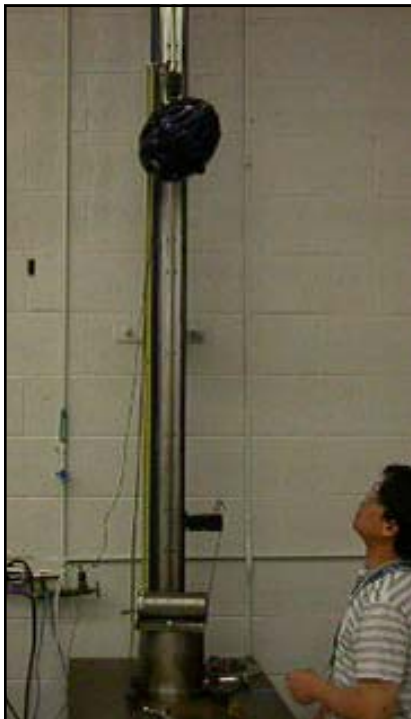
- Test line
- Pre-conditioning
- Test anvils (steel)
 - flat, hemi, curb, edge
- Impact energy
 - 58 - 110 Joules

Test zone



Impact tests

- Guided free fall onto steel anvil
- Drop height varies
- Equivalent to ~18-28 km/h



Pass criteria

- Peak acceleration measured in headform on impact
- Maximum allowable peak linear acceleration 150-300 g
- Based on historic brain injury tolerance review

Retention system tests

- Retention strength
 - dynamic
- “Roll-off”
 - positional stability

Canadian standards

- CAN/CSA-D113.2-M89
Cycling helmets
- CAN/CSA Z262.1-M90
Ice hockey helmets
- **X** CAN3-D230-M85 *-withdrawn*
Motorcycle helmets

Other helmet standards

- NHTSA FMVSS 218 (“DOT”)
- CPSC - Consumer Product Safety Commission
- ASTM - American Society for Testing and Materials
- Snell Memorial Foundation

ASTM helmet standards

- Football
- Horse sports and horseback riding
- Recreational bicycling or roller skating
- Skateboard & trick roller skating
- Short track ice skating
- Downhill mountain bicycle racing
- BMX cycling
- Recreational snow sport

Other standards – Snell

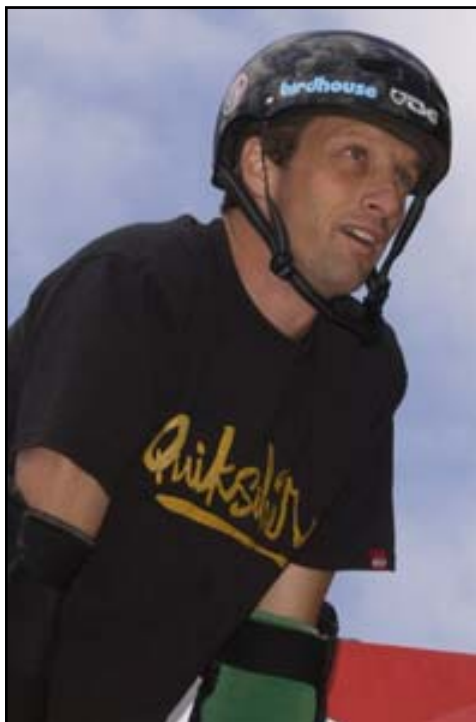
- E2001 horseback riding
- H2000 harness racing
- K-98 karting
- L-98 mopeds and low powered vehicles
- N-94 non-motorized activities
- RS-98 recreational skiing/snowboarding
- S-98 skiing
- SA 2000 competitive automotive sports

**Other factors
important to optimise
helmet effectiveness**



**Use and proper
use**





**Secure fit
on child and
adult**



Good coverage



Single and multiple impact protection



Effective regulations



Adequate enforcement



Control at point of sale

- More than just comfort padding
- Energy absorbing liner
- Certification labels



Costs

- In 1997, Health Canada estimated that “unintentional” injury costs **\$8.7 billion per year**
- Average costs for unhelmeted riders were nearly twice those of helmeted riders.

Ice hockey

- >520,000 players CHA registered
- 1999 study – 18% of sports related injuries occurred while playing hockey and 1 in 5 were head injuries





Snowboarding

- Forearms, wrists and hands most often injured (60%)
- 7% head injuries but more severe than other injuries

Downhill skiing

- 657,000 Canadians downhill ski
- Skiing injuries rank 8th in emergency room visits (sports and recreational activities)
- Head/neck 8%



CHIRPP study

1179 records for
horseback injuries
in 1996 data base



- Almost half 10 -14 years
- 77% were females
- 2.4% using helmet or hard hat



Incidence of non-reporting?

