Trauma and Sport Biomechanics

Crash dummies

https://www.youtube.com/watch?v=d7iYZPp2zYY

- Dummies are developed from measurements of sub-injury crash simulations and simulations with post mortem human and animal subjects
- Dummies are instrumented with load-cells, accelerometers, gyros, infra red devices for measuring chest pressure, belt movement sensors, strain gauges
Head injuries

The anatomy of the head

The meninges (hjärnhinnor)
The brain

Possible head injuries

Bridging veins
Fluid filled, cushion and buffer

Epidural hematoma
Head Injury Criterion

HIC = \max \left[ \frac{1}{t_2 - t_1} \int_{t_1}^{t_2} a(t)dt \right]^{2.5}

HIC-criterion:
acceleration measured in multiples of g and time in seconds, \( t_2 \) and \( t_1 \)
should be less than 36 ms apart

Probability of skull fractures
Head Injuries in Sports

### Table 3.5: Head impact data related to the risk of sustaining concussion/MTBI.

<table>
<thead>
<tr>
<th>Sport</th>
<th>Translational acceleration [g]</th>
<th>Rotational acceleration [rad/s²]</th>
<th>HIC</th>
<th>Delta-v [m/s]</th>
<th>Comment/References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Football (professional)</td>
<td>7.2 ± 0.8</td>
<td>63 ± 1.0</td>
<td>23 ± 1.5</td>
<td>2.2 ± 1.8</td>
<td>head-injury threshold values for irreversible brain injury, computer simulation Zhang et al. 2004</td>
</tr>
<tr>
<td>Football (professional)</td>
<td>60 ± 20</td>
<td>-</td>
<td>20 ± 10</td>
<td>20 ± 14</td>
<td>concussions, data from video analysis/construction using Hybrid III dummies Pellman et al. 2003 and Viano et al. 2005</td>
</tr>
<tr>
<td>Football (college)</td>
<td>81 ± 10</td>
<td>-</td>
<td>100</td>
<td>-</td>
<td>concussions, accelerometers embedded in helmets, Guskiewicz et al. 2007</td>
</tr>
<tr>
<td>Football (college)</td>
<td>32 ± 20</td>
<td>2020 ± 2042</td>
<td>26 ± 64</td>
<td>-</td>
<td>average of 333 observations, in-helmet accelerometers Duma et al. 2005</td>
</tr>
</tbody>
</table>

### Table 3.5 ctd: Head impact data related to the risk of sustaining concussion/MTBI.

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<td>Football (professional)</td>
<td>60 ± 23</td>
<td>-</td>
<td>111 ± 64</td>
<td>3.3 ± 1.1</td>
<td>no injuries, data from video analysis/reconstruction using Hybrid III dummies Pellman et al. 2003</td>
</tr>
<tr>
<td>Football (college)</td>
<td>21.23</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>no concussion, accelerometers embedded in helmets, Mihalik et al. 2007</td>
</tr>
<tr>
<td>Hockey</td>
<td>22.2 ± 10</td>
<td>15.0 ± 1.8</td>
<td>15.0 ± 1.8</td>
<td>-</td>
<td>no incidence of concussion, accelerometer placed on helmet Naunheim et al. 2000</td>
</tr>
<tr>
<td>Soccer</td>
<td>46.3 ± 4.6</td>
<td>41.8 ± 7.0</td>
<td>-</td>
<td>-</td>
<td>punches to a Hybrid III dummy head Wallich et al. 2005</td>
</tr>
<tr>
<td>Boxing (professional)</td>
<td>54 ± 12</td>
<td>63 ± 1.70</td>
<td>31 ± 49</td>
<td>-</td>
<td>punches to a Hybrid III dummy head Smith et al. 1988</td>
</tr>
<tr>
<td>Boxing (Amateur)</td>
<td>68.5 ± 5.0</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>below MTBI injury level, values determined for different punches Smith et al. 1988</td>
</tr>
<tr>
<td>Boxing (Amateur)</td>
<td>71.2 ± 32.2</td>
<td>590 ± 4485</td>
<td>-</td>
<td>-</td>
<td>non-injuries, punches to a Hybrid III dummy head Viano et al. 2005</td>
</tr>
</tbody>
</table>
Lecture exercises, bruxism

9.

A serious dental problem is bruxism, i.e. the unconscious sideways gnashing of teeth that produces major material damage by flattening out sharp teeth as well as producing erosion to the root. In order to quantify this problem, consider the digestion of food by biting involving

(i) vertical forces only, fig. 1, and

(ii) sideways chewing involving horizontal loads which act cyclically on the tooth creating this horizontal motion, fig. 2. Assume that the two force components required to chew the food are the same, 50 N. The root of the idealized tooth has a width of 4 mm and a depth of 3 mm. The root is located 10 mm below the surface where the load is applied.
Bruxism, cont.

– What is the direct stress acting on the root of the tooth for case (i)?
– What is the maximum bending stress acting on the root of the tooth for case (ii)? The area is the same as in (a).
– What is the factor of safety with sideways chewing after 1 year and 50 years if 200 such motions occur per day?

Chewing muscles
TM-joint

Figure 1. Simple model of a tooth.

Wöhler-curve

Figure 2. Fatigue curve.
Sport biomechanics

- Measuring-techniques of motions
- Evaluation of motions
- Prevention of injuries
- Anthropometry

Motion analysis

- Joint angles and angular velocities
- Intensity, frequency, duration
- Quality and direction of the motion

Body posture (e.g. Vicon system)
Force analysis

Outer forces:
- Contact point
- Support area
- Pressure direction

Inner forces:
- Force developed by the muscles

Measured using force plates, or indirect using strain gauges!

Anthropometry

Body mass index, BMI
BMI = mass/(length^2)
in kg/m^2
Kenyan runners

"Even the Gardeners Here Are Faster Than Me"
Peter Vigneron, Marathon runner, USA, on tour in Kenya

I’m staying at Silgich Hill Academy now, where even the gardener is a better runner than I am. On my morning run Sunday, as on many of my morning runs since I’ve come to Kenya, a group of children playing near the road fell in alongside me as I passed by. This morning one boy raced me, and he almost won. Before he dropped I was wondering how long I would last if he didn’t get tired very quickly. I realized when I finished that since my arrival to Kenya in early March, this boy, this nameless, anonymous child, is the first Kenyan who couldn’t hang with my pace. I don’t think he was older than 12.
Exceptions...

Stefan Holm, Sweden
• Length: 1.81 m
• Personal record: 2.40 m

Javier Sotomayor, Cuba
• Length: 1.95 m
• Personal record: 2.45 m WR

http://www.youtube.com/watch?v=ZG3_I3zFB0U
http://www.youtube.com/watch?v=qMKoyWi7vps&feature=fvwp

Relative length of segments
Length, mass, moment of inertia

<table>
<thead>
<tr>
<th>Segment name</th>
<th>Segment mass</th>
<th>Moment of inertia</th>
<th>Length</th>
<th>Mass</th>
<th>Moment of inertia</th>
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<tr>
<td>Trunk</td>
<td>523</td>
<td>0.127</td>
<td>5.18</td>
<td>0.31</td>
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<td>Head</td>
<td>523</td>
<td>0.127</td>
<td>5.18</td>
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<tr>
<td>Arms (right)</td>
<td>523</td>
<td>0.127</td>
<td>5.18</td>
<td>0.31</td>
<td>0.127</td>
</tr>
<tr>
<td>Legs (right)</td>
<td>523</td>
<td>0.127</td>
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<td>0.127</td>
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<tr>
<td>Total</td>
<td>1046</td>
<td></td>
<td>10.38</td>
<td>0.62</td>
<td></td>
</tr>
</tbody>
</table>

Body shape

- Ectomorph
- Mesomorph
- Endomorph

in a big population
Conclusion:
It is about the anatomy of the human body!

- **Skeletal bones**
  (length, width, proportions)

- **Ligaments**
  (stability around joints)

- **Muscles**
  (size and composition of fibres)

- **Joints**
  (motion range)

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**Muscle force**

- **Force-velocity relationship**

- **Power-velocity relationship**
Moment of inertia and rotation
Squat jump vs counter movement jump

Squat jump

Counter movement jump

THE END