1G VS 10G SAR AVERAGE MASS
(AND OTHER RELATED STUFF)

Dr Vitas Anderson
1g vs 10g SAR
Pennes bioheat equation

\[ \rho c \frac{\partial T}{\partial t} = K \nabla^2 T + \rho SAR + A_0 - b(T - T_b) \]

**Thermal inertia** (temporal smoothing)

**Thermal diffusion** by heat conduction

**Heat sink from blood flow** (spatial smoothing)

**Heat inputs**
Plane wave 300 MHz 10 W/m^2

Point SAR

Temperature rise (∆T)

HEATING

1g SAR

10g SAR

dB scaling

0 dB SAR = 1 W/kg
0 dB temp = 1 °C

Modelling courtesy of Robert McIntosh
ΔT vs SAR in the head for 10 W/m² plane wave exposure

\( \Delta T \) vs SAR in the head for near-field dipole exposure

ΔT vs SAR in the body of visible human for plane wave exposure

A. Razmadze et al., “Influence of specific absorption rate averaging schemes on correlation between mass-averaged specific absorption rate and temperature rise,” Electromagnetics, vol 29(1), 2009.
Published data consistently indicates that 10g SAR is better correlated with $\Delta T$ than 1 g SAR over a wide range of frequencies and for near and far field exposure
And now the other stuff …
What ICNIRP does well

- Identifies credible mechanisms for adverse RF bioeffects
  - Heating
  - Electrostimulation (at low frequencies)
  - High field effects
WBA SAR rationale

4 W/kg WBA SAR → 1/10, 1/50 safety factors → 0.4 & 0.08 W/kg WBA SAR limits

Plane wave

E & H limits with extras!
- Spatial avg
- Cumulative
- Near/far field
- Uncertainties
- etc
1st advice

Keep it \textit{REAL} when evaluating risks
WBA SAR compared to metabolic heat loads

120 × public WBA SAR limit
Adverse health effects of basketball

• *Huge* WBA thermal load: **9.9 W/kg** for 50 min !!!!

• Long list of ‘adverse effects’
  • Flushed skin
  • Profuse sweating
  • Dehydration
  • Fatigue & lethargy
  • Muscle soreness
  • Headaches
  • Annoying behaviour

• AND IT HAPPENS IN CHILDREN !!!
Review RF accident statistics

Work environments offer good opportunities for collating accident statistics

• How many people are seriously injured by RF???
• What are their injuries???
• Where do they occur???

This data is needed for assessing the effectiveness of RF safety regulations and programs
2nd advice

Consider *REAL* exposure scenarios
UNREAL RF exposure

Plane wave
REAL RF exposures

Almost always:
• Near field
• Localised
H-field is best for near field assessments

\[ SAR = \frac{\sigma}{\rho} \frac{\mu\omega}{\rho \sqrt{\sigma^2 + \varepsilon^2 \omega^2}} \left( 1 + c_{corr} \gamma_{pw} \right)^2 H_{tinc}^2 \]

3rd advice

Consider whether RF exposure limits are actually the best approach for ensuring safety
How are other heat loads managed?

- Is it possible to suffer injury from RF heating without feeling discomfort or pain first?
- Can we manage excessive RF heating by common sense procedures?
Do different RF exposure scenarios warrant different RF safety measures?

<table>
<thead>
<tr>
<th>RF exposure type</th>
<th>Potential heating hazard</th>
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<tbody>
<tr>
<td>Telecommunications terminals designed for use close to the body (≤ 1W)</td>
<td>○○○○○</td>
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<tr>
<td>Other telecommunications terminals and base stations</td>
<td>●○○○○</td>
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<tr>
<td>Radar</td>
<td>●○○○○</td>
</tr>
<tr>
<td>TV/radio broadcasting antennas and exposures at their sites (MF, HF, TV towers)</td>
<td>●●●○○</td>
</tr>
<tr>
<td>Military use of RF</td>
<td>●●●○○</td>
</tr>
<tr>
<td>Industrial RF (e.g. RF sealers and welders)</td>
<td>●●●●○</td>
</tr>
<tr>
<td>Medical uses of RF (diathermy, MRI, etc)</td>
<td>●●●●●</td>
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</tbody>
</table>
Good luck!
My ranking of the importance of RF hazards

1. shocks and burns  
   (injurious, painful, no pre-warning)

2. interference into implanted electronic devices  
   (potentially lethal, no pre-warning, plausible?)

3. surface heating  
   (painful/unpleasant, some pre-warning)

4. localized RF heating  
   (painful? injurious? pre-warning available?)

5. whole-body heating  
   (highly implausible)