Blood Flow and Pressure Changes that Occur with Tilt-in-Space

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RESNA
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Background

• Justification: lack of ability to independently reposition or do pressure reliefs (pressure ulcer prevention); current or previous skin breakdown

• What constitutes a pressure relief? Literature varies between $> 30^\circ$ and up to $45^\circ$

• How much of a tilt is needed to affect pressure or blood flow?
Aim: To determine the impact of tilting on blood flow and localized tissue loading.
Hypotheses

- **Hypothesis 1.** The minimum tilt position required to increase blood flow is less than 45°.

- **Hypothesis 2.** There is a significant decrease in loading at the minimum tilt required for increased bloodflow.
Participants

• 11 subjects with SCI
• Gender
  – 9 men
  – 2 women
• Race/Ethnicity
  – 7 African-American
  – 3 Caucasian
  – 1 biracial.
• Years using a wheelchair
  – 9.4 (5.7)
  – Range: 9 months - 18 years
Instrumentation

Laser Doppler Flowmetry Probe

Interface Pressure Sensor
Protocol

• Informed consent
• Attach interface pressure sensor to skin at ischial tuberosity while lifted with net
• Attach Doppler probe in center hole of pressure sensor
Protocol

3 trials per subject

1. Unload for 5 minutes to restore baseline flow.
2. Tilt sequences - in random order
   2 minutes at each position.

<table>
<thead>
<tr>
<th>Upright → 15° → 30°</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upright → 30°</td>
</tr>
<tr>
<td>Upright → 45°</td>
</tr>
<tr>
<td>Upright → max tilt</td>
</tr>
</tbody>
</table>
Sample data from a single trial
## Results:
### Normalized Blood Flow

<table>
<thead>
<tr>
<th>Tilt Position</th>
<th>Mean Blood Flow (SD)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>15°</td>
<td>1.08 (0.19)</td>
<td>0.016</td>
</tr>
<tr>
<td>30°</td>
<td>1.24 (0.48)</td>
<td>0.003</td>
</tr>
<tr>
<td>45°</td>
<td>1.84 (1.84)</td>
<td>0.007</td>
</tr>
<tr>
<td>Max Tilt</td>
<td>3.34 (5.09)</td>
<td>0.034</td>
</tr>
</tbody>
</table>

Normalized pressure and blood flow values (normalized by preceding upright values). Statistics were computed for normalized blood flow compared with a ratio of 1.
Hypotheses

- **Hypothesis 1.** The minimum tilt position required to increase blood flow is less than 45°. [✓]
Results: Pressure

![Graph showing pressure results for Upright, 15°, 30°, 45°, and Max Tilt positions. Peaks and means are indicated with error bars. The graph highlights significant differences marked with asterisks (*) at specific tilt angles.]
Hypotheses

• **Hypothesis 2.** There is a significant decrease in loading at the minimum tilt required for increased bloodflow.
Preliminary Pressure Relief Guidelines

- 9 of 11: increase in blood flow (≥ 10%) during the maximum tilt
- 4 of 11: increase in blood flow of ≥ 10% at 30° tilt

- A tilt for pressure relief should tilt as far as the seating system permits.
- The use of interim small tilts is also supported, as they also provide some benefit.
Actual Behavior

• Decreased loading (< 90% upright pressure)
  – Based on average pressure reduction, tilts > 24° reduce pressure by 10%
  – **Frequency**: 0.5 (0.0 – 7.6) times per hour
  – **Time**: 7% (0% - 100%)

• Increased blood flow
  – Tilts > 15° increased blood flow some
  – **Frequency**: 0.5 (0.0 – 7.0) times per hour
  – **Time**: 18% (0% - 100%)
Conclusions

• Tilting DOES increase blood flow and decrease pressure
• Increase in blood flow probably NOT from pressure change
  – Change in CoP
  – Change in pelvic angle
  – Other factors in pressure ulcer causation
    • Tissue Compression
    • Shear
Limitations

- Generalization of results
  - Small n (11)
  - Limited cushions (Roho air inflation cushion)
  - Homogenous population

- Analyzed superficial blood flow only

- Hyperaemic responses were not studied, but may be important

- Short durations of loading

- Other contributors to pressure ulcers not studied:
  - Cell deformation
  - Shear

- Guidelines do not reflect efficacy at preventing pressure ulcers
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Questions?