BLOOD FLOW AND PRESSURE CHANGES THAT OCCUR WITH TILT-IN-SPACE

Sharon Eve Sonenblum, Ph.D.
Background
Pressure Ulcer Development

Possible mechanisms for pathophysiologic responses

1. Ischaemia of soft tissues occurs as a result of the occlusion or collapse of capillaries.

2. A disruption of the equilibrium in the interstitium between cells affects terminal capillaries and lymph vessels.

3. Cell damage results from prolonged deformation.

Tilt-in-Space for Pressure Relief

- Our local seating clinic prescribed >125 in 2007
- Justification – lack of ability to independently reposition or do weight shifts (pressure ulcer prevention); history of current or previous skin breakdown
Tilt-in-Space for Pressure Relief

- Studies say interface pressure decreases as tilt angle increases.
- Many clinicians teach 45°-55° or “all the way back”
- Literature varies between > 30° and up to 45°
- More appears to be better
Tilt-in-Space for Pressure Relief

• How much pressure reduction at the buttocks with tilt?
• Does blood flow change with tilt?
• How much of a tilt is needed to affect pressure or blood flow?
• Do we have to consider the starting position?
  – Is a 15° tilt from upright the same as a 15° tilt from 15°?
Aim: To determine the impact of tilting on blood flow and localized tissue loading.
Hypotheses

• **H1.** The minimum tilt position required to increase blood flow is less than 45°.

• **H2.** There is a significant decrease in loading at the minimum tilt required for increased bloodflow.

• **H3.** Small changes in tilt angle (15°) when starting in an upright position result in:
  – increased blood flow
  – decreased pressure

• **H4.** Small changes in tilt angle (15°) when starting in a tilted position (15°) result in:
  – increased blood flow
  – decreased pressure
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

wheeled mobility in everyday life
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>Sequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upright → 15 → 30</td>
</tr>
<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

A

Tilt Position (degrees)

B

Blood Flow (AU)

C

Mean Pressure (mmHg)

Time (sec)
### Results: Normalized Blood Flow

<table>
<thead>
<tr>
<th>Tilt Position</th>
<th>Mean Blood Flow</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.

**wheeled mobility in everyday life**
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Results: Pressure

Pressure (mmHg)

- Upright
- 15°
- 30°
- 45°
- Max Tilt

Peak Pressure (mmHg) - Mean Pressure (mmHg)
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X H2. There is a significant decrease in loading at the minimum tilt required for increased bloodflow.

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wheeled mobility in everyday life
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Results:
Small Tilts from 15°

<table>
<thead>
<tr>
<th>Variable</th>
<th>15°</th>
<th>30°</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absolute Peak Pressure (mmHg)</td>
<td>87 (30)</td>
<td>75 (27)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Absolute Mean Pressure (mmHg)</td>
<td>71 (25)</td>
<td>61 (22)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Normalized Mean Blood Flow</td>
<td>1.08 (0.19)</td>
<td>1.15 (0.41)</td>
<td>0.118</td>
</tr>
</tbody>
</table>
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Preliminary Pressure Relief Guidelines

- 9 of 11: increase in blood flow ($\geq 10\%$) during the maximum tilt
- 4 of 11: increase in blood flow of $\geq 10\%$ at $30^\circ$ tilt

- Instruct users to tilt as far as the seating system permits for pressure relief.
- The use of interim small tilts is also supported, as they also provide some benefit.
How does this apply to actual tilt behavior?

- Monitored tilt behavior of 30 persons with SCI
- Pressure relieving tilts past 40° were rarely performed 0.1 times per hour of wheelchair occupancy
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
  - Frequency: 0.5 (0.0 – 7.0) times per hour
  - Time: 18% (0% - 100%)
Conclusions

• Tilting increases blood flow and decrease pressure
• Increase in blood flow NOT solely from pressure change
  – Change in CoP
  – Change in pelvic angle
  – Other factors such as Tissue Compression & Shear
• Considerable time spent with increased blood flow (18%) and decreased pressure (7%)
• Few pressure relieving tilts, infrequent changes to blood flow or pressure (every 2 hours)
• Possible explanations for not doing more PRTs
  – Large tilts may be uncomfortable and unstable
  – Large tilts may not be functional
  – Participants may not pay attention to the need for pressure reliefs
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
Future Studies

- Longer sitting durations
- Measure deeper blood flow and oxygenation
- Vary wheelchair cushions
- More subjects
- Tissue deformation in MRI
- Measure shear forces
- Training interventions to influence tilt behavior
- Study pressure relief behavior and pressure / blood flow response
  other populations
- Efficacy of pressure reliefs in preventing pressure ulcers
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Questions?