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

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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 pressure reliefs (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.
  • Chris Maurer, MPT, ATP
  • presented at ISS 2007:
    • 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 talk about 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 blood flow.
- 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

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.
Sample data from a single trial

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 (0.46)</td>
<td>0.003</td>
</tr>
<tr>
<td>45°</td>
<td>1.84 (1.44)</td>
<td>0.007</td>
</tr>
</tbody>
</table>

Max Tilt: 3.34 (5.09)  0.034

Normalized pressure and blood flow values (normalized by providing weight value). Statistics were computed for normalized blood flow compared with a ratio of 1.

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Results: Pressure

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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>79 (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>

### Hypotheses

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### 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.

### How does this apply to actual tilt behavior?

- Monitored tilt behavior of 30 persons with SCI
- Pressure relieving tilts past 40° were 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 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
- 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 relieving tilts
Limitations

- Generalization of results
  - Small n (11)
  - Limited conditions (fixed air inflation cushion)
  - Homogenous population
- Analyzed superficial blood flow only
- Hyperemic 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
- Very 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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- Data Analysis, Assumption / Analysis
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- Scott Berr
- Mobile Electromagnetic
- Mobile Cerebral

- Data Entry
- Data Reporting
- Data Analysis
- Data Collection
- Data Analysis
- Data Analysis
- Data Analysis

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