Rehabilitation Engineering & Applied Research

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

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RESNA

June 28th, 2010

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^{o} and up to 45^{o}
- How much of a tilt is needed to affect pressure or blood flow?

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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°.

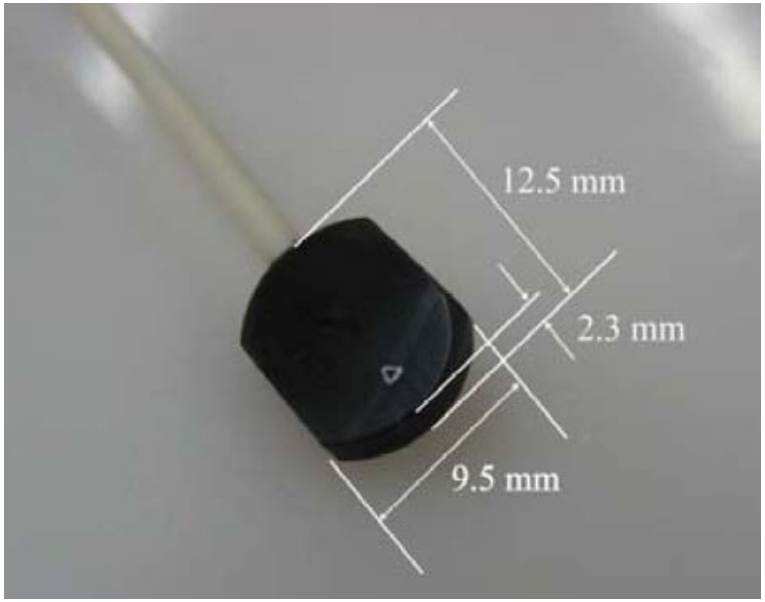
- Hypothesis 2. There is a significant decrease in loading at the minimum tilt required for increased bloodflow.

Participants

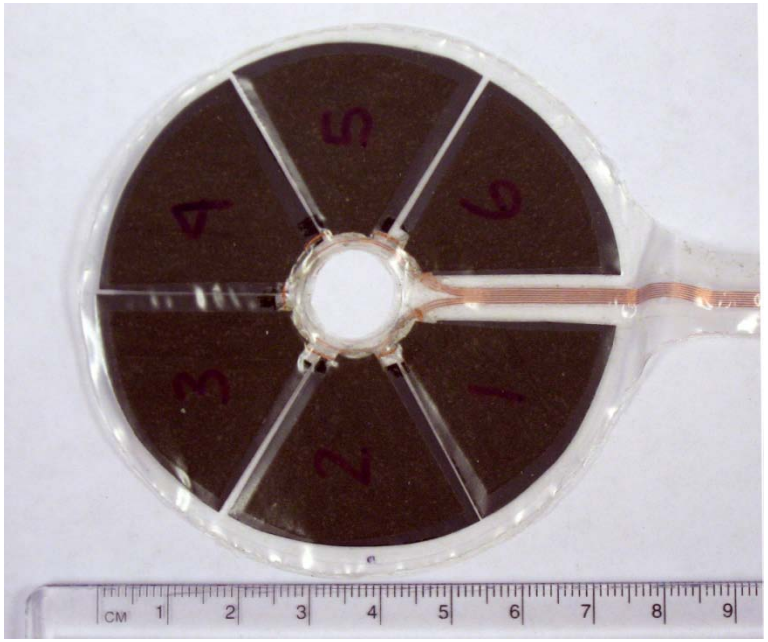
- 11 subjects with SCI
- Gender
  - 9 men
  - 2 women
- Race/Ethnicity
  - 7 African-American
  - 3 Caucasian
  - 1 biracial.
- Years using a wheelchair
  - 9.4 (5.7)
  - Range: 9 months - 18 years

Instrumentation

Laser Doppler Flowmetry Probe

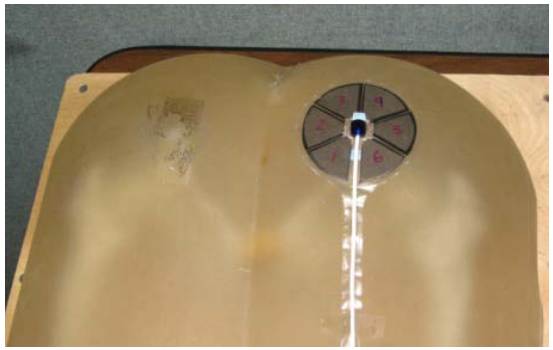


Interface Pressure Sensor



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

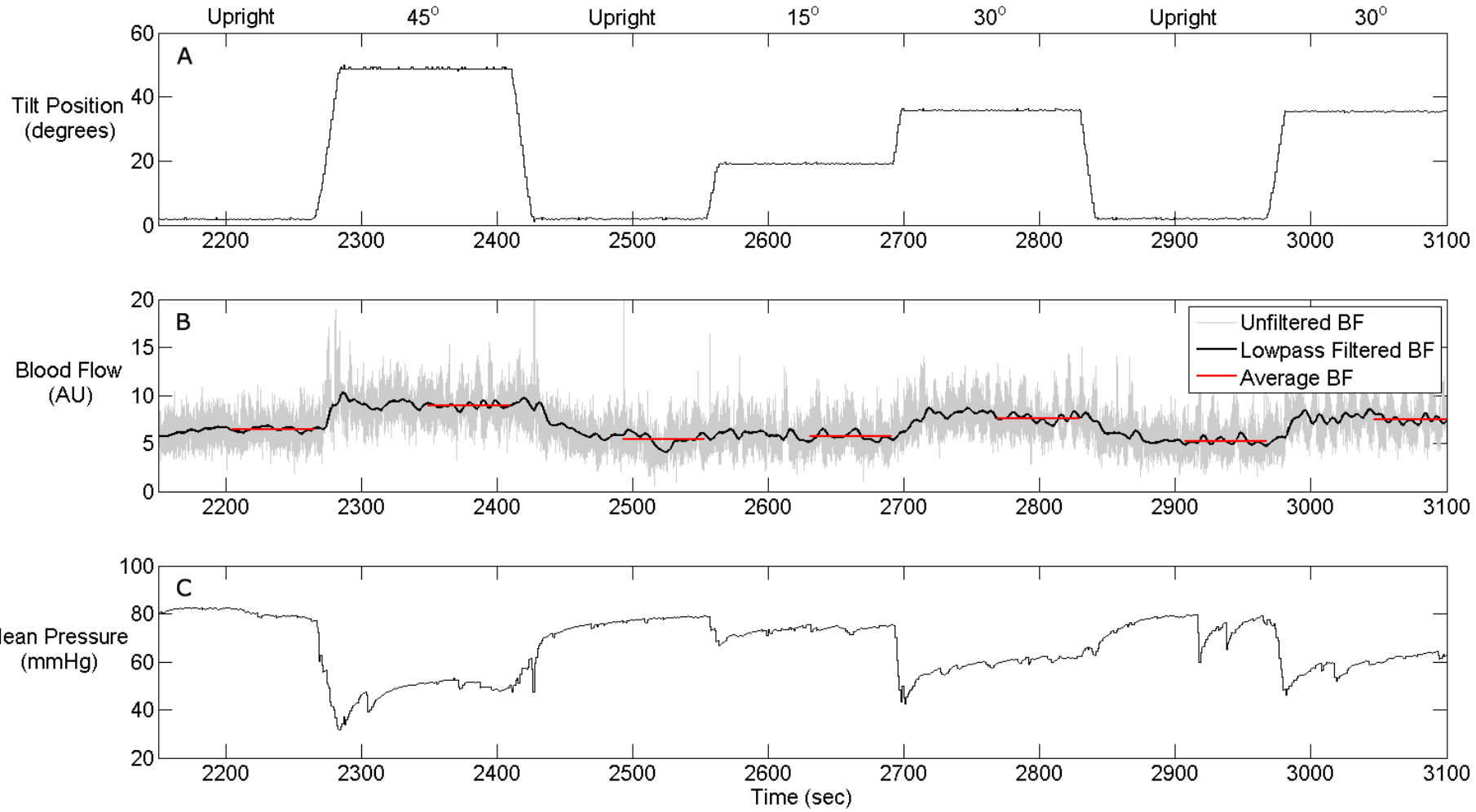
3 trials per subject

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

   2 minutes at each position.

Upright → 15°→ 30°
Upright → 30°
Upright → 45°
Upright → max tilt

Sample data from a single trial



Results:
Normalized Blood Flow

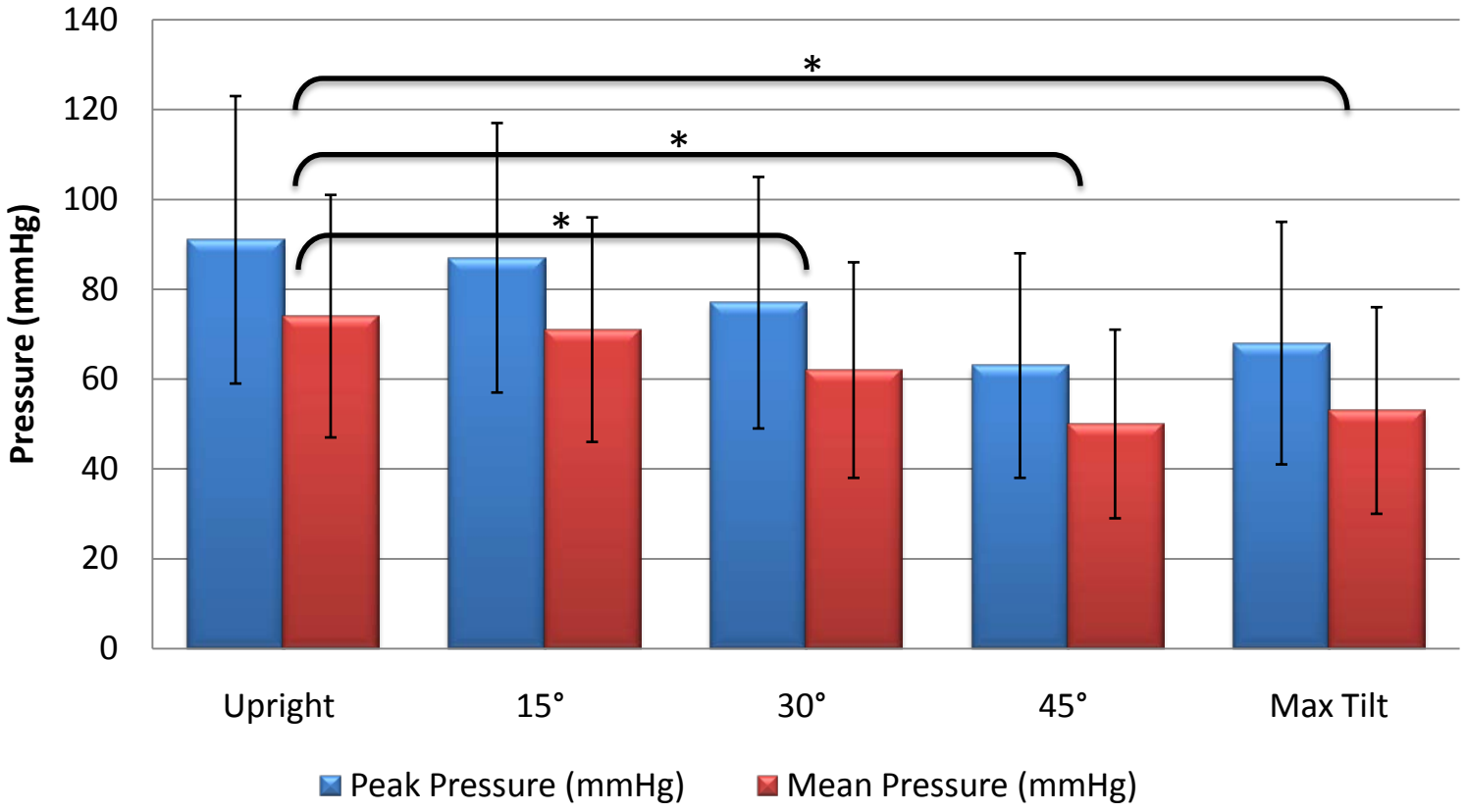
Tilt Position	Mean Blood Flow (SD)	*P*-value
15°	1.08 (0.19)	*0.016*
30°	1.24 (0.48)	*0.003*
45°	1.84 (1.84)	*0.007*
Max Tilt	3.34 (5.09)	*0.034*

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



Hypotheses

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

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

Acknowledgements

- Stephen Sprigle, Ph.D., PT
- Clinical Team
  - Stephen Sprigle, Ph.D., PT
  - Chris Maurer, MPT, ATP
  - Kim Davis, MSPT
  - Michelle Nemeth, P.T., C.C.R.P
- Subject Recruitment
  - Chris Maurer
  - Kim Davis
  - David Rivard
  - Brian Dunlap
  - Seating Clinic (David, Robin, Jennith)
- Stats help
  - Bill Delaune
- Research Participants
- Funding Sources
  - NIDRR – RERC on Wheeled Mobility
  - NSF Graduate Research Fellowship Program
- Levo & Consonics – equipment support
- Geoff Taylor and Andrew Frank at Vista Medical
- Data Logging Equipment & Subject Instrumentation
  - Adrienne Davis
  - Bobby He
  - Rubin Jin
  - Shawn Lankton
  - Ricardo Lopez
  - Linghua Kong
  - Tobias Meyer
  - Daniel Smith
  - Eric Whitaker

This research was completed as part of the Mobility RERC, which is funded by the National Institute on Disability and Rehabilitation Research of the U.S. Department of Education under grant number H133E030035. The opinions contained in this presentation are those of the grantee and do not necessarily reflect those of the U.S. Department of Education.

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Questions?