# A New Approach to Pressure, Friction, Shear and Microclimate Management in Wheelchair Seating – Imagine the Possibilities

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# Concept Overview

- Clinical Goals
- Design Criteria
- Technical Results
- Outcome Experiences

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# Clinical Goals

- Avoidance of tissue trauma at the seating interface
- Support of healing (of pre-damaged soft tissue)
- Functional postural control and comfort for extended daily use

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# Design Criteria

- Combination Seat Support Surface:
  - Pressure redistribution
  - Reduce friction in at-risk zones
  - Be microclimate friendly
- Provision of a functional seating alignment
  - Accommodation / Correction
  - Stability
- Streamline a highly precise molding and fitting process

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# The Technical Results


Microclimate

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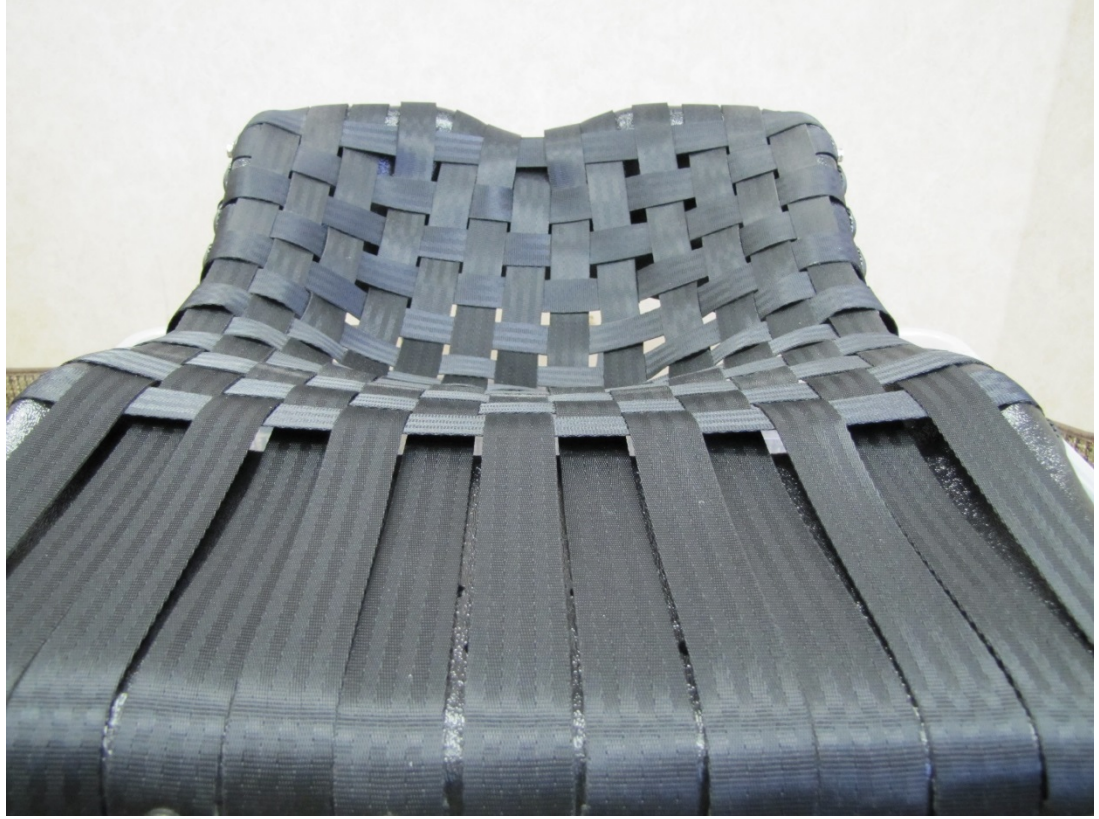
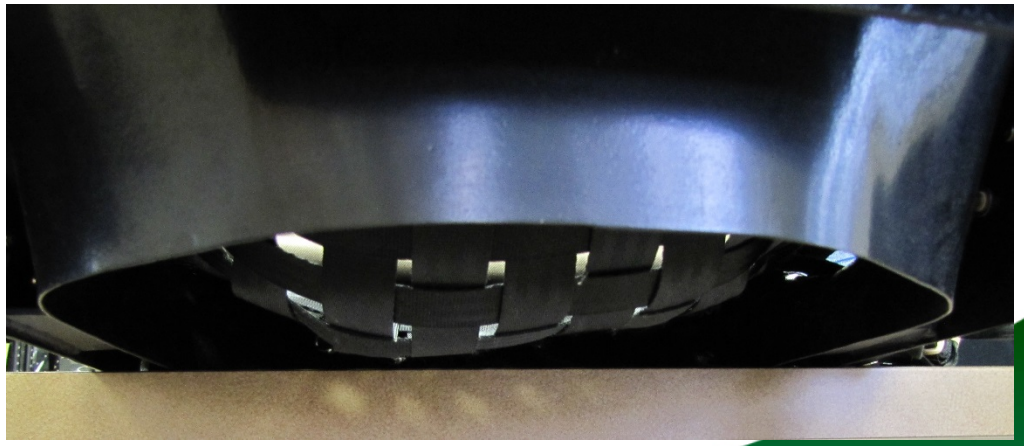
# Managing Pressure





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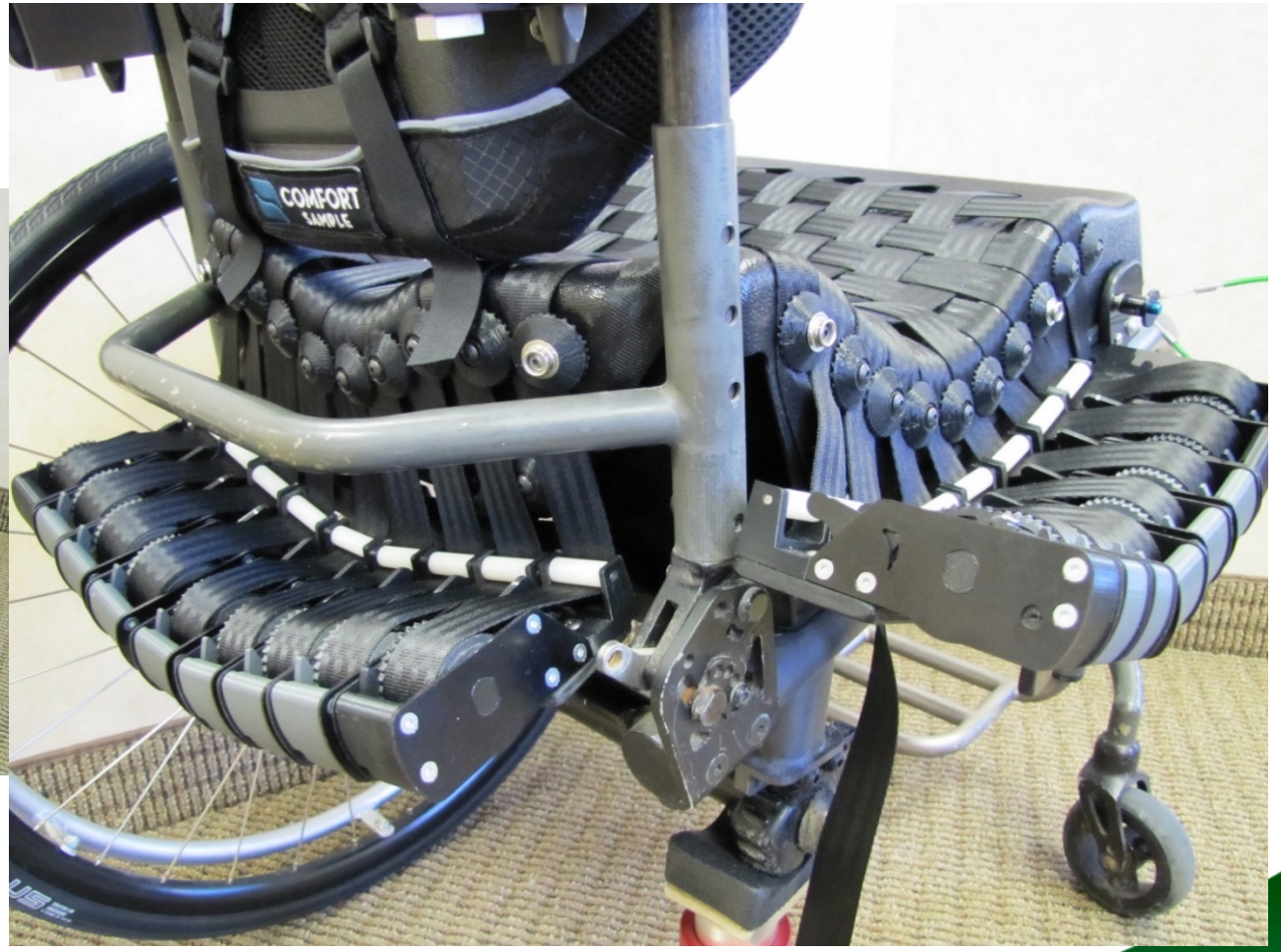
# The Molding Process



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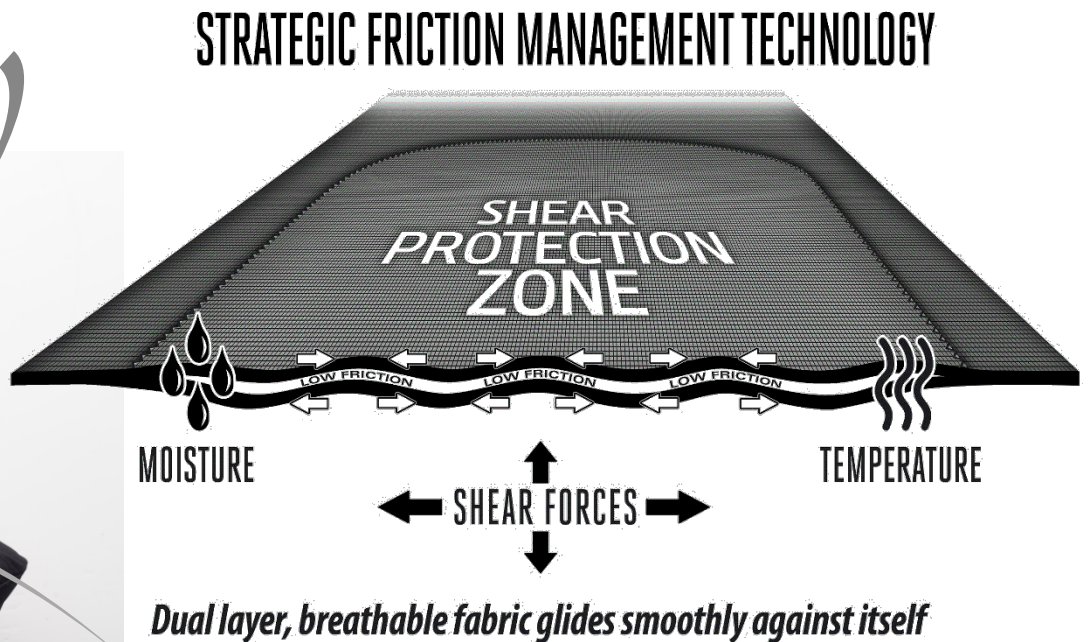
# Managing Friction and Shear

Shear Protection Zone




Stability Zone

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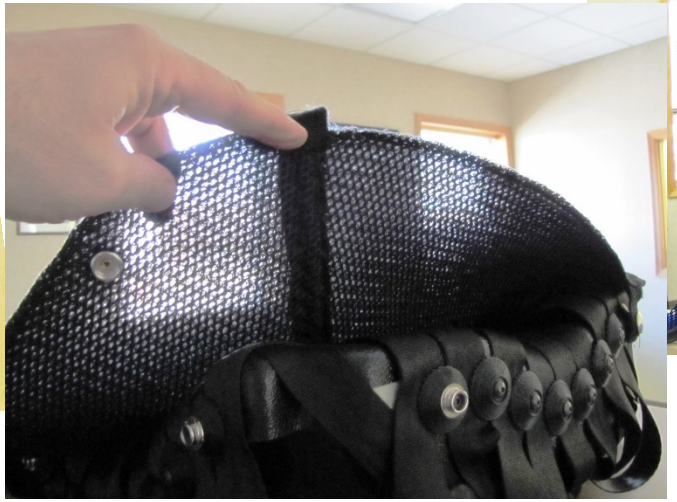
# Managing Microclimate



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# Outcome Experiences

- Two design versions
- External microclimate bench testing
- First clinical trials done
- Beta testing underway
- Future microclimate pilot study planned

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# Integrated Version

# Cushion Version

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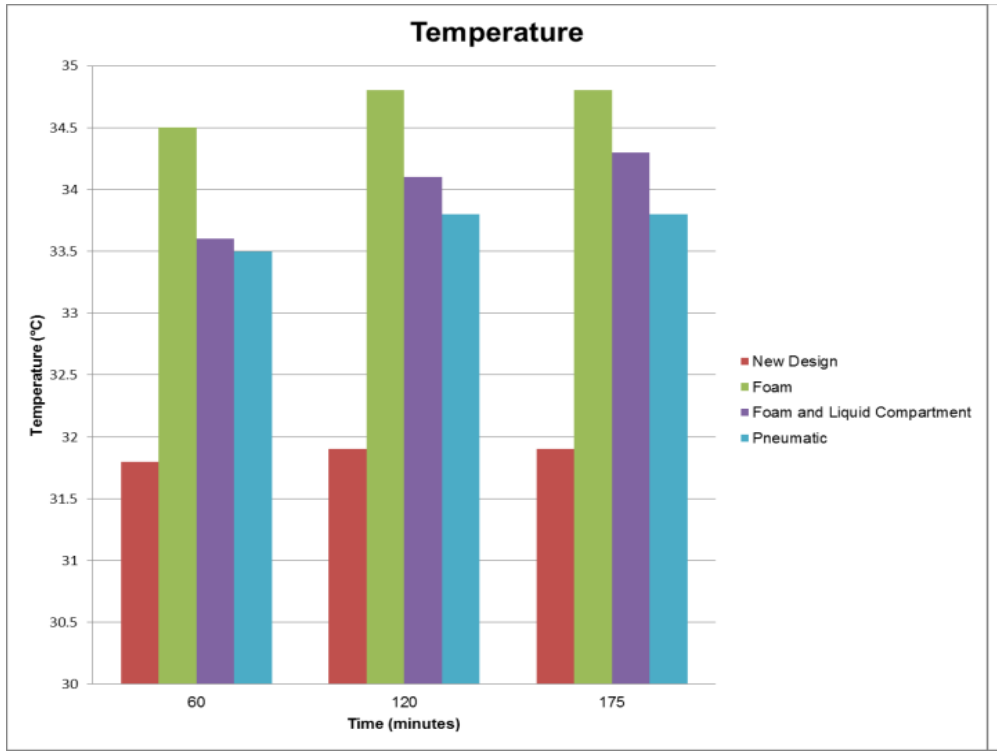
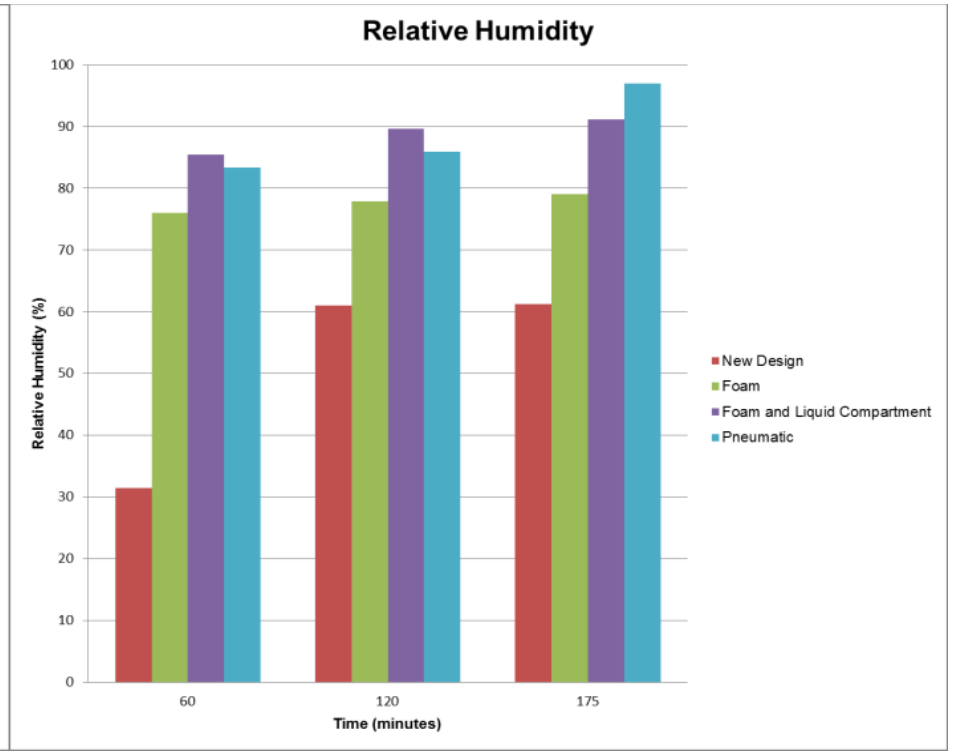
# Heat and Water Vapor Test Data




Future Human Subject Microclimate Pilot Study in 2016

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**Confirmed that Fit & Function meets Clinical Criteria**

**Confirmed intra and inter - personal repeatability**:
(3 w/c users, 3 therapists)

**http://www.rehab.research.va.gov/jour/2014/518/jrrd-2014-01-0007.html**

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Pages 1255–1264

# Pilot study of a strap-based custom wheelchair seating system in persons with spinal cord injury

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**Abstract**—Custom wheelchair seats can be used to help prevent pressure ulcers in individuals with spinal cord injury. In this study, a strap-based system was evaluated in three Veterans with spinal cord injury. Interface pressure distributions were measured after transfers, wheeling, and pressure relief maneuvers and after fittings by three different therapists. We found that pressure distribution measures were not generally affected after transfers and wheeling using the strap-based wheelchair and that pressure relief maneuvers were able to be performed. Additionally, all therapists were able to customize the wheelchair seat to clinically acceptable levels in 4 to 40 min for the three subjects. Future studies can test the long-term effects of using the strap-based wheelchair seat and identify individuals that would most benefit from a rapidly customizable wheelchair seat.

**Key words:** custom seating, custom wheelchair, interface pressure mapping, pressure relief maneuvers, pressure ulcer, SCI, spinal cord injuries, transfers, ulcer prevention, wheelchairs.

## INTRODUCTION

Pressure ulcers are a common and serious complication of spinal cord injury (SCI) [1–3]. Because individuals with SCI frequently spend several hours daily seated in wheelchairs, pressure ulcers often develop over bony prominences that sustain large loads during sitting, such as the ischial tuberosities and the coccyx. Using a wheelchair seat that redistributes interface pressures is an important component of a pressure-ulcer prevention strategy [4].

The process of selecting a seating surface for a wheelchair requires considering many factors. These factors include the distribution of pressure and shear stresses on soft tissues, moisture accumulation, heat accumulation or heat loss, stability, thickness, durability, cost, and appearance [5]. Each individual's needs are different, and there is no single wheelchair cushion that works for all wheelchair users [6].

While selecting or adjusting a wheelchair cushion, therapists often use interface pressure mapping (IPM) to visualize the distribution of interface pressures in real time. IPM can be used to calculate several measurement variables to quantify the quality of pressure distribution of the seating surface. Sprigle et al. found three such measures to be clinically useful and reliable: peak pressure index (PPI), dispersion index (DI), and contact area (CA) [7]. PPI is the highest average pressure across a load-bearing area, such as under an ischial tuberosity. DI is the percentage of the total pressure that is supported by

**Abbreviations:** CA = contact area, DI = dispersion index, IPM = interface pressure mapping, PPI = peak pressure index, SCI = spinal cord injury, T = thoracic, VA = Department of Veterans Affairs.

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# Beta testing

| User | DX | Reason for Use | Time in use* | Outcome | Acceptance | Functional Issues |
|---|---|---|---|---|---|---|
| 1 | SCI -para | multiple, severe, non healing wounds | 30 months | wounds closed - wounds improved | easy and fast | none |
| 2 | SCI -para | severe pain and discomfort | 21 months | pain free comfortable | easy and fast | none |
| 3 | SCI -para | wound prevention and stability | 9 months | wound remaining closed and is stable | easy and fast | transfers more difficult |
| 4 | SCI -quad | discomfort | 8 months | comfortable | easy and fast | none |
| 5 | SCI -para | wound and unilateral hip ext contractur | 8 months | wound closed and contracture accomodated | easy and fast | none |
| 6 | SCI -para | posture, pain and comfort | 7 months | improved posture, pain relief and comfortable | easy and fast | transfers more difficult |
| 7 | SCI -para | wound, discomfort | 4 months | wound closing comfortable | easy and fast | transfers more difficult |
| 8 | SCI -para | wound | 3 months | wound closing | easy and fast | none |
| 9 | SCI-quad | wound | 2 months | wound closing | easy and fast | transfers more difficult |

*Time in use as of 2016 ISS

# Case Example

SCI T-5

- Severe pain and discomfort
- Rigid pelvic obliquity
- Severely reducing sitting schedule – missing work

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# Case Example

In use 21 months

- Pain and comfort resolved
- Back to desired busy/long days
- Skin continues to be in very good condition
- Pelvic obliquity accommodated
- Chiropractor visits reduced from 12-14 times/yr to 2 times/yr

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# Thank You for your attention!

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# Literature recommendation

**The 5 most related ones among recent publications**

Ferguson, J.E. et al:

**Pilot Study of a strap-based Custom Wheelchair Seating System in Persons with Spinal Cord Injury**

JRRD Volume 51, Number 8, 2014 Pg. 1235-1264

European Pressure Ulcer Advisory Panel and National Pressure Ulcer Advisory Panel:

**Treatment of pressure ulcers - Quick Reference Guide**.

Washington DC: National Pressure Ulcer Advisory Panel; 2009.

**Pressure Ulcer Prevention – Pressure, Shear, Friction and Microclimate in Context. International Review – A Consensus Document.**

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**Pathology and Clinical Presentation of Friction Injuries. Case Series and Literature Review.**

J. Wound Ostomy Continence Nurs. 2015; 42(1):47-61. Lippinkott Williams & Wilkins

Gefen, A.:

**Deep Tissue Injury: What do Cells in the Buttocks sense During Sitting?**

Dept. of Biomedical Engineering, Faculty of Engineering, Tel Aviv University, 2014

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# Four Localized Physical Factors Contribute to the Onset and Progress of Tissue Trauma

- Prolonged Excessive Pressure
- Excessive Friction Forces
- Heat
- Moisture

} Microclimate

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# Pressure

- Excessive Contact Pressure (Approx. 35mmHg) will Impede Capillary Flow, Cause Ischemia and Compromise Cell Viability.

- Predominantly impacts tissue at bony prominences

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# Friction Forces Tangential to the Skin Surface:

- Trigger shear stress & strain (deformation) in soft tissue
- Impair metabolism and lead to cell death
- Is especially damaging near bony prominences

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# Injurious Friction

- Dynamic Episodes and
- Prolonged Static

# Microclimate

## Temperature:

- 1°C rise = 10% rise in the metabolic rate
  - Increase in metabolic rate demands more $O_2$
  - Additional toxic cellular waste leads to cell death
- Mechanical strength of the stratum corneum at 35°C is 25% of skin at 30°C

## Moisture:

- Weakens the outer epidermal layer (stratum corneum)
- Increases coefficient of friction of the skin