The Role of Friction and Shear Forces in Pressure Ulcer Generation

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Disclosure

Mark Payette
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Tamarack is the manufacturer of friction control materials and
products under the trade names ShearBan®, ENGO®, and
GlideWear™
Learning Objectives

1. Participants will be able to define three extrinsic factors which contribute to pressure ulcer formation.

2. The participants will be able to explain the significance of each extrinsic factor, state how each factor contributes to tissue trauma, and discuss what mitigation possibilities exist for each factor.

3. The participants will be able to define the terms “friction” and “shear” and be able to contrast the differences between friction and shear.

4. The participants will be able to recognize and understand the relationship which exists between friction and pressure, and describe why the Coefficient of Friction (CoF) of materials is important.
Learning Objectives

5. The participants will be able to associate the damaging effects of friction/shear in both dynamic and static loading contexts and be able to explain why this is so.

6. The participants will be able to name at least three strategies for controlling friction between the weight bearing surface and a sitter and describe how doing so will reduce shear loads against the skin and deep tissue.

7. The participants will be able to evaluate the ability of any seat interface material to reduce shearing and list at least three important seat interface characteristics.
Seating Related Pressure Ulcers: The Statistics

• 2.5 Million pressure ulcers each year in the US (Reddy et al. 2006)
• 50% of all admissions and 8% of all deaths at specialized spinal cord injury hospitals are due to pressure ulcers (Thomas 2005)
• 25% of people with a spinal cord injury develop pressure ulcers each year (Salzberg 1996)
• According to the National Spinal Cord Injury Statistical Center there are app. 262,000 people with traumatic SCI – that means that app. 65,000 people may develop a pressure ulcer (NSCISC 2010)
Economic Cost

• $43,180 Center for Medicare Services (CMS) fiscal year 2007 (Armstrong et al. 2008)
  ○ 65,000 people X $43,000 = $2.8 billion

• Expenditures for treatment of pressure ulcers in the US as high as $11 billion
  (Estimates by Reddy et al. 2006)
Accountability Cost

• Section 2702 of the Patient Protection and Affordable Care Act (PPACA) – disallowing federal funding for certain “never events” – (these HCAC, OPPC, and HAC conditions includes pressure ulcers)

• NPUAP proclaims every November 16 to be “Pressure Ulcer Awareness day”
  o 17,000 lawsuits annually relating to pressure ulcers
Human Cost

• Treatment time (Down time!)
• Destroy careers, upend lifestyles, reduce independence, depression
• Amputations (reaching the trans-pelvic level)
• Sepsis / death
• Skin never fully recovers (scar tissue heightens future risks)
NPUAP defines a Pressure Ulcer as...

“...a localized injury to the skin and/or underlying tissue usually over a bony prominence, as a result of pressure, or pressure in combination with shear. A number of contributing or confounding factors are also associated with pressure ulcers; the significance of these factors is yet to be elucidated.”

– but recognizes that other factors exist...

International NPUAP – EAUAP Pressure Ulcer Definition - 2009
www.npuap.org
Mechanisms known to produce PU

- Ischemia
- Muscle deformation (from compression and shear)
- Duration of time exposed to ischemia (varies by muscle, fat and skin – muscle is potentially more susceptible to damage than skin)
- Reperfusion
- Balance of interstitial space (transport of nutrients and waste)
- Cell death and tissue necrosis
Pressure Ulcer Generation Factors

- **Intrinsic factors**
  - Vascular health, muscle tone, nutrition, age, etc.

- **Global Factors**
  - Client education, motivation, lifestyle, program follow-up, etc.

- **Extrinsic factors (mechanical factors)**
  - Pressure
  - Microclimate
  - Shear (Friction causes shear)
Recommended Resource

International Review: Pressure, shear, friction and microclimate in context

A consensus document


Managing Pressure Ulcer Generation Factors increases the patient’s Margin of Safety

Pressure only managed
Very Narrow Margin of Safety

Additional extrinsic factors managed…
Wider Margin of Safety

As many factors as possible managed…
Widest Margin of Safety!
Despite awareness of multiple factors, the primary intervention effort is directed at managing pressure.

It is important that pressure is well managed!
Pressure

- Perpendicular/vertical force
- compression
- vertical force (e.g.; lbs./sq.in. or mm/Hg)
Modeling Illustration:
Pressure (compression)
Mitigating Pressure

Support Surfaces (foam, pneumatic, liquid, gel) mitigate pressure by:
- Spreading out pressure load over greater area
- Reducing peak pressure values (especially on vulnerable bony prominences)

But, peak areas will remain in the same locations
Microclimate: Moisture and Temperature

**Moisture**

- Reduces strength of stratum corneum (outermost layer of the dermis)

- Causes irritation (urine and/or bowel material)

- Moisture *increases the interface friction coefficients*, therefore increasing the possibility of shear induced tissue damage
Microclimate:

Temperature affects the metabolic rate

• 1°C (1.8°F) elevation of temperature of a human cell will increase metabolic rate by 10% (Kosiak, 1991)

• Increased metabolic rate increases need for nutrients and oxygen and produces greater volume of waste (expedites ischemic conditions if perfusion capacity is not available)
Microclimate:

Temperature

• Temperature increases of 3.75°C (6.75°F) were found after sitting for two hours on certain seat support surfaces (Ferguson-Pell et al. 1985)

This translates to a 37% higher metabolic rate

The “margin of safety” thus shrinks:

A small rise in tissue temperature can destabilize a previously safe, but marginal, condition
Microclimate:

Temperature

• Local tissue temperatures are affected by heat transfer and insulation properties of the sitting support surface

• Local increases in tissue temperature may increase due to hyperemia (natural healing response to slight amounts of tissue trauma)
Microclimate:

Moisture and temperature may be mitigated by any measure that:

• Allows for ventilation to keep the skin, clothing, and support surfaces dry

• Controls the support surface/skin temperature
Friction and Shear

• Friction
  • Static Friction verses Dynamic Friction
  • Coefficient of Friction (CoF)
  • Limiting Friction Load (LFL)

• Shear
Friction (Frictional Force):

“The force which resists an effort to slide one surface over another”

Friction is a FORCE

Note:
The term “Friction Force” is same as “Shear Force”
Friction (Frictional Force):

“The force which resists an effort to slide one surface over another”

The term “friction” is commonly used as a verb describing something sliding across a surface (but “friction” is a FORCE)
Friction “Conditions”

Static – Dynamic

Dry – Moist
**Static friction** is the resistance between a **resting** object and its support surface (Static friction keeps the object from moving)

**Dynamic friction** is the resistance between a **moving** object and its support surface
Static and Dynamic Friction

- Low dynamic friction
- Loss of static friction
- Static and dynamic friction and shear
- High static friction
Friction

Static Friction $\rightarrow$ Limiting Friction Load is exceeded $\rightarrow$ Dynamic Friction

Movement is not occurring
• Laying in bed (horizontal)
• Sitting in a chair
• Settling into/onto a support surface

Movement is occurring
• Sliding down on a bed (head raised)
• Sliding transfers
• Sliding while sitting in a chair

*Take home point: Friction loads peak while in the static condition, before motion begins*
What static friction may do:

• Static friction **WILL** lead to shear stress within a structure and this stress **MAY** lead to internal destruction

• Shear stress imposed on a structure may cause it to distort, pull or stretch—with possible damage or destruction to some internal component

• Reducing static friction may reduce stress in situations where excessive stress is present, or expected to be occurring
What **dynamic friction** may do:

- Dynamic friction **MAY** lead to abrasion but abrasion is **NOT** dynamic friction
- Abrasion is a process of superficial scraping or wearing away
- Reducing dynamic friction may reduce abrasion where it is occurring or expected

So – how do we reduce static and dynamic friction?...
Coefficient of Friction (CoF):

Ratio:

Friction force between the two materials
(friction is the force resisting the relative motion of two surfaces)

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The force pressing two materials together

The CoF is always related to two surface materials

A lower friction coefficient indicates that there is less resistance to sliding/motion
CoF Video Demonstration

Which child/slide combination has the lower CoF?
Coefficient of Friction in Typical Wheelchair Seat Cushions and Cushion Covers

Friction Coefficient:
Average with High - Low

Average values a-p and m-l per Seat cushion cover researched including standard deviation

Test Procedure Notes: Inclined Plane Method (Ref - ASTM D3334)
Block Size: 16mmHg
Atmosphere: 75(0) F, 20% RH
90% C.I. maximum 0.07 CoF
CoF: Fabric/foam demonstration

Side A: Static Dry CoF is .18

Side B: Static Dry CoF is .40 - .60
Limiting Friction Load (LFL)  
“Threshold of Motion”

Note: LFL = “pressure” times the “CoF”
Friction force peaks just before sliding begins

Note: LFL = “pressure” times the “CoF”
Video Demonstration

Different CoF’s between the girl and slide alters the Limiting Friction Load
“Tendency to Slide”

Friction is preventing “sliding” off the chair (high CoF)

Reduced friction allows sliding (low CoF)

Seating interfaces **must** strike a balance

Shear loading!
“Tendency to Slide”

• Friction forces will prevent sliding (up to a point)

• Friction forces may be very high and sustained after initial sliding motion stops (think of the child stuck halfway down the slide) – relate this to a person settled onto a seat support surface)

• Misconception: “I don’t have friction/shear problems because I am not slipping!”
Video Demonstration

CoF / Limiting Friction Load (LFL) / Tendency to Slide
Friction “Conditions”

Static – Dynamic

Dry – Moist

“Environmental” conditions;
Important because the CoF of most materials increases in a moist environment
Shear:

The **distortion** or **deformation** of a body by two oppositely directed parallel forces

*(pressure and friction are the forces)*

1. Shear stress **augments** the ischemic effect of pressure  *(Bennett L, et al 1979)*

Note the Shear-induced distortion and increased damage.
Shear: Oreo Cookie demonstration
“Shear Loading”

• Begins when a tangential force is present but sliding (movement) is not yet occurring

• The shear load peaks at the Limiting Friction Load (LFL)

• Movement occurs when the Limiting Friction Load (LFL) is met (onset of dynamic condition)
“Shear Loading”
“Shear Loading”

In a wheelchair:
• Trunk reclined
• Hips extended (downward incline)
• Orientation in space (tilt)
• Seat support surface contours (structure)

Think about bed situations:
• trunk/head elevation
Skin “Mobility”:
A Critical friction loading issue (shear strain)

- Scarred / Adhered Areas
- Skin grafts

Requires special attention to avoid shear trauma because of reduced skin/tissue mobility
Case example

Continuous breakdown cycle stopped by reducing shear
Techniques to Mitigate Friction & Shear

• Reduce tangential forces (seating or bed interventions/positioning which reduce the “Tendency to Slide”)

• Avoid actions that induce tissue distortion (sliding dragging)

• Increasing support surface contact area

• Skin lubricants / dressings

• Seat surface interface considerations (targeted – balanced) – positioning “release”
Reduce tangential forces - interventions which reduce the “Tendency to Slide”

- Thigh angle
- Back recline
- Orientation in space (tilt)
- Seat contouring (cradling)
- Componentry (straps, knee blockers)

*Minimizing the “tendency to slide” is critical*
Seating Alignment and Position is Critical
Case example
Case example
Case example
An interface is the area where two surfaces meet and loads are transferred from one structure to another.

Sitting/weight bearing loads (a combination of pressure and shear) are transmitted through the skin and soft tissue to the skeleton.
Interface technologies can reduce tissue damage from friction and shear

• Support surface covers should have low CoF characteristics

• Target the “at risk” area to ensure stability

“Friction Management”
Interface Video Demonstration

No interface  
With low friction interface
A cushion cover is an interface

Cushion covers can function as a friction and shear mitigating interface between the cushion and clothing/skin.

But, specific characteristics must be present.
Friction is not all bad!

• Friction is only “bad” where it peaks high enough to cause a problem
• Friction helps maintain stability, control, etc.

Targeting CoF reduction in identified problem / at risk areas is “Friction Management”
Seating Interface Design Considerations

• Allow support surface to conform to bony prominences (no “tenting” allowing immersion)

• Slippery (Low CoF) in targeted areas to reduce friction/shear forces only in at-risk areas

• Retain the higher CoF on the remainder of the surface to maintain postural stability

• Moisture and air permeable
Summary: Take Home Points

• Friction force causes Shear stress

• Pressure and the Coefficient of Friction (CoF) are the factors which determines the limiting friction load (LFL)

• Shear stress peaks before motion/sliding occurs
Demonstration
(Break into two smaller groups)

Learn how to assess for “friction control” on a seat cushion cover (interface)

Compare three cushion cover interface possibilities

You can feel this!
Demonstration

• Can you feel the reduced friction (low CoF) area?

• Is the low CoF area global? Targeted?

• Is there a direction to the low CoF area?

• How noticeable is the low CoF area (comparison between samples)

• Do you stay positioned on seat surface? (can you differentiate between “settling” and sliding downwards?)

• Is stability compromised?
Discussion Period

Summarize group experience / Questions
For more information

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LEARNING OBJECTIVES:
The Role of Friction and Shear Forces in Pressure Ulcer Generation – Session WS6 30 June 2012

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Shear: Oreo cookie demonstration

Push straight down with equal pressure

While maintaining equal pressure, push your hands forward

Materials: smooth clipboard, sheet of paper, tape, Oreo Double Stuff cookies