Using The Science of Materials to Compare Wheelchair Cushions

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Faculty Disclosure

- W. Darren Hammond, PT, MPT, CWS
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  - Clinical Education Manager, West Region
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- Physical Therapist since 1993 – Certified Wound Specialist since 1996
- SCI rehab – seating & wheelchair prescription background
- University Professor
- Wound management focus of treatment
- Permobil/ROHO for over 11 years

Objectives of Presentation

- Explain two mechanisms and resulting forces that occur while load is applied to three different cushion materials
- List three different load redistribution methods used in cushion design and construction
- Explain the three quantifying methods used to compare and contrast cushion materials surfaces

Objectives of Presentation

Our goal is to make you a better critical thinker to improve your client outcomes!

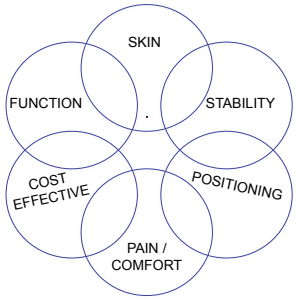
SUNRISE MEDICAL
ROHO
permobil
THE POWER OF MOBILITY

No endorsement any particular model, brand of product or manufacturer

Goals of Wheelchair Seating

- Clinical Reasoning
  - Skin protection
    - Manage extrinsic factors - redistribution of load
    - Heat and moisture dissipation
  - Provide dynamic stability
  - Provide positioning
  - Comfort
    - Sitting tolerance
    - Impact and vibration damping
  - Maintain optimal function
  - Ease of use and cost effective

Goals of Wheelchair Seating



Clinical Decision Making

- What level of skin protection is needed?
  - Extrinsic risk to be managed
  - Method of load redistribution
- How much positioning is needed?
  - Accommodation versus correction
- How much stability required?
  - For function
- Consistency of orientation to the load

Clinical Decision Making

- What changes are predicted to occur
- How capable and compliant will client be at needed maintenance?
- What are the lifestyle considerations?
  - Transferring and transporting
- Reimbursement available
- And the list goes on and on . . . .

Clinical Decision Making

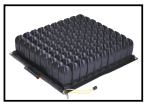
- If we don't know these clinical things – How can we determine what minimal essential features are necessary for our clients?

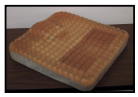
Are We Doing This?

Can the cushion do it all?

The Impact of Equipment Choices

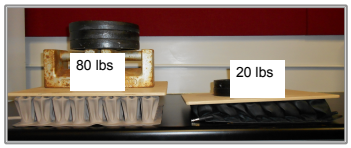
- The Cushion
  - Material considerations
    - Know the options
    - Understand how materials behave
    - Make smart choices
    - Consider client's history



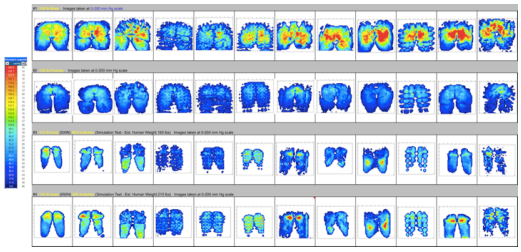


Decisions Decisions

Differences Within Products



Non-adjustable vs. Adjustable



Clinical Tendencies

- Needs of client based upon assessment
- What we are comfortable with
- What is available at facility
- Past experiences with similar clients
- What supplier carries in stock or suggests
- What sales representative tells us
- Marketing material
- What the client wants
- What is reimbursed
- And . . . . .

Challenges to Prescribers

- Prescribers have significantly different levels of technical knowledge
- Little or no GOOD evidence that any product is effective or superior to another product

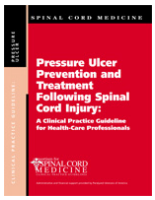
Research vs. Ritual

- Evidence based practice

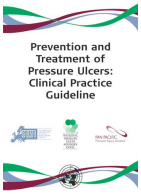
  Rappolt, 2003
  - Research evidence
  - Professional expertise
  - Client evidence
  - Integration
  - Clinical decision making

Utilization of Clinical Practice Guidelines

WOCN
www.WOCN.org



PVA
www.PVA.org



NPUAP/EPUAP
www.NPAUP.org

Have We Progressed Beyond . . .

"Foam is bad because if it gets wet it will break down"

"Jay is for positioning, ROHO is for skin"

"They don't need that cushion, they aren't an individual with a spinal cord injury"

"We don't carry that product, it costs too much"

"We decided just to carry three cushions since there are so many on the market"

One Solution: The Scientific Approach!

What is the Science IN Seating?

- Understanding:
  - Humans vary in shape and load
  - Materials used in seating work differently
  - Cushions react to shape and load
  - Every interaction of cushion and human is unique

Bodies Vary in Load and Shape

Pictures courtesy of Stephanie Tanguay

Bodies Vary in Load and Shape

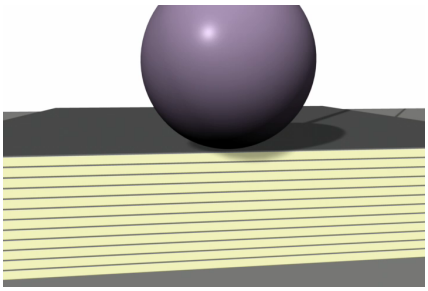
Result

- Each cushion and body interaction create a unique loaded contour shape

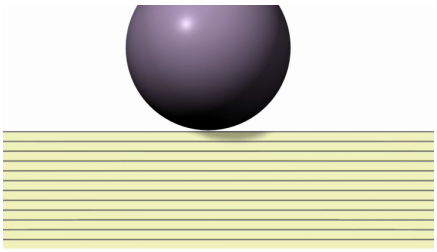
Accommodating Load and Shape

- Mechanisms
  - Compression
  - Displacement
- Forces at work
  - Reaction
  - Hydrostatic

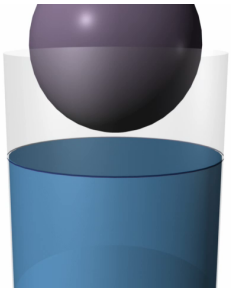
Compression



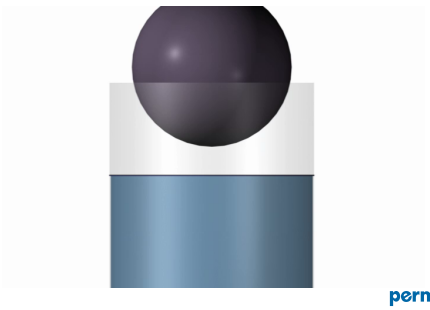
Reaction Forces



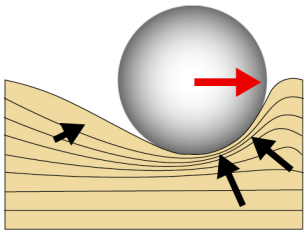
Displacement



Hydrostatic Forces



Forces with Movement



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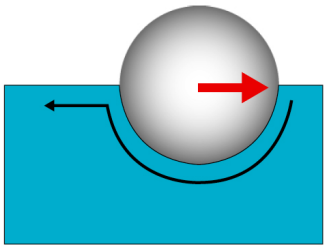


Clinical Significance

- Reaction forces – peak forces
- Hydrostatic forces - redistributed forces
- How do the forces react with human tissue?
  - What is the resultant forces internally
  - What are the affects of deformation?
- What clinical presentations respond better to different forces?

Materials

- Foam
- Elastomers
- Fluids
- Gels

Basic Foam Types

- Open cell
  - Polyurethanes
  - Visco-elastic foam
- Closed cell
  - Polyethylene
- Constructed hybrids
  - Brock

Foam

- Mechanism
  - Compression
- Forces
  - Reaction

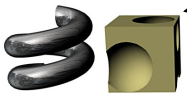
Foam

Density: Pounds per Cubic Foot (PCF)

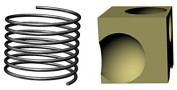
IFD – Indentation Force Deflection: a measure of firmness (or spring)

Example 1

These micro-samples have equal density, but different firmness (or spring)



(30 IFD), (2.5 PCF)
More firm

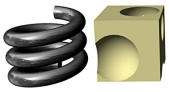


(13 IFD), (2.5 PCF)
Less firm

Example 2

These micro-samples have equal firmness, but different density

(More material)



(24 IFD), (2.5 PCF)
More dense

(Less material)

(24 IFD), (1.2 PCF)
Less dense

Density

- Used as an indicator of performance
  - Comfort
  - Support – ability of foam to push back – prevent bottoming out
  - Durability
- Greater density – greater cost
- Low – packing foam
- High – seat cushions and automotive seats

Dense Foam

- Maintains its firmness (or spring) longer
  - Greater amount of support
- Maintains its height longer
- Has greater durability

– Polyurethane Foam Association, "In Touch" article, Volume 1, Number 2, May 1991

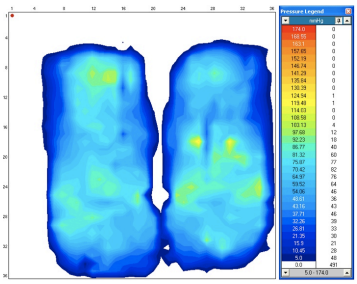
Clinical Significance - Foam

- Density (PCF) and firmness (IFD) define a foam's durability and pressure redistributing properties
- Softer foam (low IFD) allow for better pressure redistributing capabilities
  - Too soft could lead to bottoming out
- Density must stay above 2.5 PCF – if not will be less expensive but durability will be sacrificed

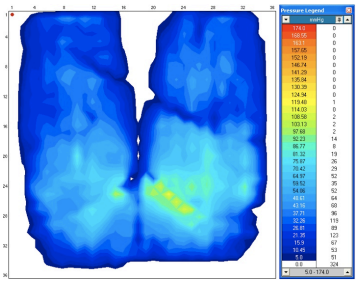
Clinical Significance - Foam

- If your concern is skin. . .
  - Reaction forces cause greater peak pressures and more tissue deformation

Foam - Basic



Foam - Viscoelastic



Evidence on Foam

- Using contoured foam results in lower pressure and more acceptable pressure distribution versus flat foam
- Sitting on softer foam (lower IFD) resulted in lower pressures versus stiffer foam
  - Greater envelopment and immersion

Sprigle et al. 1990
Garber & Krouskop 1997

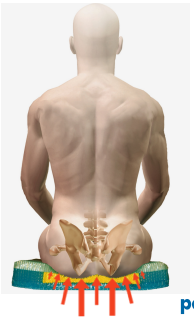
Evidence on Foam

- After 6 months 70% of foam cushions showed physical signs of fatigue
  - demonstrated by compression set
- 40% of cushions 7-12 months showed clinical signs
  - demonstrated by increased pressure or discomfort
- >60% after >12 months showed clinical signs
- Compression set occurred before clinical signs
- "Certain temporary wheelchair users may benefit from a foam cushion"

Sprigle, ISS 2009, Orlando, FL

Elastomers

- Mechanism
  - Compression
- Forces
  - Reaction



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Clinical Significance - Elastomers

- Know the goal of the product
- Same conclusions about contouring versus flat
- Concern same as foam with reaction forces on internal soft tissue
- Consider air as an insulator and concern for increased temperature

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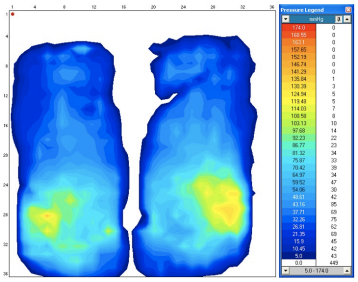
Elastomers



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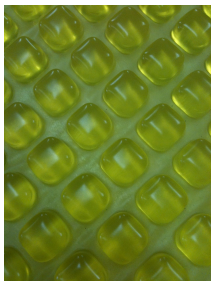
Gels



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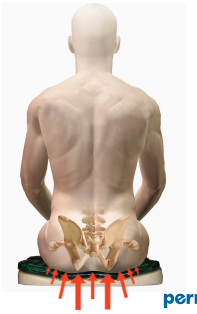
Gels

- Mechanism
  - Displacement
- Forces
  - Reaction



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Clinical Significance - Gel

- Know the goal of the product
- Same conclusions about contouring versus flat
- Concern regarding increased reaction forces on internal soft tissue
- Heat and moisture dissipations issues

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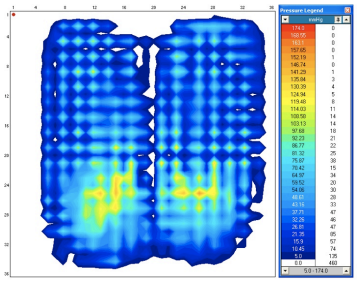
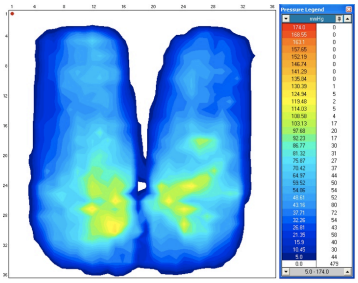
Gel - segmented



Gel - single bladder



Fluids

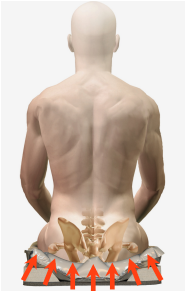
- Newtonian
- Non-Newtonian

Fluids

- Newtonian
  - Air
  - Water
- Non-Newtonian
  - Jay Flow
  - Floam

Non-Newtonian Fluid

- Mechanism
  - Displacement
- Forces
  - Hydrostatic



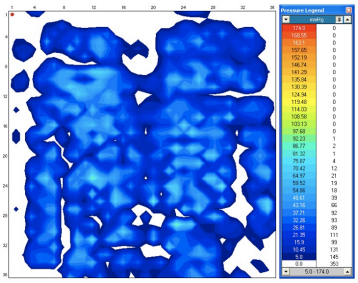
Newtonian Fluid - Air

- Mechanism
  - Displacement
    - Compression
- Forces
  - Hydrostatic
    - Reaction

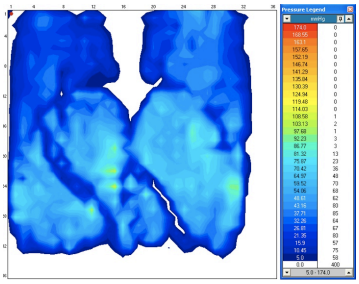
Clinical Significance

- Know the goal of the product
- Hydrostatic forces better for distribution of forces
- Lower reaction forces on internal soft tissue
- Heat and moisture dissipations issues

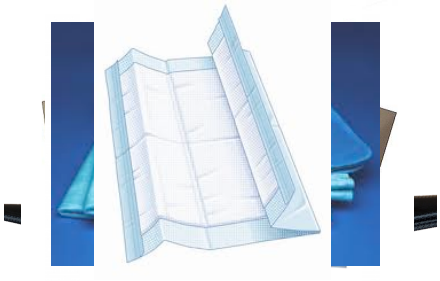
Segmented Air



Viscous Fluid



What About Tension?



Clinical Significance

- Ability to immerse and envelop into the medium
- Increased magnitude
- Potential increase in tissue deformation
- Increase in microclimate and moisture concern

Have You Ever Asked?

- Why is this cushion designed like this?
- What is the specific material characterization and why was it chosen?
- How is it really supposed to work?
- What is the load redistribution method?

Design Goals

- Primary
  - Redistribution of load
  - Stability
  - Positioning
- Secondary
  - Heat and moisture dissipation
  - Impact and vibration dampening
- What else?
  - Increase sitting tolerance (comfort)

Construction Materials

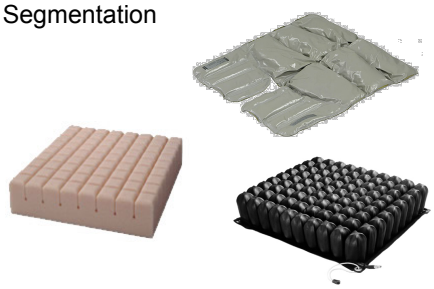
- Foam
- Air (container)
- Elastomers
- Foam and Gel (container)
- Foam and Viscoelastic foam
- Foam and Fluid (container)

Design Techniques

- Segmentation
- Firmness Layering
- Pre-contouring

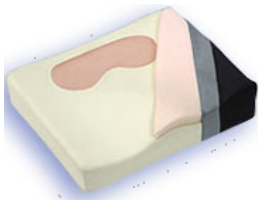
Design Techniques

- Segmentation



Design Techniques

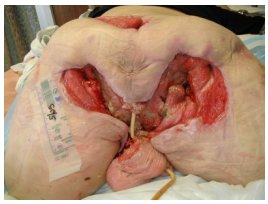
- Firmness layering



Design Techniques

- Pre-contouring

How to Manage the Extrinsic Risk Factors for Pressure Injury Development

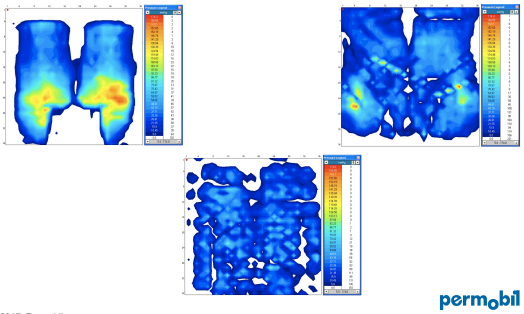


Clinical Decision Making

- What level of skin protection is needed?

What is the Method of Load Redistribution?

Do You Know?



Redistribution of Load to the Thighs

- Pre-contour to facilitate immersion
- Density layer under the ischials so they sink deeper

Redistribution of Load to Trochanters

- Immerse deep enough to load the trochanters
- Pre-contour to facilitate immersion
- Density layer under the ischials so they sink deeper
- Use fluid under ischials to immerse

Redistribution of Load

1. Hydrostatically load entire seated area

Redistribution of Load

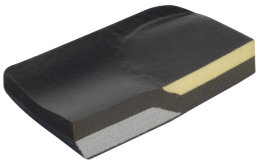
2. Load the ischials and trochanters hydrostatically and redirect load to the thigh

Redistribution of Load

3. Load the ischials hydrostatically and redirect load to the thigh and trochanters

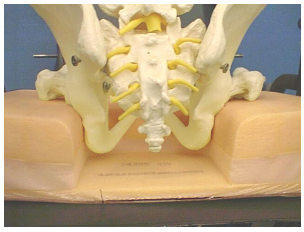
Redistribution of Load

4. Reduce the load at the ischials and trochanters and redirect load to the thigh



Redistribution of Load

5. Offload the ischials and redirect load to the thigh and trochanters

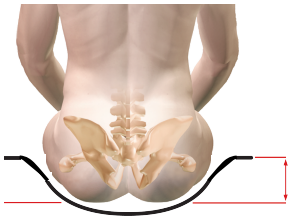


Quantifying the Effects of Redistribution

- Immersion
- Envelopment
- Magnitude

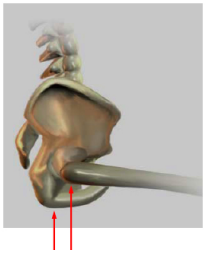
Immersion

- Capability of a cushion to allow the body to sink into it



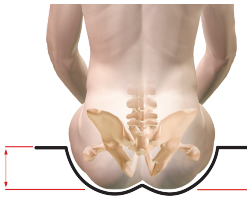
Immersion

- How much should the pelvis sink in?
- Remember the ischials in a bony person need to be able to immerse approximately 2” without bottoming out



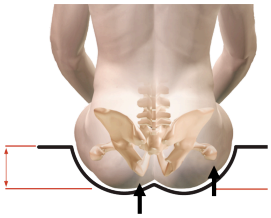
Envelopment

- Capability of cushion to deform around and encompass the shape of the body



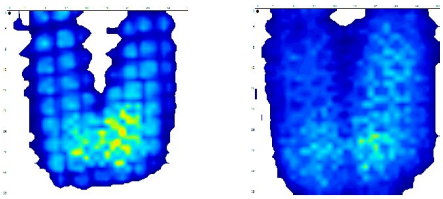
Magnitude

- How much force is concentrated on the bony prominences



Pressure Imaging as a Tool

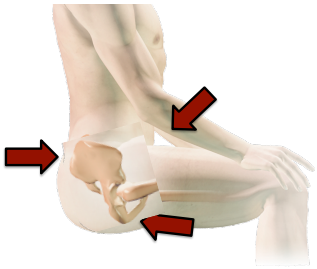
Surface contact area
Immersion and envelopment



Pressure Distribution

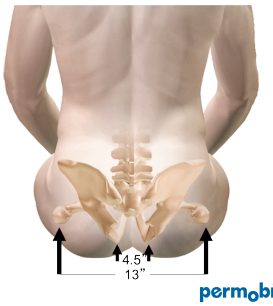
How Is Stability and Positioning Managed?

Principle of Design



Lateral Stability

- How broad is the base of support
- How stiff is the material at the point of support



Forward Stability

- What is the depth of immersion?
- How stiff is the material forward of the ischials?
- What is the friction between user and cushion?

Positioning

- Positioning is the ability to control shape to accommodate or correct posture.

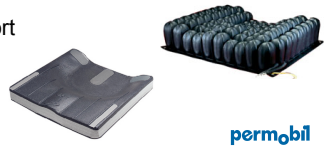
Positioning, Creating a Shape:

1. Pre-contouring
2. Modification of the material
3. Adding or subtracting components
4. Controlling the volume and location of a fluid
5. Combination of these techniques

Contouring

Seat Contour

- Posterior contour
  - Accommodate anatomical shape
  - Help secure the ischial tuberosities
  - Discourage forward sliding
  - Match contour of pelvis for pressure distribution
  - Increase comfort



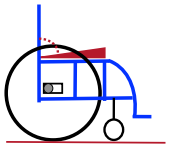
Seat Contour

- Anti-thrust
  - More aggressive contour
  - Secure ischial tuberosities and prevent forward sliding
  - Ischial tuberosities should be 1-1.5 inches away from anterior shelf

Modification of the Material

Cushion Modifications

- Wedge cushion or base
  - Help support pelvis in neutral
  - Prevent sliding forward
  - Requires appropriate hip flexion!
  - Consider transfers



Adding or Subtracting Components

Controlling Volume & Location of Fluid

Heat and Moisture Dissipation

- Temperature extremes are a problem
- Trapped moisture is a problem

Clinical Significance

- "Severity of the resultant tissue injuries correlated with an increase in applied temperature." (Kokate, 1995)
- Moisture softens the skin making it more susceptible to breakdown (Leyden, 1977,1984 & Zimmerer, 1986)
- Increased moisture increases friction between the skin and surface materials resulting in increase shear stress (Lachenbruch, 1999)

Clinical Significance

- Kokate (1995) and Patel (1999) have suggested lower temperatures have benefit on skin
- "At a given pressure, … lower temperatures exert a significant protective influence with respect to the development of pressure ulcers" - Kokate (1995)
- Lachenbruch (2005) stated that a 8ºC decrease in skin temperature is equivalent to 29% reduction in interface pressure

Impact and Vibration

Low Impact Transmission

- Compressible materials reduce impact transmission

Impact and Vibration

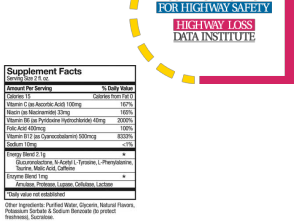
Higher Impact Transmission

- Non-compressible materials have diminished ability to reduce impact transmission

Clinical Significance

- Must determine need of client
  - Activity level
  - Need for shock absorption
- Equipment being utilized
  - Frame
  - Accessories

What's Missing



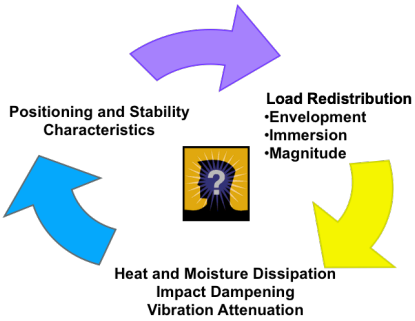
Supplement Facts
Serving Size 9 fl. oz

Amount Per Serving	% Daily Value
Calories 15	Calories from Fat 0
Vitamin C (as Ascorbic Acid) 100mg	167%
Niacin (as Niacinamide) 33mg	165%
Vitamin B6 (as Pyridoxine Hydrochloride) 40mg	2000%
Folic Acid 400mcg	100%
Vitamin B12 (as Cyanocobalamin) 500mcg	8333%
Sodium 10mg	<1%
Energy Blend 2.1g (Glucuronolactone, N-Acetyl-L-Tyrosine, L-Phenylalanine, Taurine, Malic Acid, Caffeine	*
Enzyme Blend 1mg Amylase, Protease, Lipase, Cellulase, Lactase	*

*Daily value not established

Other Ingredients: Purified Water, Glycerin, Natural Flavors, Potassium Sorbate & Sodium Benzoate (to protect freshness), Sucralose.

Clinical Decision Making



Essential Clinical Questions

- Will the client be able to consistently orient to the pelvic loading area
- What changes are predicted to occur with the client?
- Is the product adjustable
- Is the product adaptable
- How capable and compliant will the client or caregiver be at needed maintenance?
- What are the lifestyle considerations?
  - –Transferring
  - –Transporting

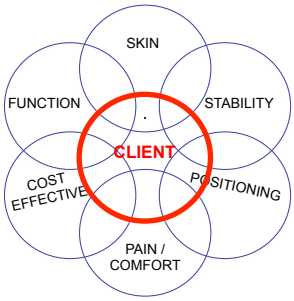
Essential Clinical Questions

- Can the client carry out all functional activities on the selected product
- IS IT COMFORTABLE? …For the client!! Has sitting tolerance been increased?
- Have we provided all the necessary justification
- What is the consequence of the client not getting this equipment

What To Look at With Each Cushion

- Check cover material and tension
- What materials are used
  - –Mechanisms and forces
- What design techniques are present
  - –Segmentation, density layering, and pre-contouring
- What's the load distribution method
  - –Consider ischials, trochanters, and thighs
- Lateral stability
- Forward stability
- Positioning

Goals of Wheelchair Support Surfaces



Take Home Message

- Consider science of the materials
  - Consider mechanisms and resulting forces
  - Consider design and construction of products
- We must chose products that meets the individual's needs
- Continue to monitor changes in testing

Questions?

Topics for Discussions?

Thank you

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