

# SOCKET DESIGNS

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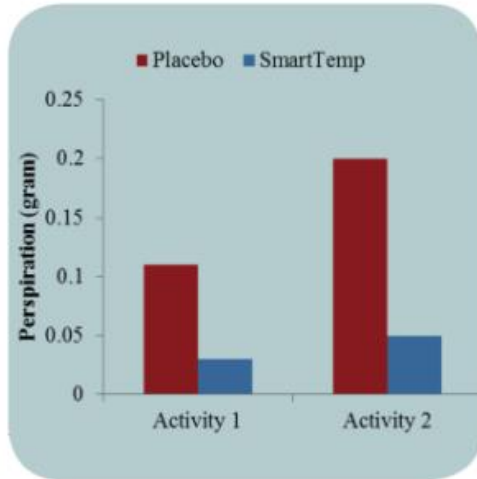


*WillowWood*<sup>®</sup>  
Education  
Patents  
**CORE**  
CENTER FOR OUTCOMES, RESOURCES & EDUCATION

*WillowWood*<sup>®</sup>

# WHAT IS CORE?

- Center for Outcomes, Resources, and Education



OUTCOMES



RESOURCES



EDUCATION

# WHO IS CORE?

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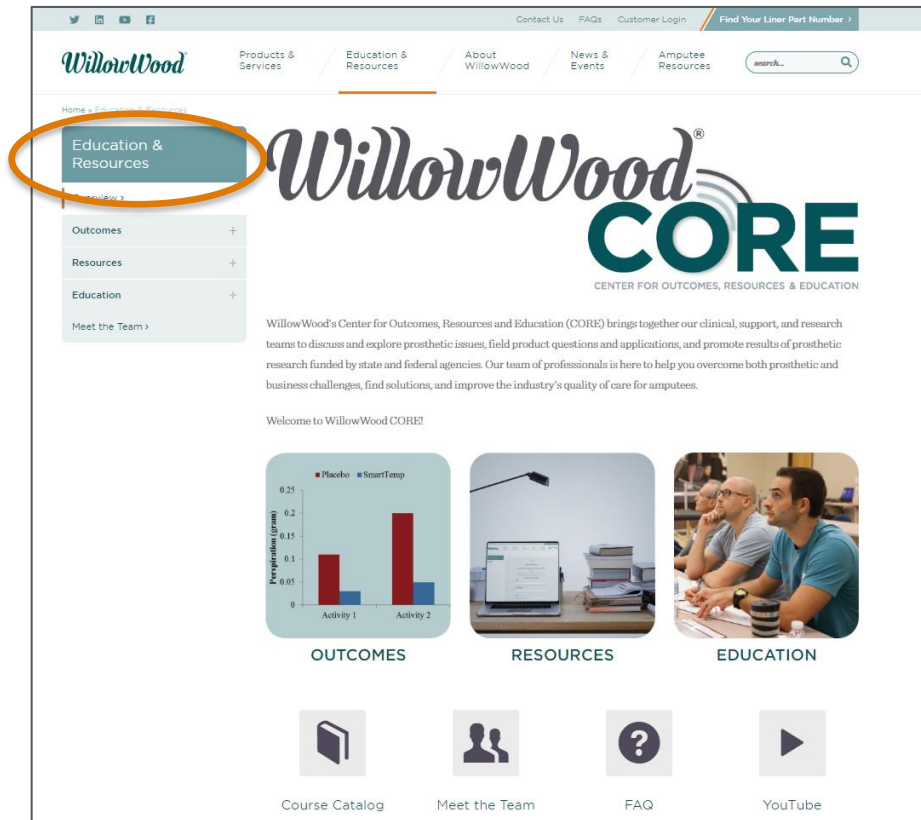
# WHAT DOES CORE DO?

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- Discuss and explore prosthetic issues
- Field product questions and applications
- Promote results of prosthetic research funded by state and federal agencies







The screenshot shows the WillowWood CORE website. The navigation bar at the top includes links for Contact Us, FAQs, Customer Login, and Find Your Limb Part Number. The main navigation menu on the left has the following items: Home & Overview & Services, Education & Resources (circled in orange), Outcomes, Resources, Education, and Meet the Team. The main content area features the WillowWood CORE logo, a description of the center's mission, and a welcome message. Below this, there are three columns: Outcomes (with a bar chart comparing Placibo and SmartTemp), Resources (with an image of a laptop and books), and Education (with an image of two people in a meeting). At the bottom, there are four icons representing Course Catalog, Meet the Team, FAQ, and YouTube.

WillowWood

Products & Services | Education & Resources | About WillowWood | News & Events | Amputees Resources

Home & Overview & Services | **Education & Resources** | Outcomes | Resources | Education | Meet the Team

# WillowWood<sup>®</sup> CORE

CENTER FOR OUTCOMES, RESOURCES & EDUCATION

WillowWood's Center for Outcomes, Resources and Education (CORE) brings together our clinical, support, and research teams to discuss and explore prosthetic issues, field product questions and applications, and promote results of prosthetic research funded by state and federal agencies. Our team of professionals is here to help you overcome both prosthetic and business challenges, find solutions, and improve the industry's quality of care for amputees.

Welcome to WillowWood CORE!

**OUTCOMES**

Bar chart showing Perseparation (gram) for Activity 1 and Activity 2, comparing Placibo (red) and SmartTemp (blue).

Activity	Placibo (gram)	SmartTemp (gram)
Activity 1	0.10	0.03
Activity 2	0.20	0.04

**RESOURCES**

**EDUCATION**

Course Catalog | Meet the Team | FAQ | YouTube

# OUTCOMES



## Meet the Team

**Research & Technology**

**Jim Colvin**  
jcolvin@willowwood.com

Jim is the Director of Research and Technology at WillowWood. His roles include product and technology development, customer studies, grant applications and management, and intensive product management. Jim is a member of ASTM D2028 Prosthetic Limb Board Steering Committee, ISO Technical Committee 93 Standard on developing safety and performance standards for lower limb prostheses, ASTM Standard on the Prosthetic and Pedestrian, and The Ohio State University Biomimetic Engineering Advisory Council. Jim is also a member of the Ohio State University Biomimetic Engineering Research Center of Ohio designing and testing adaptive lower limb sockets and prosthetic systems and as a Researcher at The Ohio State University evaluating the efficacy of prosthetic sockets and as a Researcher in BS in Civil Engineering from the University of Notre Dame and MS in Biomimetic Engineering from The Ohio State University.

**Matthew Wernke, PhD**  
matt.wernke@willowwood.com

Matthew is an applied research engineer. He earned a PhD in Biomimetic Engineering from The University of South Florida in 2013 and was a research assistant for the Center for Prosthetic Research and Rehabilitation, and Biodesign Technologies. His research focused on the development of robotic devices and motion analysis tools to quantify motion of the residual limb relative to the prosthetic socket. His roles include product and technology development, customer studies, grant applications and management, and disseminating the research results at conferences and peer-reviewed publications.

**Parents Plead Scrutiny, but there is no need for fitting. My reputation for being durable has now reached the size of my ego and the size of the office.**  
**Little Women Park** is an all-in-one design built in Tennessee.

**Colvin, James M. MS**  
SmartTemp Prosthetic Liner Significantly Reduces Residual Limb Temperature and Perspiration. Journal of Prosthetics & Orthotics. 2015; 27(4): 134-139.



## Clinical Outcomes

**Results**

Wearing the SmartTemp Liner reduced residual limb temperature and the amount of perspiration when compared with wearing the plastic liner. At the start of the activity there was not a significant difference in skin temperature, suggesting an equivalent starting point between conditions. However, each timepoint thereafter showed a significant reduction in skin temperature when using the SmartTemp Liner.

	End of Baseline (°C ± SD)	Start Activity (°C ± SD)	End Activity (°C ± SD)	Start Rest (°C ± SD)	End Rest (°C ± SD)
Placebo	32.4 ± 1.4	32.2 ± 1.8	32.2 ± 2.0	32.4 ± 1.8	32.2 ± 2.0
SmartTemp	32.2 ± 1.6	32.4 ± 1.6	30.4 ± 2.2	30.4 ± 1.6	30.2 ± 1.8
<b>p-value</b>	0.02	<0.0001	<0.0001	<0.0001	<0.0001

Perspiration was also reduced when using the SmartTemp Liner compared to the placebo (Figure 2).

On average, there was a 25% reduction in perspiration across the 16 subjects in the study. The one outlier subject in the study always had less perspiration on the limb that was wearing the SmartTemp Liner compared to the placebo (Figure 3).

**Figure 2: Perspiration across the 16 subjects in the study. The y-axis represents the amount of perspiration in grams per hour. The x-axis represents the time in hours.**

**Figure 3: The outlier subject. The y-axis represents the amount of perspiration in grams per hour. The x-axis represents the time in hours.**

**Conclusion**

The alpha SmartTemp Liner has shown to be effective at reducing temperature, and more importantly perspiration within a prosthetic socket. Reducing perspiration will reduce the potential for injury to the skin tissues.

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111. 945.884.8377 WillowWood



## Research Partners



## Bibliography

### Liter References

Wernke, Matthew M. PhD; Schroeder, Ryan M. BS; Kelley, Christopher T. MS; Denune, Jeffrey A. CP; Colvin, James M. MS. SmartTemp Prosthetic Liner Significantly Reduces Residual Limb Temperature and Perspiration. Journal of Prosthetics & Orthotics. 2015; 27(4): 134-139.

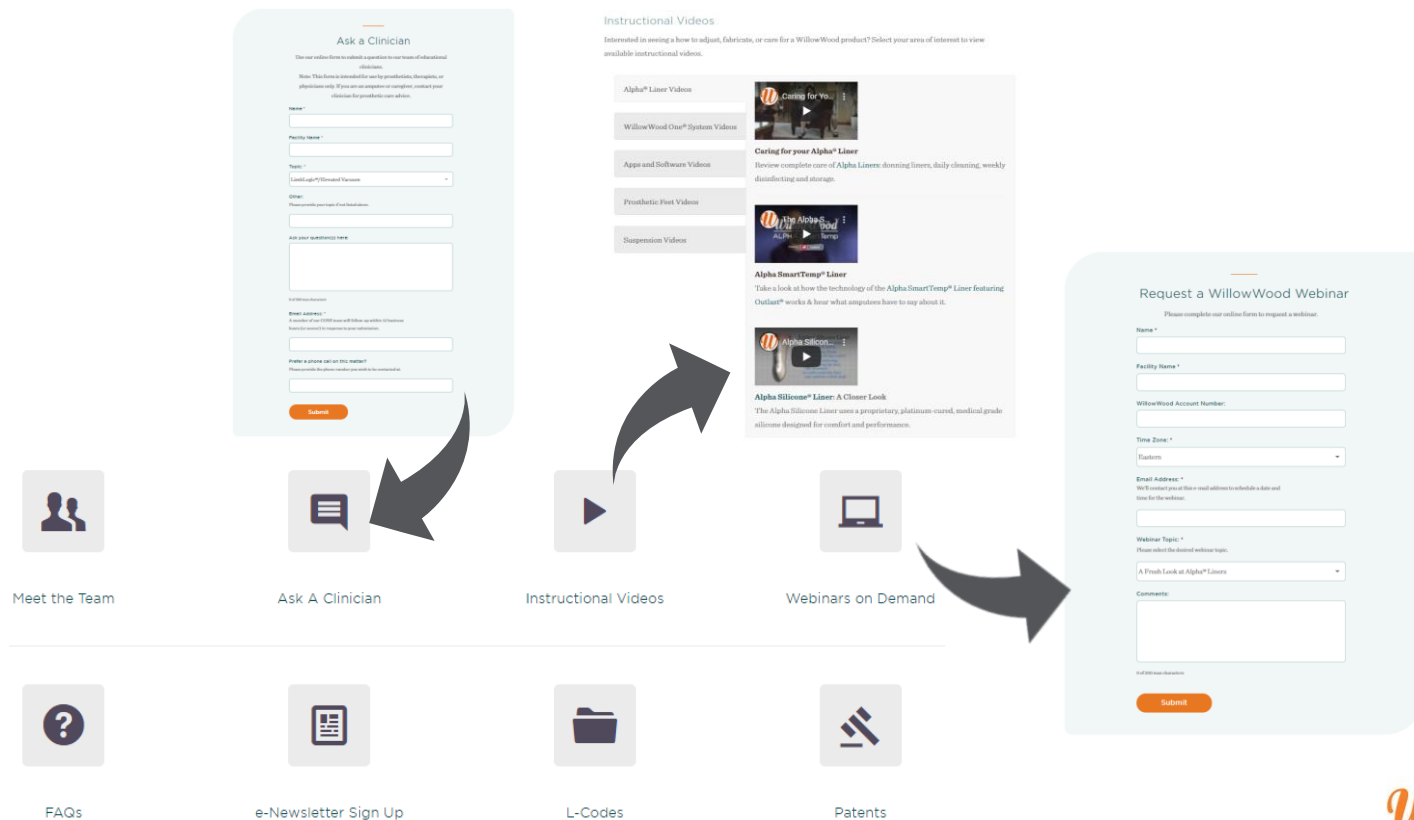
Wernke M, Kelley C, Haynes M, Gerschütz M, Colvin J. Management of Skin Temperature and Perspiration Using a Prosthetic Liner Incorporating Phase Change Material. OrthoBode. Nr.3/2014.

Beil TL, Street GM. Comparison of interface pressures with pin and suction suspension systems. Journal of Rehabilitation Research and Development. 2004;41(6A):821-828.

Denune, J. Managing Difficult Limb Shapes with Custom Liners. The Academy Today, March 2006: AS-9. <http://www.oandp.org/AcademyToday/2006Mar/7.asp>

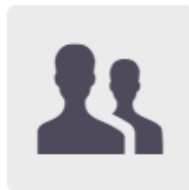
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# RESOURCES





# EDUCATION



## Meet the Team



**Andrew Marsland, CP/LPS, BOCP®**  
amarsland@willowwood.com 614.222.0886

Andrew began his prosthetic career in 1982, starting as a technician in a variety of prosthetic centers across the country. He moved to WillowWood in 1998 and has since become a leader in the field. He has been a member of the CP/LPS since 1998 and has been a member of the BOCP since 2000. He has been a member of the CP/LPS since 1998 and has been a member of the BOCP since 2000. He has been a member of the CP/LPS since 1998 and has been a member of the BOCP since 2000.

*He is proud to be a part of the WillowWood team and to be a part of the CP/LPS and BOCP communities.*

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**Jennifer Dowell, CP/LPS**  
jdowell@willowwood.com 614.226.3333

Jennifer began her prosthetic career in 1982, starting as a technician in a variety of prosthetic centers across the country. She moved to WillowWood in 1998 and has since become a leader in the field. She has been a member of the CP/LPS since 1998 and has been a member of the BOCP since 2000. She has been a member of the CP/LPS since 1998 and has been a member of the BOCP since 2000.

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**Bill Marmorek, CP/LPS**  
bmarmorek@willowwood.com 614.222.0828

Bill Marmorek graduated from Laramie University in Laramie, Wyoming, with a Bachelor's Degree in Prosthetics and Orthotics. He worked for 10 years as a prosthetist in a variety of settings, including a hospital, a private practice, and a research facility. He moved to WillowWood in 1998 and has since become a leader in the field. He has been a member of the CP/LPS since 1998 and has been a member of the BOCP since 2000. He has been a member of the CP/LPS since 1998 and has been a member of the BOCP since 2000.

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**Raymond Spindus, CP/COF**  
rspindus@willowwood.com 614.222.2077

Raymond began his prosthetic career in 1982, starting as a technician in a variety of prosthetic centers across the country. He moved to WillowWood in 1998 and has since become a leader in the field. He has been a member of the CP/LPS since 1998 and has been a member of the BOCP since 2000. He has been a member of the CP/LPS since 1998 and has been a member of the BOCP since 2000.

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


## Course Catalog

**COURSE CATALOG**

### Continuing Education and More!

**Register online** or call toll-free 1.877.665.5443.



**On this Page:**

[CP/CO/CPD-Tier 1](#)

[CP/CO/CPD-Tier 2](#)

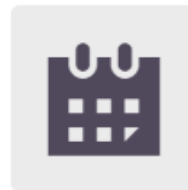
[Technician](#)

### CP/CO/CPD: Tier 1

**Alpha Liners: Get Back to the Basics**

**Webinar:** Duration: 1 hour Credits: 1 ABC / 1 BOC

This course provides an overview of the selection, fitting, and use of the Alpha Liner for prosthetists who are just entering the field or who have no experience with this type of product.



## Calendar of Events

### Calendar of Events

Active in our industry, we regularly attend regional and national trade shows and conduct education seminars through the United States. We are committed to educating clinicians about advances in the industry and about how our products benefit amputees. Join WillowWood at any of our education sessions or at upcoming events.

Don't see a webinar you're looking for? We offer several webinars by request. Review our webinar offerings and then, if interested, submit a request.

**List of Upcoming Events**

Filter Events: From  To

☒ Conferences ☒ Seminars

Date	Title	Type
Thu 2/13 1:00 pm	Webinar: Alpha Liners: Get Back to the Basics	Seminars
Mon 2/17 1:00 pm	Webinar: OMEGA: Foundation	Seminars
Tue 2/18 1:00 pm	Webinar: OMEGA: Transfemoral	Seminars
Wed 2/19 1:00 pm	Webinar: OMEGA: Transfemoral	Seminars
Thu 2/20 1:00 pm	Webinar: OMEGA: Cranial	Seminars
Fri 2/21 11:30 am	Webinar: OMEGA: Trial Liners Consultation	Seminars
Tue 2/25 1:00 pm	Webinar: A Fresh Look at Alpha Liners	Seminars
Tue 2/27 1:00 pm	Webinar: WillowWood Socket Designs	Seminars
Fri 4/17 1:00 pm	Webinar: Spring Ahead: Choosing a Foot for Your Patients	Seminars

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## CORE

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Our team of professionals is here to help you overcome both prosthetic and business challenges, find solutions, and improve the industry's quality of care for amputees.

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# AGENDA

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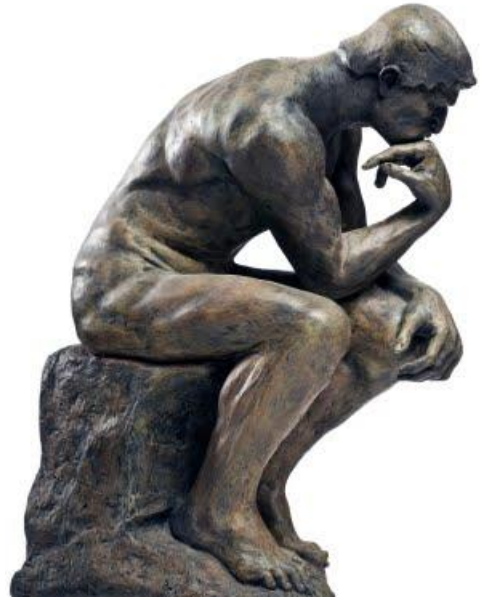
- Traditional Socket Designs
- Total Surface Bearing
- Adjustable Sockets
- Ischial Containment and Beyond
- Vacuum Suspension
  - Vacuum Research
- Shape Capture Methods



# SOCKET DESIGNS

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- Emerging and innovative designs and techniques continually emerging
- How does the clinician choose among competing philosophies
- Experience and compliance of amputees
- Residual limb anatomy
- Activities





# IMPORTANCE OF SOCKET FIT

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# SOCKET DESIGN

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- Must be comfortable and functional
- At least three key functions
  - Contain residual limb tissues
  - Transfer weight from the residual limb to the floor
  - Sitting comfort



# SOCKET DESIGN

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- Primary connection between residual limb and prosthesis
  - Thorough understanding of biomechanical variables involved
  - Must provide comfort and function
- Alignment: Spatial relationship between prosthetic socket and components such as prosthetic knee and foot
  - A/P positioning
  - Weight distribution
  - Energy efficient gait
- Sitting comfort

# SOCKET DESIGN

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- Human skin does not have intrinsic capacity to remain undamaged under prosthetic pressure
- Poorly fitted sockets result in mechanical trauma to skin, resulting in ulcers
- Pressure and weight induced stress
- New techniques and materials
  - Shape capture and rectification methods
  - Flexible liners
  - Interface materials
- Evolutionary or revolutionary

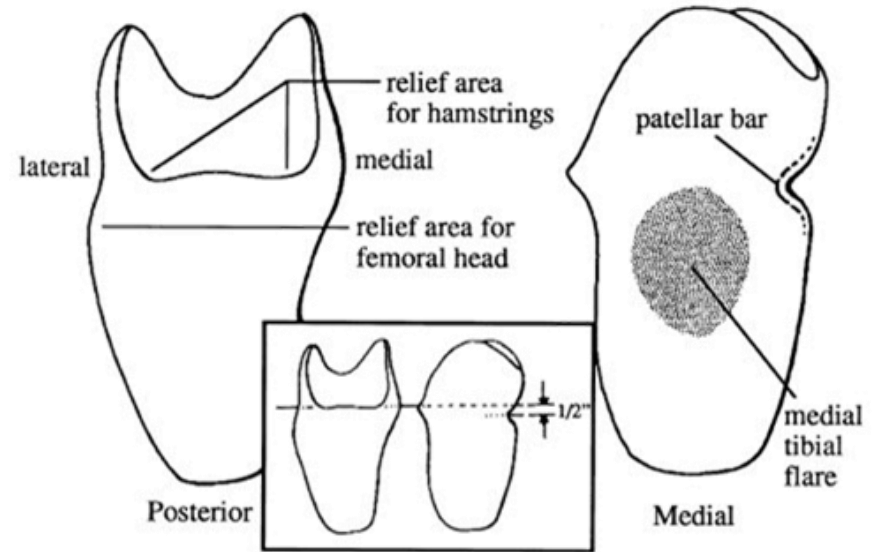


TRANSTIBIAL

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# PATELLA TENDON BEARING

- Utilizes the patella ligament as a major weight-bearing region
- Medial flare
- Medial and lateral walls extend proximal to adductor tubercle
- Rotation control
- M/L knee stability
- Reliefs and depressions
- Posterior wall design



## TOTAL SURFACE BEARING (TSB)

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- Weight is distributed over the entire surface of the residual limb, including areas which have in the past been considered pressure-sensitive

# TSB PRESSURE CAST

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- Pressure cast hydrostatic socket
- Conceptually solidifies the residual limb into one mass
  - Theoretically there is equal pressure throughout the socket
- Contours without the reliefs and depressions of a PTB design
- Cast is modified by reducing the positive model globally
- Interface liners flow from high pressure regions



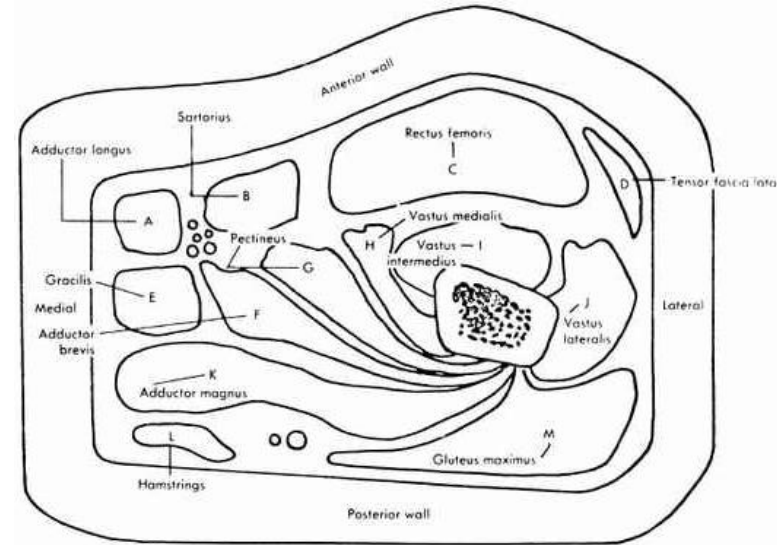


TRANSFEMORAL

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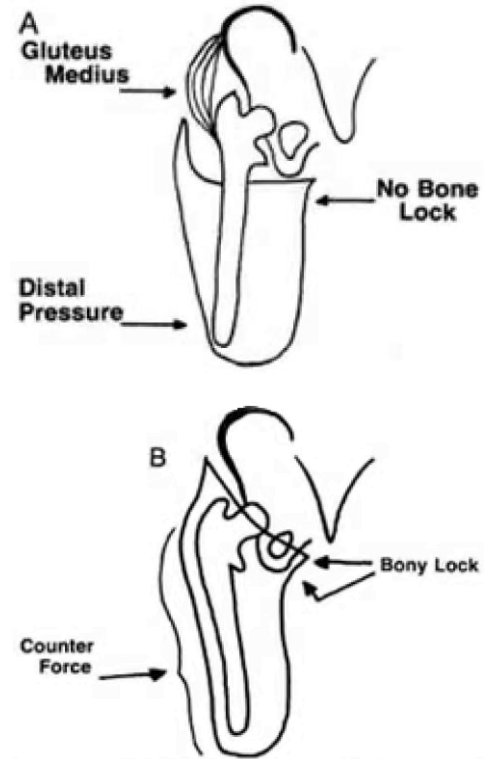
# QUADRILATERAL SOCKETS

- Weight-bearing achieved through combination of skeletal and muscular anatomy
  - Ischium and gluteal musculature rest on a wide seat on the proximal posterior wall
- Total contact
- Narrow A-P, wide M-L
- Specific reliefs for various muscle groups and tendons
- Longer limbs



# ISCHIAL CONTAINMENT

- “Bony lock”
  - Enclosure of IT and ramus
- Forces required for M-L stability borne by the bones of the pelvis
- Total contact
- Less emphasis on narrow A-P
- Shorter limbs
- Variations of design and technique



# ISNY SOCKETS

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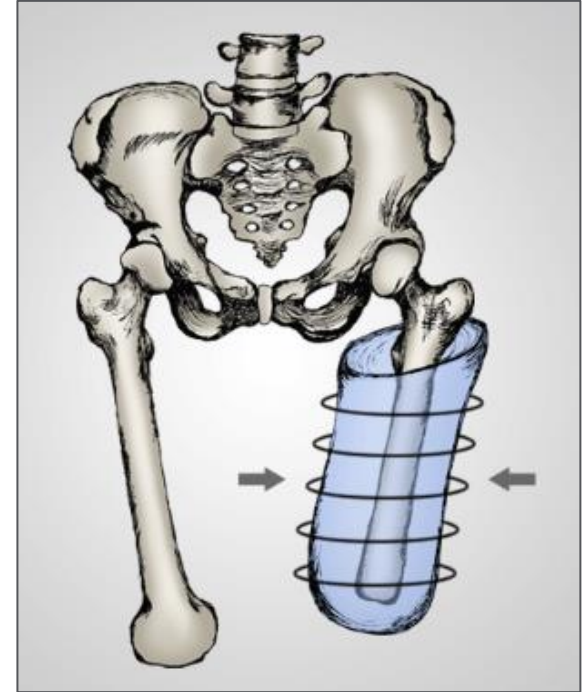
- Flexible thermoplastic sockets supported in a rigid or semirigid frame
  - Improved comfort and proprioception
  - Decreased weight
  - Minor volume changes accommodated
  - Temperature reduction (improved heat dissipation)
  - Enhanced suspension
  - Not linked to any one philosophy of TF socket design



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# SUB ISCHIAL SOCKETS

- Proximal trimlines do not impinge on the pelvis
- Utilizes interface liners
- Often utilized with vacuum to minimize movement and maximize femoral control
- Evenly distributes weight-bearing forces on entire surface of the residual limb





NU-FLEXSIV SOCKET

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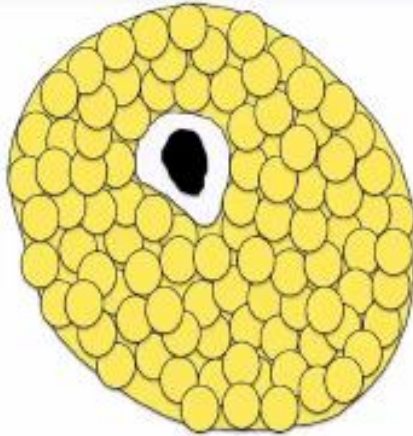
# NU-FLEXSIV SOCKET

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## Tissue Mechanics: Application of Vacuum



### Transfemoral Limb

- Many more cells with less bony structures to lock against.
- Tissue stiffening in this case will require a stiffer liner to compress the tissues prior to hydration.

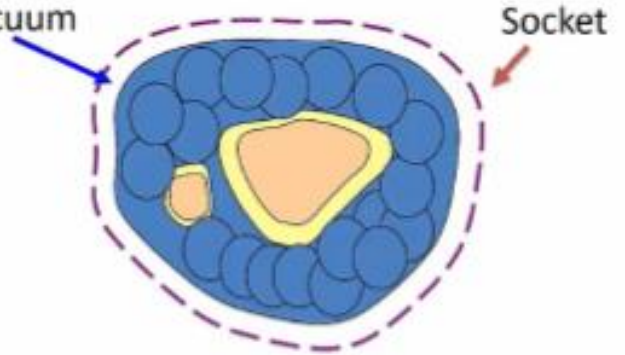
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NORTHWESTERN  
UNIVERSITY

## Tissue Mechanics: Application of Vacuum

Applied Vacuum  
creates a  
“locked”  
structure



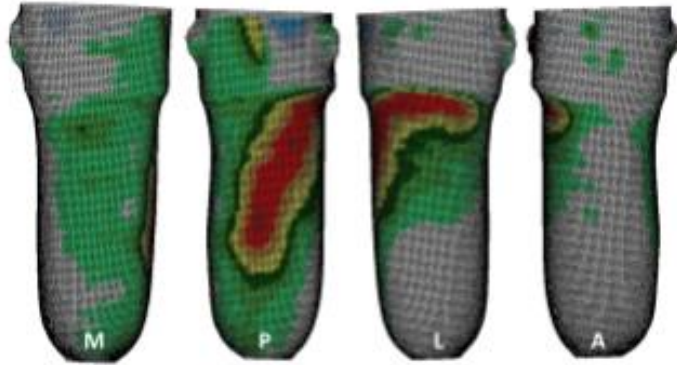
Source: Ohio WillowWood

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# NU-FLEXSIV SOCKET

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- Combination of compressive liners, flexible socket materials, vacuum suspension, and impression and rectification techniques
- Clinical algorithm for model rectification





# HIFI™ (HIGH-FIDELITY) INTERFACE

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# HIGH-FIDELITY INTERFACE

- Soft tissue that has not been optimally preloaded allows skeletal motion within the socket prior to the socket responding
- Utilizes longitudinal struts for compression of soft tissue nearly the entire length of the bone
- Increased compression on the intrinsic bone
  - Greater than what can be achieved by hydrostatic or other traditional socket designs



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# HIGH-FIDELITY INTERFACE

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- May improve walking ability, balance and confidence
- Eliminates need for high trimlines
- Use with flexible inner socket
- Uniquely designed windows between the struts help manage the gradual release of displaced soft tissue
- TF and TT configurations



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# ADJUSTABLE SOCKETS

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# ADJUSTABLE SOCKETS

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- Accommodate residual limb volume changes
- Allow patients to adjust
- Reduce follow ups and socket remakes
- Patients need understanding of appropriate socket fit and dexterity to manage fit
- Variations for different levels of lower and upper extremity amputation

# CLICK MEDICAL REVOFIT2™

- Adjustable multi panel socket design to provide targeted or global compression
- Micro and macro adjustments
- Adjustable through clothing
- Reduce sock requirements
- Bulbous distal ends
- Single or multiple panel designs
- TT and TF

Transfemoral



Transtibial



# REVOFIT2 PROCESS

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1. Standard check socket
2. Adjustable check socket to define design
3. Definitive socket



# MARTIN BIONICS

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- Open frame socket design
- Uses a combination of fixed and floating struts attached to a base and connected by adjustable straps
- Various TT and TF configurations
- Modular **Socket-less Socket**™
  - Breathable
  - Conforming
  - Micro-adjustable



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# MARTIN BIONICS

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- **TF SwingBrim™** conforms like a hammock
  - Provides a soft floating cushioned seat
- Sleeveless TT socket
- Suspension and rotation control enhanced by **SharkSkin Suspension™** interface on inner struts
- **TF Femoral Lock Pad**
- Lightweight

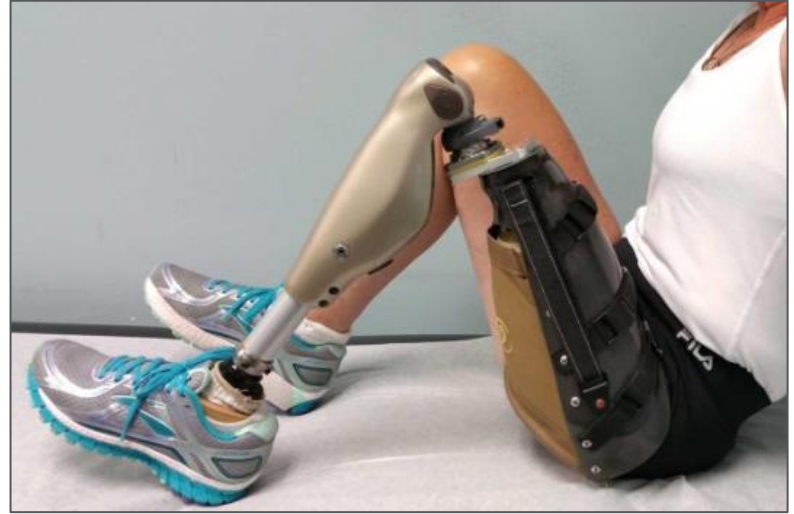


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# CJ SOCKET

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- Three main parts
  - Rigid J-shaped socket covers 50% of residual limb
  - Posterior aspect covered by custom-made, non-elastic *Sail* garment
  - User-adjustable closure
- Eliminates ischial extension stop
- Increases socket useful lifetime



# CJ SOCKET

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- Reduced weight
  - J-shaped socket covers approximately 50% of the residual limb
- Fluctuations in residual limb volume
- TT and TF designs
- TF may be fully donned while sitting
- Sitting comfort







# WILLOWWOOD ONE SYSTEM

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# WILLOWWOOD ONE SYSTEM

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- Vacuum or suction options
- Internal seal
- Seal durability
- Improved suspension
- Improved knee range of motion (TT)
- Lower socket trimlines (TF)
- Lubricants not required for donning



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# ONE TRANSTIBIAL SYSTEM

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Duo Liner with  
One Gel Sock



Flexible inner  
socket



One Sleeve



Laminated socket  
with One Link

# ONE TRANSFEMORAL SYSTEM

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Liner



One Gel  
Sock



One Seal



Removable  
Brim



Sealing Fins



Socket

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# SHAPE CAPTURE

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# SHAPE CAPTURE

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- Scanning



- Hand Casting

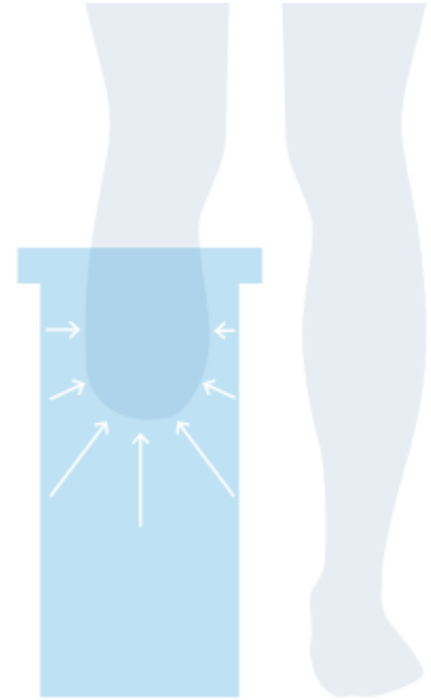
*Note specific training or equipment requirements for specific socket designs*

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# SYMPHONIE® AQUA SYSTEM

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- Full weight bearing hydrostatic plaster cast
- Calculated cylinder pressure
- Minimal modification
- TT and TF system options
- Digital impression



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# VACUUM CONSIDERATIONS

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# VACUUM CONSIDERATIONS

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- Limb maturity and stability
- Technology tolerance
- Tolerance to vacuum
- TSB socket design
- Patient dexterity and cognition



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### Elevated vacuum suspension preserves residual-limb skin health in people with lower-limb amputation: Randomized clinical trial

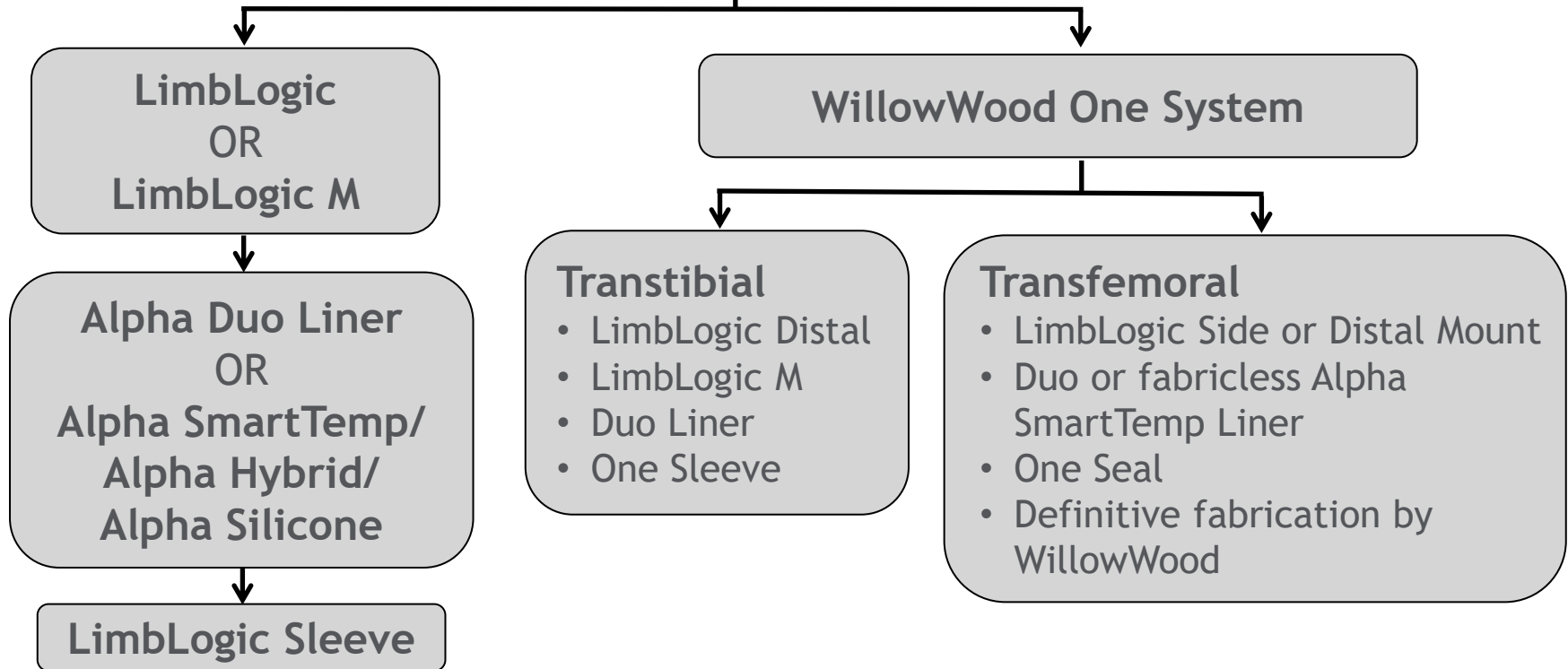
Cameron Rink, PhD;<sup>1</sup> Matthew M. Wernke, PhD;<sup>2</sup> Heather M. Powell, PhD;<sup>3</sup> Surya Gynawali, PhD;<sup>1</sup> Ryan M. Schroeder, BS;<sup>2</sup> Jayne Y. Kim, MS;<sup>3</sup> Jeffrey A. Denune, CP;<sup>2</sup> Gayle M. Gordillo, MD;<sup>1,4</sup> James M. Colvin, MS;<sup>2</sup> Chandan K. Sen, PhD<sup>1\*</sup>

<sup>1</sup>Department of Surgery, Comprehensive Wound Center, and Dorothy M. Davis Heart and Lung Research Institute, The Ohio State University Wexner Medical Center, Columbus, OH; <sup>2</sup>Ohio Willow Wood Company, Mt. Sterling, OH; <sup>3</sup>Department of Biomedical Engineering, The Ohio State University, Columbus, OH; <sup>4</sup>Department of Plastic Surgery, The Ohio State University Wexner Medical Center, Columbus, OH

**Abstract**—A growing number of clinical trials and case reports support qualitative claims that use of an elevated vacuum suspension (EVS) prosthesis improves residual-limb health on the basis of self-reported questionnaires, clinical outcomes scales, and wound closure studies. Here, we report first

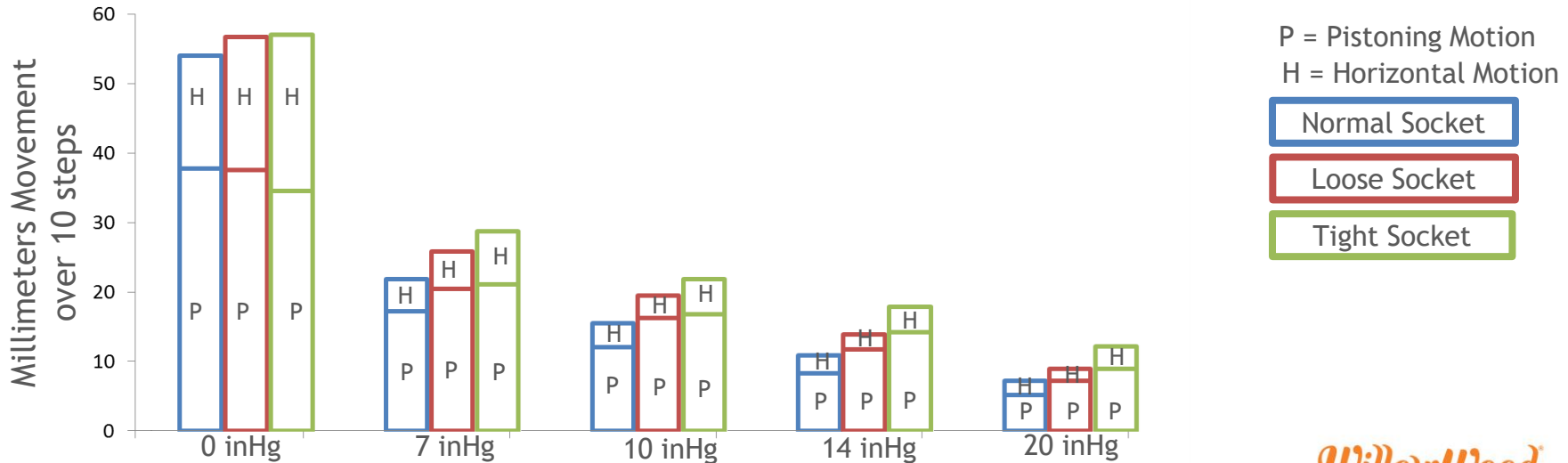
**Key words:** amputation, elevated socket suspension, perfusion, prosthesis, residual limb, socket, suspension, transfemoral, transtibial, vacuum.

## LimbLogic Options



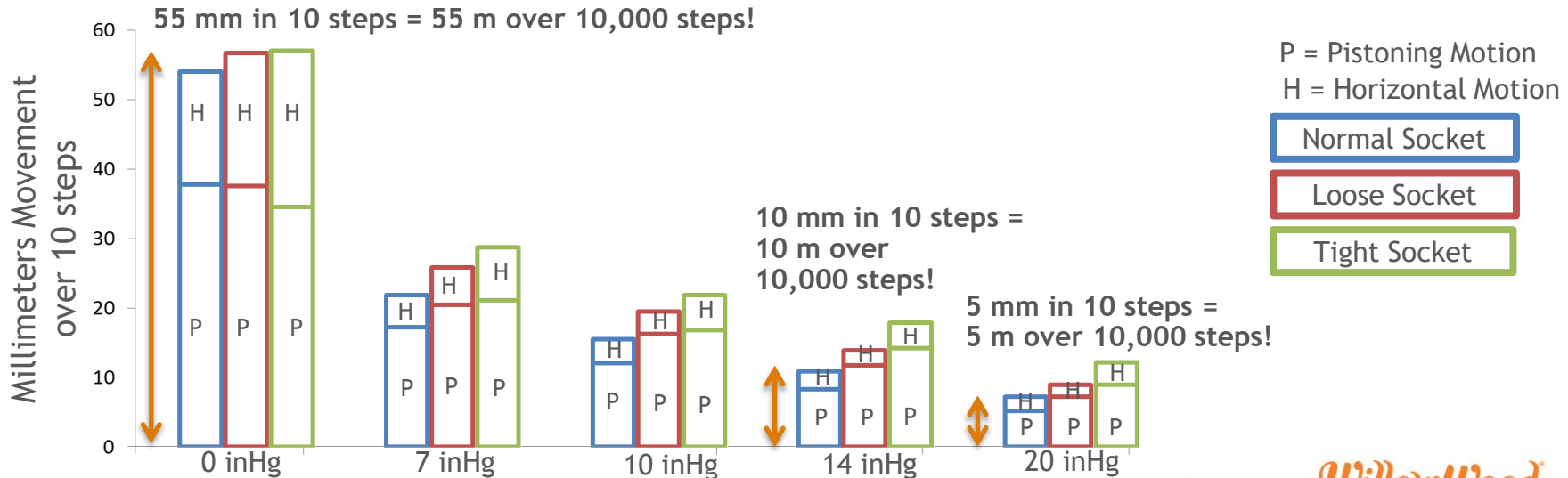
# GLOBAL FIT CHANGES: INDUCTIVE SENSOR RESULTS

- Pistoning motion accounted for 61% - 82% of the overall motion
- Horizontal motion accounted for 18% - 39% of the overall motion
- EVS significantly reduced both motions ( $p=3.8e^{-7}$  and  $p=2.9e^{-7}$  respectively)



# GLOBAL FIT CHANGES: INDUCTIVE SENSOR RESULTS

- Socket fit significantly impacted the amount of total motion ( $p=5.3e^{-7}$ )
  - Near significant for pistoning motion ( $p=0.06$ )
  - Significant for horizontal motion ( $p=0.01$ )





# INTERFACE MATERIALS

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# INTERFACE MATERIALS

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- Interface material and liner characteristics
- Suspension
- Skin and limb integrity
- Patient preference or allergies



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# SOCKET DESIGNS

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