The Quadruple Aim: Working Together, Achieving Success

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Military Performance Laboratory

Measuring Motion to Enhance Function
Factors Limiting Performance

- Injury Severity
- Socket Fit - Limb-Socket Dynamics
- Prosthetic Functionality
- Orthotic Function
- Walking Stability – Fall risk
- Training – Type, Timing, Dosage
- Energy Consumption
- Comorbidities
Limb-Socket Interface
Limb-Socket Interface

- Trans-tibial Amputations: Reliability of Kinetic and Videofluoroscopic assessment in Global War on Terrorism Veterans (Tucker, Wilken, Teyhen, Granville)
Limb-Socket Interface

**Limb-Socket Displacement**

- **Mean Displacement from 0-100% BW**
  - \(= 20.1\text{mm}\)
Limb-Socket Interface

The Effect of Vacuum Assisted Suction Suspension on Limb-Socket Dynamics, Physical Performance and Perception

(Wilken, Darter, Dingwell)
Limb-Socket Interface

18.4 mm
Prosthetic Functionality

- Initial Clinical Implementation of a New Microprocessor Controlled Powered Prosthetic Foot/Ankle System (Wilken)
Prosthetic Functionality

- Prosthetic feet are unable to fully replicate the function of the intact ankle
- Act as a spring returning stored energy
- Persistent gait deviations
  - Asymmetry
  - Decreased efficiency
  - Low back pain
  - Osteoarthritis
Prosthetic Functionality
Prosthetic Functionality
Ankle Angle

Symbol Significance Between
† Conventional and PF
* Conventional and Intact
^ BiOM and Intact
♦ Normal and Conventional

Ankle Range of Motion

p = 0.001
p = 0.013
p = 0.022
p = 0.001
Prosthetic Functionality

Ankle Power

Peak Ankle Power

Symbol Significance Between

† Conventional and PF
* Conventional and Intact
^ BiOM and Intact
♦ Normal and Conventional
♦ Normal and BiOM

Peak Ankle Power

p = 0.001

2011 MHS Conference
Orthotic Functionality

- The Effect of Ankle-Foot Orthosis Type on Agility, Power and Running Performance in Patients Undergoing Limb Salvage after Severe Lower Extremity Trauma
Available orthoses are unable to meet the demands of many injured service members

Provide inadequate support and energy return

Problem: Functional limitations
(Consider amputation to improve function)

Solution:
Intrepid Dynamic Exoskeletal Orthosis (IDEO)
Intrepid Dynamic Exoskeletal Orthosis

- Reinforced Carbon lamination
- Proximal supportive bi-valve or monolithic cuff
- Low profile supramalleolar foot section
- Modular Trulife Littig dynamic carbon strut

CFI Dynamic Strut AFO
Ossur Cheetah Sprint foot
Orthotic Functionality
Hypothesis: Use of the IDEO leads to improved performance on functional measures of speed, power and agility as compared to commercial off the shelf orthoses and no brace.
Orthotic Functionality

- Eighteen Patients
  - IDEO
  - Allard Blue Rocker (BR)
  - Posterior Leaf Spring (PLS)
  - No brace (NONE)
- One testing session
- Brace order randomized

www.allardint.com/products/bluerocker.html
www.flaorthopedics.com/srchproducts/contracturesplints/footdropsplint.htm
Running – Without AFO
Running – With IDEO
Forty Yard Dash

![Forty Yard Dash Chart]

- NONE: 13.4
- PLS: 12.8
- BR: 11.9
- IDEO: 8.5 *

Significance Levels:
- p = 0.002
- p < 0.01
- p = 0.02
- p < 0.01
Five Time Sit to Stand (5STS)

- Commonly performed to assess lower extremity strength, endurance, and mobility (Whitney, 2005)
- Tests ability to rise from a chair and sit back down five times in quick succession
- 3 trials
Five Time Sit to Stand

None: 8.5
PLS: 8.6
BR: 9.1
IDEO: 8.2*

p = 0.014

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Timed Stair Ascent
Timed Stair Ascent

Timed Stair Ascent

<table>
<thead>
<tr>
<th></th>
<th>NONE</th>
<th>PLS</th>
<th>BR</th>
<th>IDEO</th>
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<tbody>
<tr>
<td>Value</td>
<td>6.8</td>
<td>7.1</td>
<td>7.4</td>
<td>5.7</td>
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<td>p</td>
<td>&lt; 0.001</td>
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Four Square Step Test (FSST)

- A dynamic test of balance and mobility (Whitney, 2007)
- Test measures ability to move forward, backwards, and laterally over an approximately one inch obstacle
- One practice trial followed by 4 timed trials
Four Square Step Test
Four Square Step Test

- NONE: 7.0 (p < 0.001)
- PLS: 6.5 (p = 0.004)
- BR: 6.9 (p < 0.001)
- IDEO: 5.8*
1. How comfortable do you find the IDEO?

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2. How frequently do you develop skin problems (blisters, rash, abrasions, etc) in the IDEO?

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3. How difficult is it to put on or take off the IDEO?

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4. How difficult do you find it to keep the IDEO clean?

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<tr>
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5. How durable do you find the IDEO?

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Results

Orthosis Preference

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<th>Appearance</th>
<th>Overall</th>
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<td></td>
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<tr>
<td>PLS</td>
<td>3</td>
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<td>BR</td>
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Clinical Outcomes

- 13 patients were considering amputation
  - 8 selected to continue limb salvage
  - 2 undecided
  - 3 selected amputation
- Significant improvements in physical performance
- Continued room for improvement
Conclusion

- Recent advances in prosthetics and orthotics hold great promise for maximizing physical function for patients who have experienced severe extremity trauma.
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  - LTC Scott Shaffer, PT, PhD
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  - Benjamin Darter, PT, PhD
  - Jon Dingwell, PhD
  - LTC Joseph Hsu, MD
  - Ryan Blanck, CPO
  - Johnny Owens, PT
  - CPT Jeanne Patzkowski, MD

- Student Researchers
  - 1LT Jesse Ellwein, SPT
  - CPT Rachel May, SPT
  - 1LT Tyson Kovach, SPT
  - 1LT Danny Matta, SPT
  - 1LT Eric Tomalis, SPT

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  - Telemedicine and Advanced Technology Research Program

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