WATER RESISTANT BOOT FOR WALKING CAST

Team Members: Taylor Jaraczewski, Lucas Schimmelpfenning, Baljit Kler, Joe Benert

Department of Biomedical Engineering

Advisor: Tracy Puccinelli, Ph.D

Client: Donita Croft M.D.

Abstract

Illnesses such as spastic cerebral palsy can result in muscle contracture. Serial casting is commonly used to therapeutically treat this contracture. These casts are changed on a weekly basis, and constantly change dimensions. Further, if moisture comes in contact with the skin, tissue degeneration can occur, thus the casts must be protected from water. The design team has created a dynamic water resistant bag boot as a protective cover. Testing shows that the bag boot is completely water resistant and has no significant impact on gait.

Background

Cerebral Palsy

• An impairment of motor function and postural tone
Cause: non progressive brain lesions[1]

• Most common type is spastic
  • Characterized by increased muscle tone, termed contracture[2]

• Treatment: Serial Casting
  • Non-operative therapeutic treatment
  • Uses series of fiberglass casts to stretch soft tissue
  • Removed and reapplied weekly
  • Casting period ranges anywhere from 4 to 6 weeks[3,4]

Figure 1: An example of a patient with serial casts[4]

• Moisture inside of the cast can lead to tissue degeneration[5]

Current Practices

Figure 2: Waterproof socks are commonly used over casts[6]

Figure 3: A shower bag used to cover a serial cast[7]

• Both products are difficult to put on and take off
• Excessive sweating can occur due to low breathability
• Shower bag is not durable, thus, cannot be used outside

Design Requirements

• Create a serial cast cover that is:
  • Durable and water resistant
  • Easy to put on and take off
  • Adjustable in terms of size and shape
  • Light weight
  • Ergonomically friendly
  • Does not significantly impair gait

Bag Boot Design

Figure 4: Boot Skeleton used for support and traction

BASE

• Composed of the sole and back of a winter boot, which gives traction and support

• Cotton lining provides cushion and stability

Figure 5: Boot with the bi-layered Gore-Tex bag

BAG

• A bi-layered Gore-Tex bag is stitched into the boot skeletal structure

• No seams penetrate both the exterior and interior of the bag

• Gore-Tex allows the boot to conform to different shapes and sizes

Figure 6: The final Bag Boot with a serial cast secured within.

Features

• Straps ensure the boot will fit snugly around the cast and not hinder the patient's gait

• Nikwax™ water proofer was added for extra water resistance

Results

Water Resistance

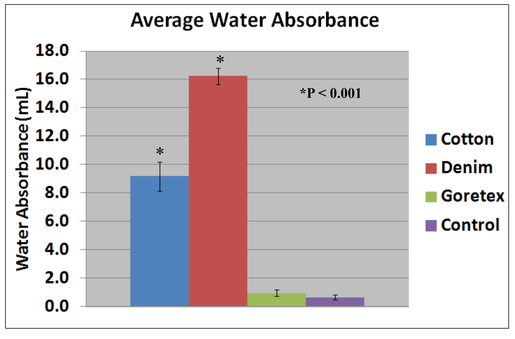

Figure 7: Average ± standard deviation of absorbance of three test materials (cotton, denim, and Gore-Tex) and plastic wrap control. *Cotton and denim absorbed statistically more water than the control, while Gore-Tex did not.

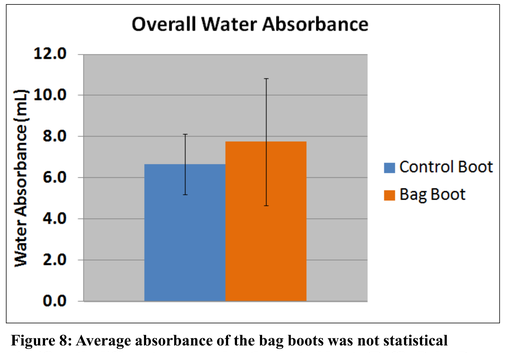

Figure 8: Average absorbance of the bag boots was not statistical significantly different compared to the control boots (Baffin Polar Proven Winter Boots), thus, proving to be water resistant. Error bars indicate standard deviation.

Gait Analysis

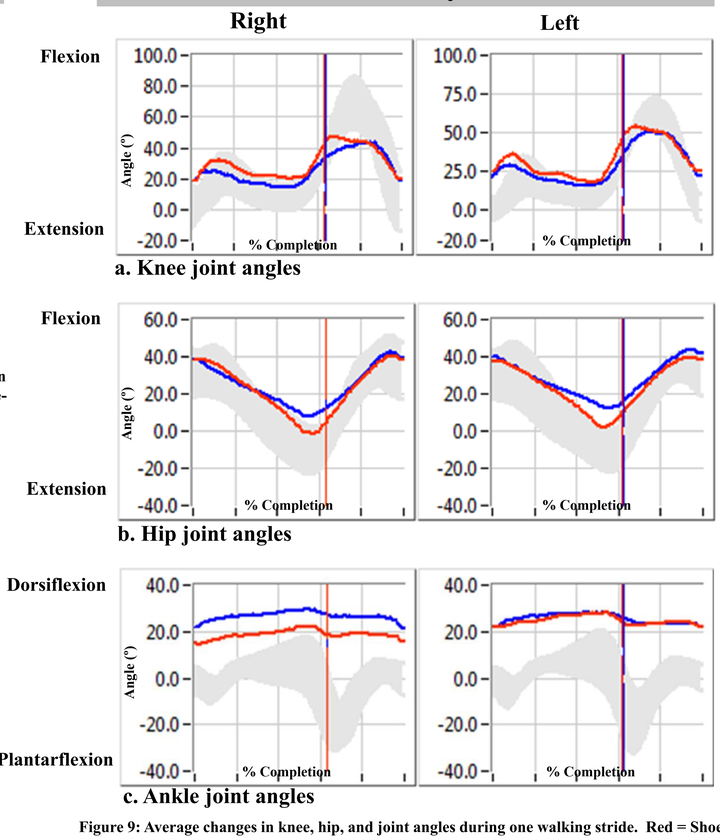

Figure 9: Average changes in knee, hip, and joint angles during one walking stride. Red = Shoe, Blue = Boot, Gray = Average unimpaired seven-year-old girl ± 2 standard deviations. There was no statistical difference between use of the shoe and bag boot.

Discussion

Water Resistance
• The bag boot has the same water resistance as the control boot: Baffin Polar Proven Winter Boots

Gait Analysis
• Gait analysis showed no significant hindrance to gait
• Spatial and temporal testing (not shown) showed some difference in velocity and stride length
  • Due to first time boot use
  • Reluctance to perform testing
• Total support times (%) were similar

Cost Analysis
• Easily produce for under $50.00
  • Boots …….. $30
  • Gore-Tex …… $10
  • Straps, buckles and Nikwax™……$10

• Costs will decrease when mass produced
• Large market with more than 1 million procedures annually
• Profitable when priced competitively in market

Figure 10: Patient using the Bag boot design during motion capture analysis

Future Work

• Optimize water resistance by making less seams

• More widespread testing of gait effects
  • More subjects
  • Explore dynamics of motion and ground reaction forces

• Research sizing constraints
  • What qualities would allow for longer use

• Enhance tightening mechanism with drawstring
  • In place of folding excess Gore-Tex
  • Drawstring network tightens entire Gore-Tex bag

• Improve aesthetics
  • Lower profile components: straps, excess bag, stitching
  • Various colors and designs

• Expand design to cover other casts
  • Non-walking casts
  • Arms – Gloves

• Pursue patent

Acknowledgements

Tracy Puccinelli, Ph.D
Donita Croft M.D.
Gracie Croft
Professor Darryl Thelen
Rachel Lenhart
Christa Wille
Franco Shoe Repair

References:
[1]Alvarez, N. (2008, January). Cerebral Palsy. In *MedicineNet.com*. Retrieved February 25, 2012, from http://www.medicinenet.com/cerebral_palsy/article.htm#tocb
[2] Stanley F, Blair E, Alberman E. Cerebal Palsies: Epidemiology and Causal Pathways. London, United Kingdom: MacKeith Press; 2000.
[3]Blackmore, A., Chan, M., & Anttila, H. (2009). Serial Casting of the Lower Extremity Clinical Care Guideline . In *Cincinnati Children's Hospital Medical Center*. Retrieved February 25, 2012, from www.cincinnatichildrens.org/workarea/linkit.aspx?
[4]Chang, S., & Chang, M. (2008). Serial Casting. In *Dynamic Orthopedics*. Retrieved February 25, 2012, from http://dynamicorthopedics.com/serialcasting.html
[5]Marino, C. (2006, June). Skin Physiology, Irritants, Dry Skin and Moisturizers. In *Washington State Department of Labor & Industries*. Retrieved April 30, 2012, from http://www.lni.wa.gov/Safety/research/dermatitis/files/skin_phys.pdf
[6]Clark, W. (2010). SealSkinz Waterproof Long Socks. In *Clark Forest*. Retrieved May 2, 2012, from http://www.clarkforest.com/shop/safety-clothing/socks/sealskinz-waterproof-long-socks
[7] Roberts, B. (2012). In *Briggs Healthcare*. Retrieved May 2, 2012, from https://shop.mabisdmi.com/