DYNAMIC SLING TO SUPPORT SHOULDER AFTER INJURY TO RETURN TO AN ACTIVE LIFESTYLE

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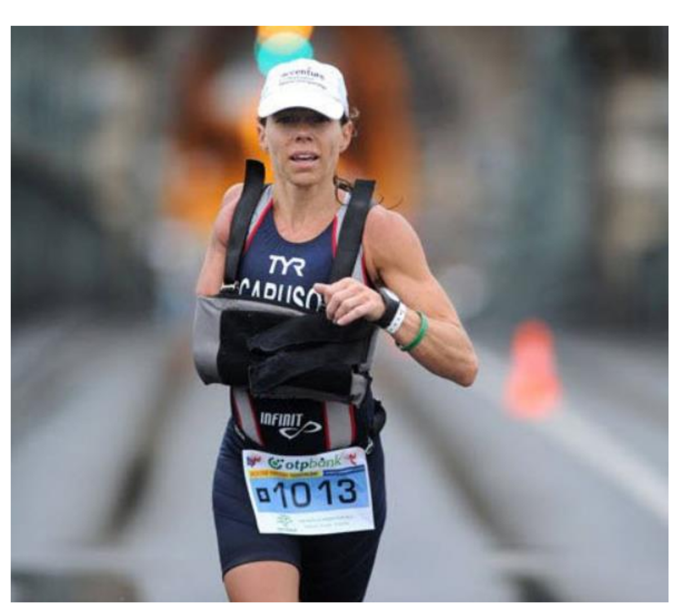
1. Abstract

Karen Blaschke, an occupational therapist with UW Hospitals and Clinics, works with patients suffering from brachial plexus injury and has requested a sling that will allow these patients to return to an active running lifestyle. Our aim was to create a sling that would properly support the should and arm, and adapt to patients with different types of shoulder injuries and stages of rehabilitation. A one-piece vest design was manufactured using neoprene and a nylon-polyester blend. To determine the efficacy of the sling, quantitative and qualitative data was collected. The neoprene did not deform or fail during mechanical testing, which aimed to mimicked the loads placed on the material during normal use. Also, ten individuals ran while wearing the sling and rated it high for its comfort, support, and overall impression.

2. Background/Motivation

The original intent of the sling was to assist individuals suffering from brachial plexus injury. The brachial plexus is a neural network that provides motor control and sensory perception to the upper extremity. Injury to this nerve cluster can result in varying degrees of disability throughout shoulder, upper arm and forearm[1]. These symptoms are experienced by patients who suffer from other types of shoulder injuries, and most rehabilitation processes begin by requiring complete support and immobilization of the arm and shoulder area to prevent pain and further injury. Once this phase is completed, there is a need for a dynamic rehabilitation program to stimulate new growth of atrophied muscles[2].

Figure 1. Distance runner using current static sling device. This is an example of the current slings on the market that immobilize the shoulder and arm[3].



3. Design Specifications

The dynamic sling for rehabilitation must meet the following requirements:

- Stabilize the shoulder
- Mimics proper arm movement, as well as elbow angle and orientation
- Must be visually appealing, breathable, washable
- Must not cause abrasions, chaffing, or restrict blood flow
- Last the entirety of the patient's therapy
- Adjustable to accommodate different body types
- Easy to assemble

4. Final Design

Figure 2. Front view of the sling including vest component, shoulder strap, arm sleeve, bands, belt loop holes, front zipper, forward facing adjustable arm straps, attachment point, and elastic band at bottom of torso portion. Tension distributed along neoprene (black) while athletic material (grey) is cooler and more comfortable.

Figure 3. Side view of the sling includes shoulder strap, arm sleeve, bands, attachment points, belt loop holes, and forward facing adjustable arm bands.

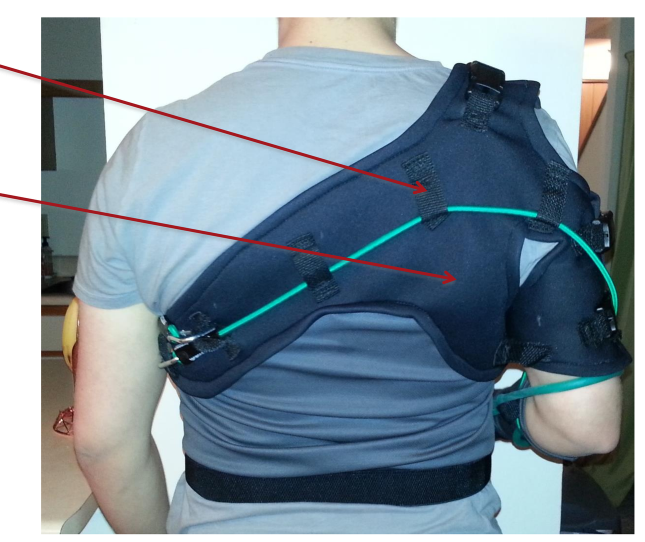


Figure 4. Back view of the sling including vest components, bands, belt loop holes, and elastic band at bottom of torso.

5. Testing

Mechanical Testing

- Dynamic force analysis yielded a realistic force of 50N that would be experienced using the sling.
- SolidWorks modeling confirmed that the sling would survive both a 50N and 100N load.
- To validate our SolidWorks model, and to explore the maximum stress of the sling's load-bearing material, we mechanically loaded a sample of neoprene.
  - Following ASTM protocol D2240, we fashioned a sample of neoprene with the following dimensions:
    - 4 mm thickness, 19.69 mm width
  - Sample was placed within an MTS tensile loader, and displaced 5 mm stepwise while recording force induction.
  - Sample was displaced until failure was achieved.
  - Stress vs. strain of the neoprene material was plotted and a factor of safety was confirmed.

Human Subject Qualitative Testing

- 10 subjects wore the sling for a one mile run in the Camp Randall Sport Center Complex
  - Five subjects tested the small sling
  - Five subjects tested the large sling
- After completion of the run each subject was asked to complete a survey inquiring about the sling. Information collected included:
  - Comfort of sling both during static and dynamic motion
  - Support of the arm and shoulder during static and dynamic motion
  - Ease of application
  - Whether the subject had any prior shoulder injuries
  - Suggestions to improve the sling
  - If the subject would wear it for longer periods of time
  - When (if ever) the subject felt uncomfortable in the sling.

6. Results

Mechanical Testing

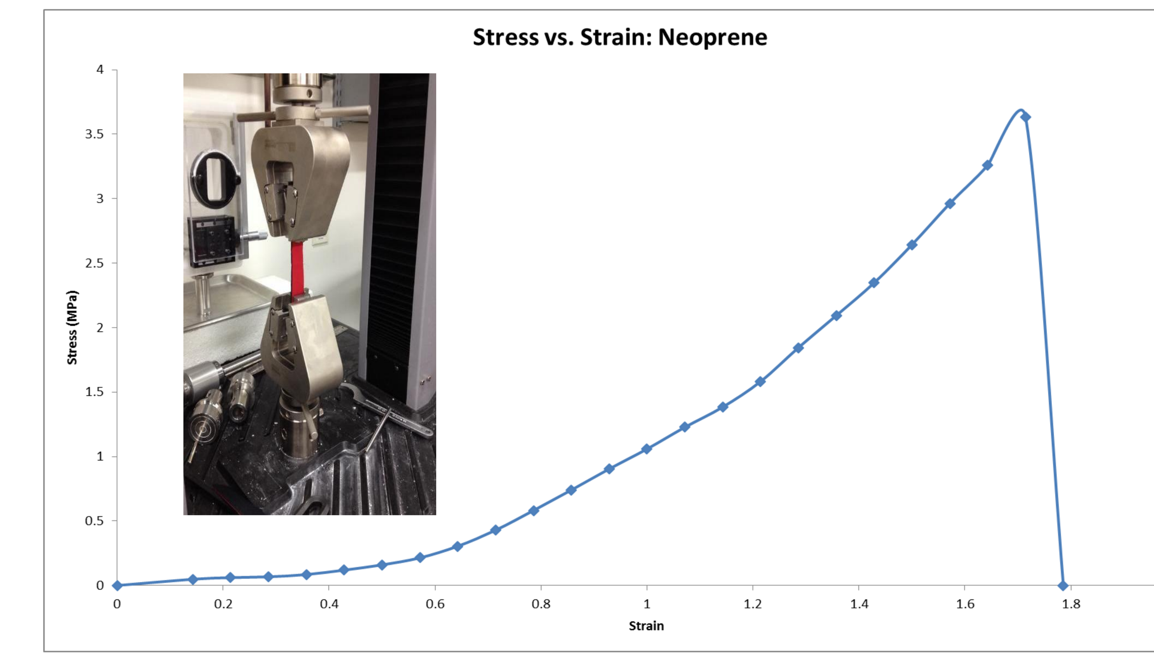


Figure 5. Mechanical tensile testing of a sample of neoprene. Included picture of testing set-up

- The structural integrity of the neoprene was maintained until an applied load of 286 N
- In conclusion, the material will not fail under expected loads

Human Subject Qualitative Testing

- **90%** of subjects found the sling to be comfortable to very comfortable at rest and while running
- **100%** of subjects felt almost complete support to complete support of the arm at rest and while running
- **70%** of subjects felt almost complete support to complete support of the shoulder at rest
- **90%** of subjects felt almost complete support to complete support of the shoulder while running
- **90%** of subjects said they would wear the sling again and for longer runs

8. Future Works

- Test on subjects suffering from Brachial Plexus Injury and other shoulder injuries
- Submit an Inventors Disclosure Report to WARF

9. Acknowledgements

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10. References

[1] Functional Anatomy Blog. 2010. *Anatomy Review: The Brachial Plexus.* http://functionalanatomyblog.com/2010/03/16/anatomy-review-the-brachial-plexus/. Accessed March 5, 2013
[2] Hassan, S and Kay, S. 2003. *Brachial Plexus Injury.* Surgery (Oxford), 21 (10):262-264.
[3] Delly Carr Sports Photography. www.sportsphotography.com/au