UW Adapted Fitness Grip Mechanism

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Abstract

- Traumatic brain injury (TBI) survivors often experience impaired control and precision in their grip motion.
- Tasked with device that assists with hand extension while improving grip strength over time.
- Fabricated half-glove with tendon-like bungee cords that pull fingers into extension position.
- Backplate of glove contains multiple hooks for various levels of extension.

Motivation

- Many TBI survivors experience reduced control of finger extension, making everyday tasks difficult and slowing rehabilitation progress.
- Affordable, non-electronic solutions for assisted hand extension are limited compared to existing grip-flexion devices.
- Restoring extension requires supplementing weakened tendon and forearm muscle function in a safe, consistent way.
- A customizable half-glove with bungee-based “tendons” offers a practical way to support extension training and improve functional hand use over time.

Problem Statement

- The client has impaired hand function and needs a device that improves their ability to open and close the hand with greater strength, control, and independence.
- Current grip-training tools are inadequate because they lack assistance, adjustability, safety features, and progress-tracking for users with limited mobility.
- The device should be comfortable, lightweight, easy to don and remove, durable for gym environments, and capable of accurately measuring and storing grip-strength data over time.
- The overall goal is to create a safe, adaptable, and user-friendly hand-assist device that supports rehabilitation and enhances functional hand performance in daily activities.

Background Research

- Tendons down each finger of the hand connect hand bones to extensor digitorum muscles to allow for extension of the hand.
- Muscles that are extrinsic on the forearm are what control most of the grip strength in the human hand.
- Active Hands grip assist is glove design currently used at the UW adaptive fitness center to help with grip flexion of patients.
- Many other competing robotic glove designs that use electronics to power the extension of the hand from a fist.
- Material such as bungee and fishing line can provide adequate tension to extend.

Design Specifications

- All materials must biocompatible, comfortable, and easily sanitized
- Bungee cords must support the complete weight of an individual finger
  - The average weight of an adult male finger is 18-22 grams [1]
- Hand must extend from balled fist (180°) to a flat hand (0°) [2]
- Hand muscle extension must be strengthened over time
  - Glove must be quick and easy to put on and take off
  - After 12 weeks of use, should see improvement of 8°-10° [2]

Final Design

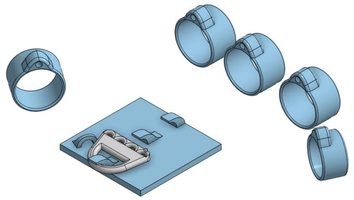

Fig. 4: Full Assembly of all 3D-printed parts

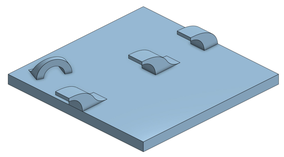

Fig. 1: Onshape rendering of under-glove backplate

Fig. 2: Onshape rendering of large ring and small rings

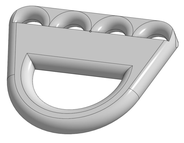

Fig. 3: Onshape rendering of hook connector

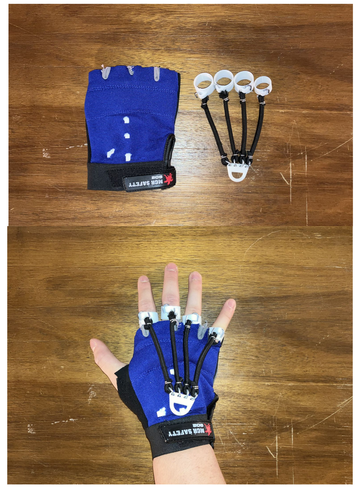

Fig. 5: Final Prototype

Materials and Cost

Materials	Cost
Glove	$19.99
S-Hooks	$4.39
Rubber Bands	$5.79
Heat Shrink Tubing	$15.00
3D Rings	$7.00
3D Backing Connector	$2.00
Washers	$1.00
Bungees	$10.00
Fishing Line	$14.00

Estimated Cost: $70.00

Actual Cost: $79.17

Testing

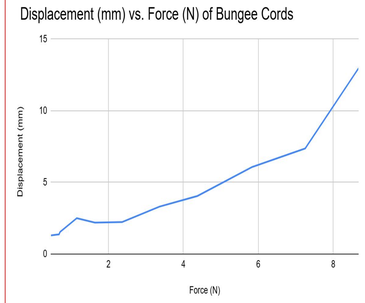

Fig. 6 Graph of Displacement due to Force

- We determined the K value of our bungee cords to be 0.75 N/m by using Hooke’s Law (F=kx) and Newton's Second Law of Motion (F=ma) Where a is the acceleration due to Earth’s gravity, or 9.81 m/s^2.
- We tested the design on several different hand sizes. This design was fitted specify to our client, but it works for similar hand sizes as well. The design did not provide enough force to hold the hand open. We need to provide a stronger force, possibly by moving the hooks further up the arm
- Our client was able to put on the device with assistance opening their hand. The glove was not difficult to put on or take off, the client had no complaints about comfort.

Future Work

- Shortening and tightening the bungee cords for increased force and tension in the fingers.
- Creating a split that includes the wrist and possibly extends to further up the arm.
- Redesign of the hooking mechanism for a possible knob adjustment system to increase the tension by attaching the cords to one central turning knob.
- A new design that encompasses the thumb and allows for tension along the joints of the thumb.

Acknowledgements

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- Dr. Randy Bartels
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- UW Adapted Fitness

References

McFadden, Dennis. “Http://Www.Sciencedirect.Com.Ezproxy.Library.Wisc....” *Relative Weight of Fingers and Toes in Human Males and Females*, 2002, www.sciencedirect.com.ezproxy.library.wisc.edu/science/article/. [1]

Terzis, Julia. “Radial Nerve Injuries and Outcomes: Our Experience : Plastic and Reconstructive Surgery.” *Plastic and Reconstructive Surgery* , 2011, journals.lww.com/plasreconsurg/abstract/2011/02000/radial_nerve_injuries_and_outcomes__our_experience.30.aspx. [2]