

CLIMBER'S FOREARM TRAINER



Team Members: Brittany Glaeser, Kaitlin Lacy, Marissa Harkness, Zoe Schmanski, Jonathon Murphy
 Client: Dr. Chris Vandivort
 Advisor: Dr. John Puccinelli



College of Engineering
 UNIVERSITY OF WISCONSIN-MADISON

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Abstract

"Climber's Elbow" is a condition experienced by many climbers where the tendon between the forearm flexors and medial epicondyle of the elbow develops microtears. The Forearm Trainer was designed to aid in prevention and rehabilitation of Climber's Elbow. The device includes variable resistances and a grip strengthener handle. The portable device strengthens the flexors and extensors as well as pronators and supinators of the forearm.

Motivation

Climber's Elbow, also known as Medial Epicondylitis, affects many rock climbers and can be treated through resistance training of the forearm flexors and extensors. A portable device can help aid in the prevention and rehabilitation of this condition.

Background

- 4 major forearm muscles [1]
- Pronator teres is the muscle of focus
- Movements:
 - Pronation of hand
 - Flexing of the elbow
- Medial Epicondylitis / "Climber's Elbow"
 - Micro-tearing of the pronator teres [2]
 - overuse of the tendon without sufficient recovery
 - Imbalance in strength of flexor muscles versus the extensor muscles = excessive strain [3]

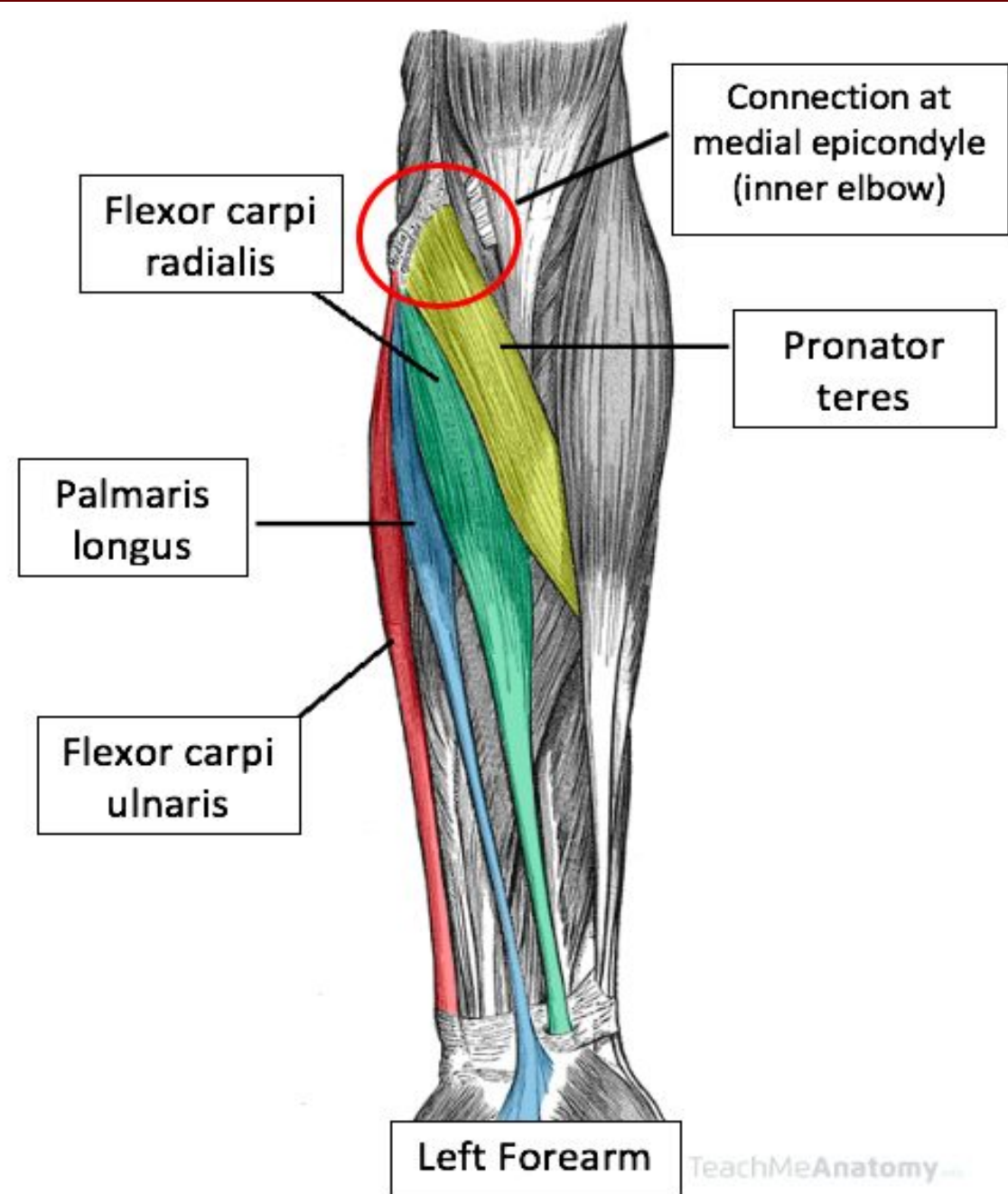


Figure 1: The 4 main muscle groups attached at the medial epicondyle [4]

Current Devices



Figure 2: Hangboard [5]

Figure 3: Vive Health Finger Exerciser [7]

Figure 4: Handmaster Plus [6]

Design Criteria

- Effectively targets forearm muscles
- Variable resistances of 5-30 lbs
 - Average forearm length of 23.1 - 26.4 cm
 - Average upper arm length of 29.2 - 33.4 cm [8]
- Durable to withstand daily use for many years
 - Five to ten years for plastic pieces and straps
- Includes grip strengthening component
- Follows ASTM Standards of Fitness [9]
- Easy to use, safe, comfortable, portable and low cost

Materials

- 3D print - PLA
- Rollerblade straps
- Sponge foam padding
- Flex seal
- Resistance bands
- Carabiners
- 1" Nylon straps
- Hook eye screws
- 0.25" Eyelets
- Brass knurled inserts

Total Costs: \$120.93

Testing and Results

FEA of Base Design

- Base design will withstand the stress of the bands
- Maximum deflection of 2.86 mm

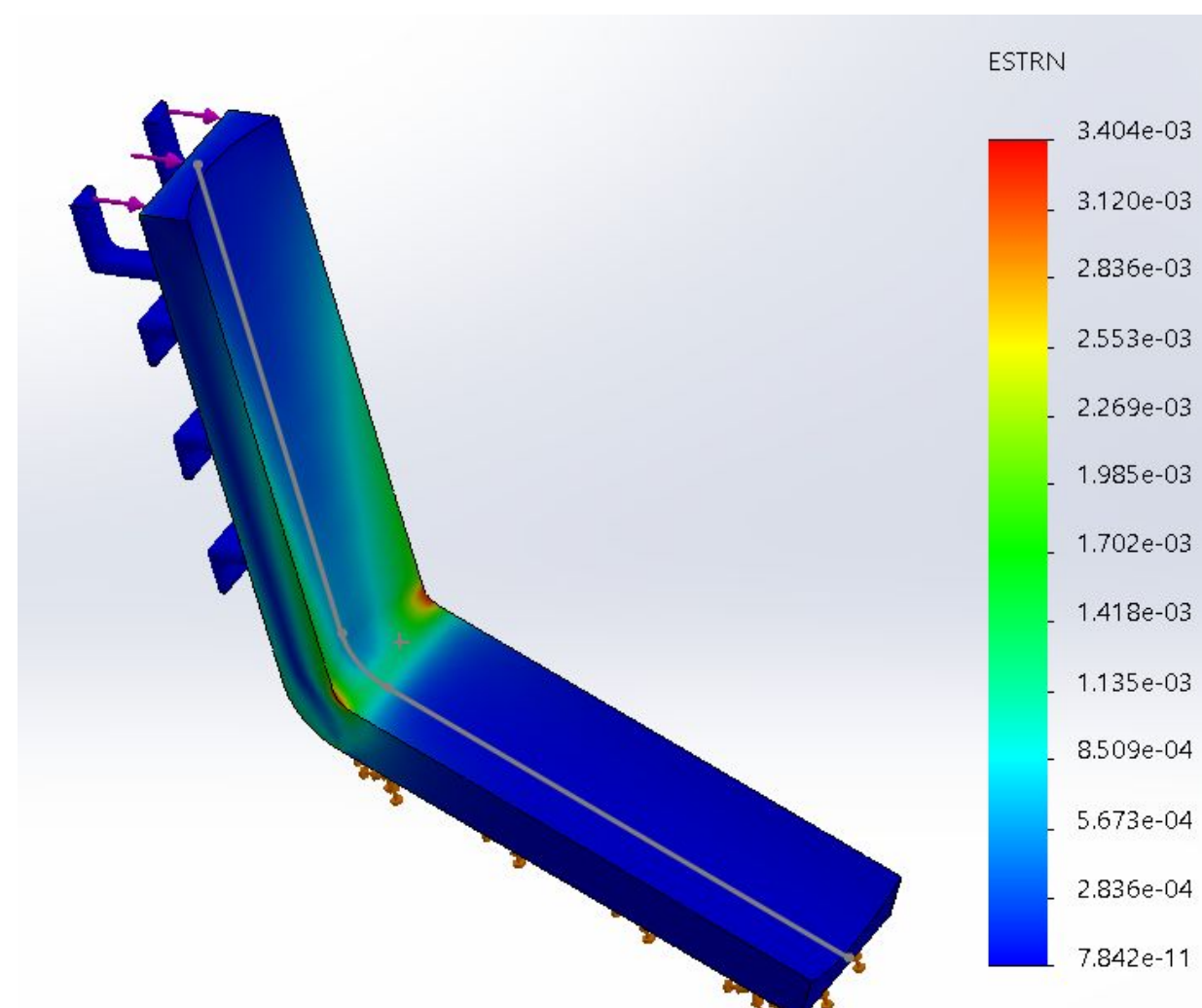


Figure 5: Strain representation of base design under resistance band load

FEA of Handle Design

- Handle design will withstand the stress of the bands
- Maximum deflection of 3.57×10^{-4} mm.

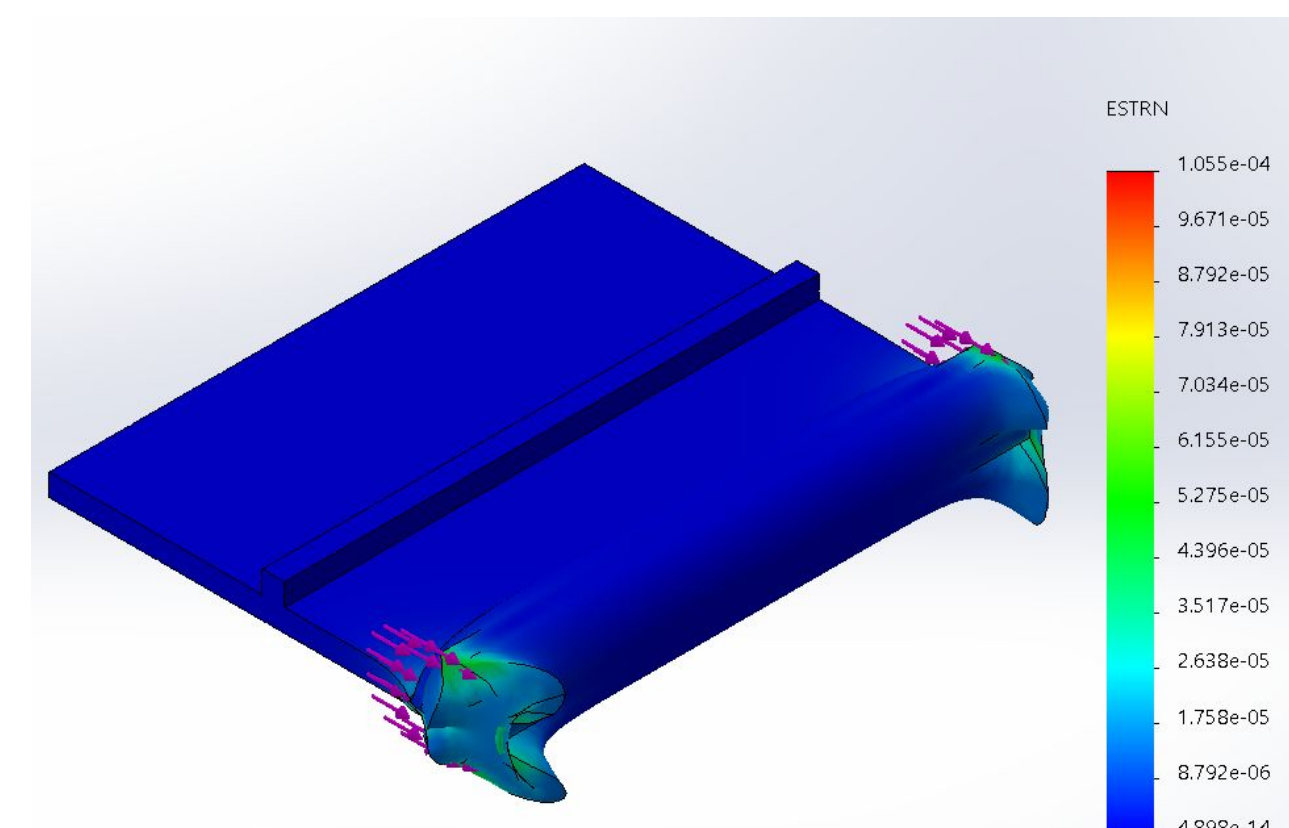


Figure 6: Strain representation of handle design under resistance band load

Conclusion

- Full design has the ability to withstand the force exerted by the bands.

Final Design



Figure 7: Original design with updated resistance bands

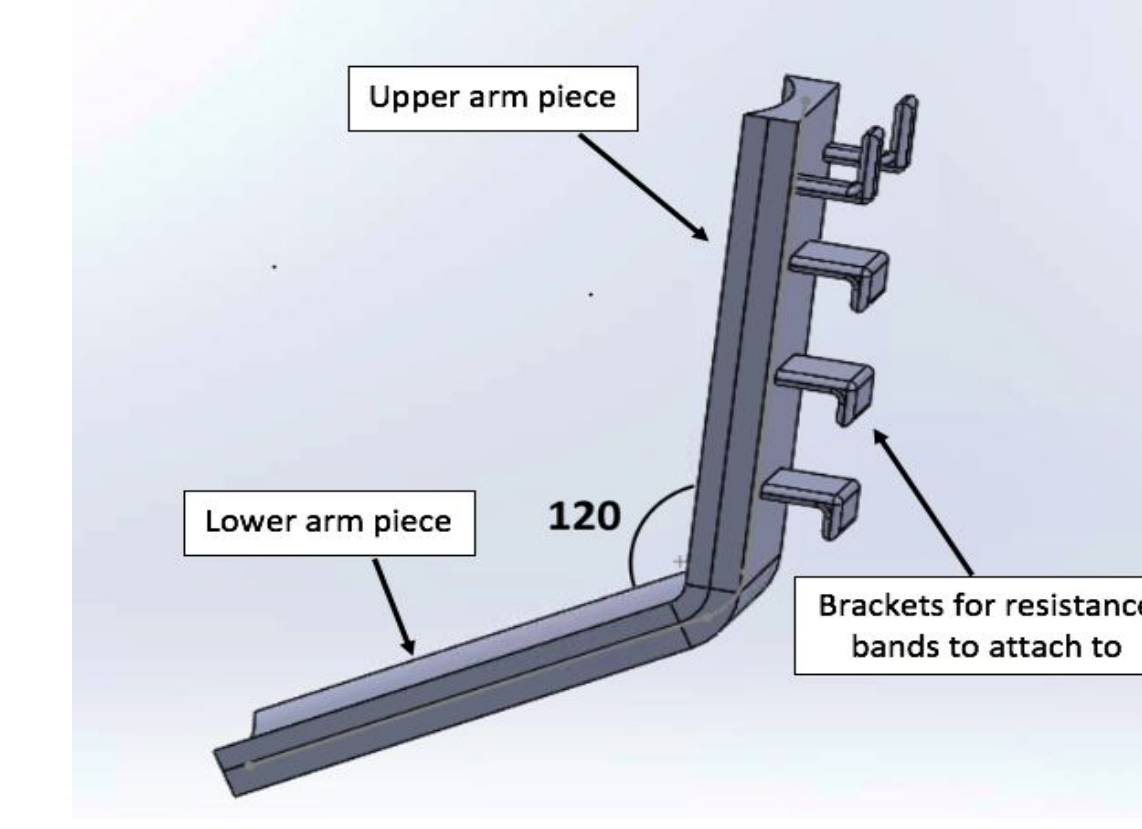


Figure 8: Proposed design of back piece

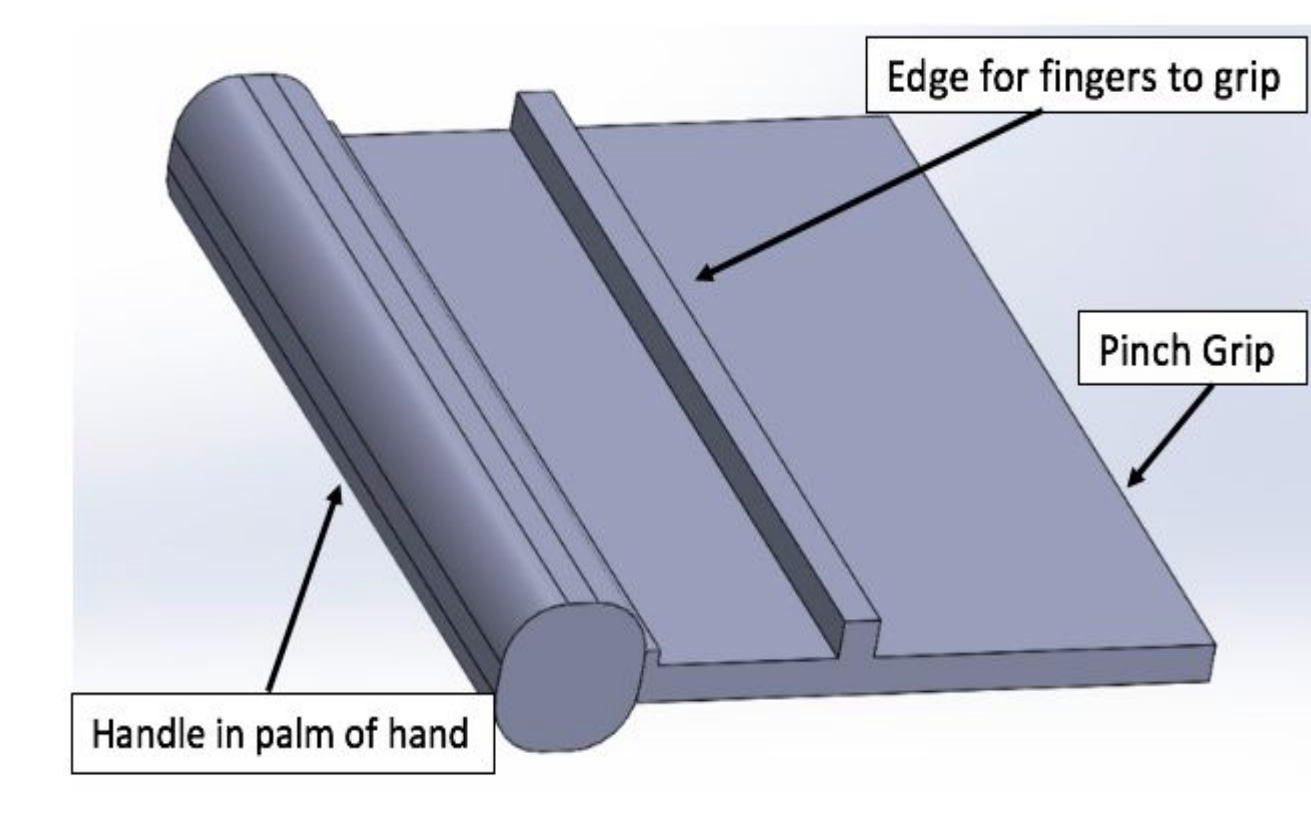


Figure 9: Proposed handle design for grip strengthening

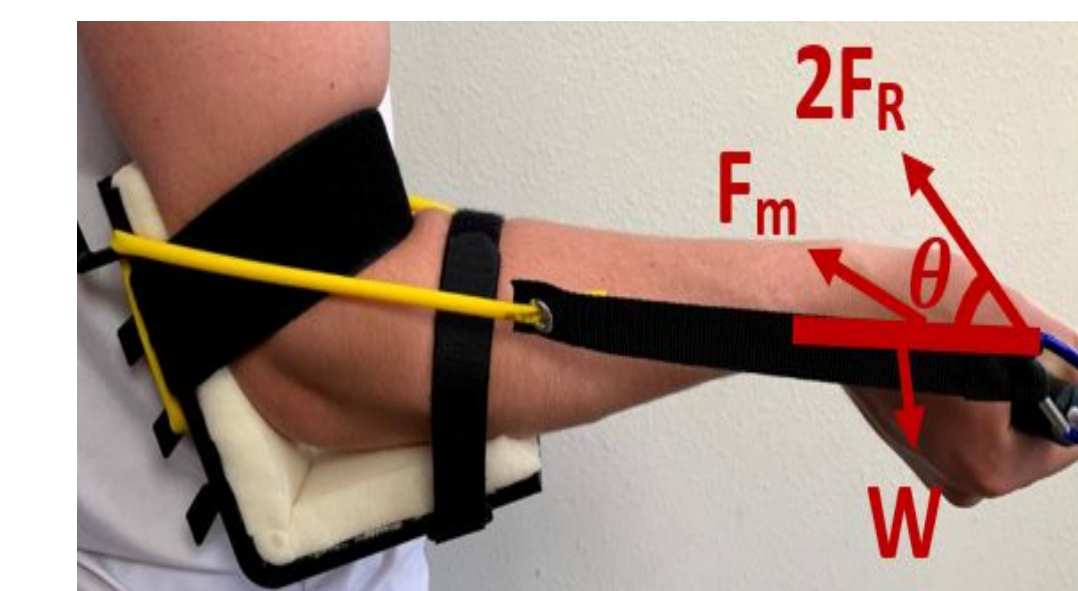


Figure 10: FBD for the extensors and flexors

$$F_m = \frac{L \cdot 2F_R \sin \theta - W \cdot d_w}{MA}$$

$$F_m = \frac{2F_R \sin \theta}{MA}$$

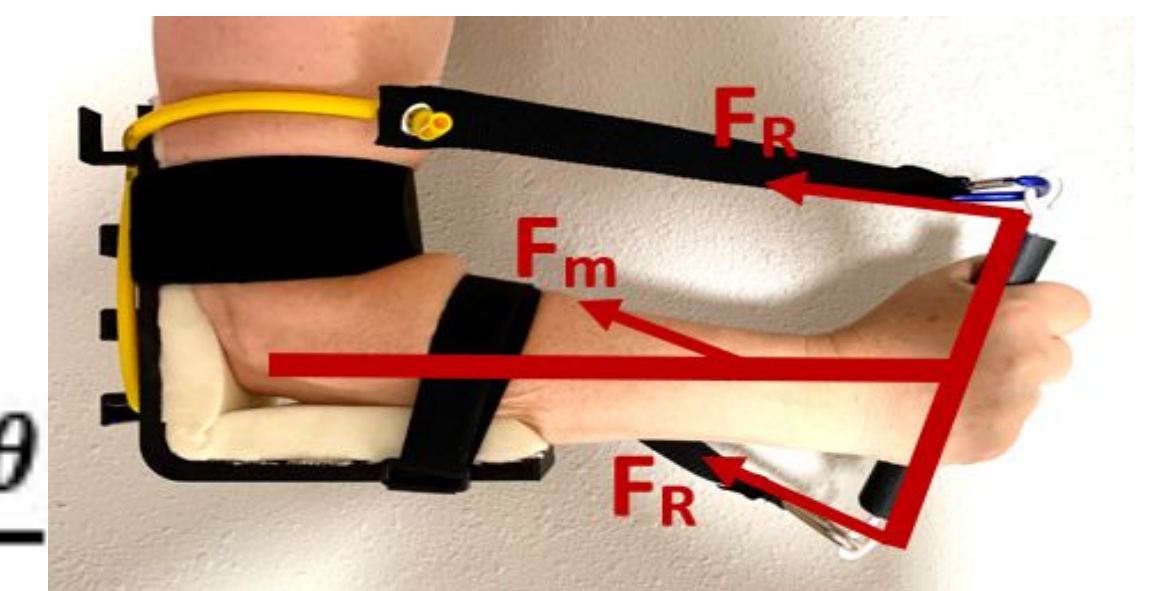


Figure 11: FBD for the pronator teres



Figure 12: Forearm motions used with the device. Shown is the original design with updated resistance bands.

Future Work

- Tightening mechanism for straps
 - A tension lock similar to those on backpack
- Injection Molding
 - Considered as a mode of fabrication for final prototype after CAD designs are finalized
 - Protolabs Manufacturing
- Removable pinch grip feature
- Testing
 - EMG to confirm isolation of forearm muscles from bicep
 - MTS testing of resistance tubes
 - Usability survey

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