CLIMBER'S FOREARM TRAINER

College of Engineering
UNIVERSITY OF WISCONSIN–MADISON

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

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Abstract

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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:
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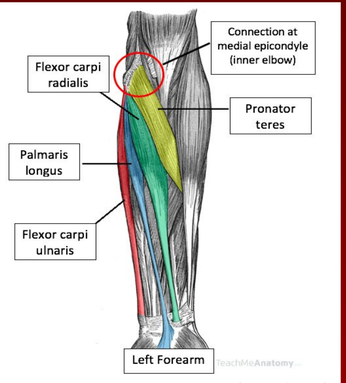

Figure 1: The 4 main muscle groups attached at the medial epicondyle. [4]

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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
- Adaptable to different sized forearms and hands
  - Average forearm length of 23.1 - 26.4 cm
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- Durable to withstand daily use for many years
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- Easy to use, safe, comfortable, portable and low cost

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- 3D print - PLA
- Rollerblade straps
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- Resistance bands
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- 1" Nylon straps
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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

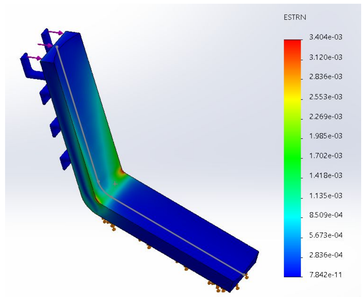

Figure 5: Strain representation of base design under resistance band load

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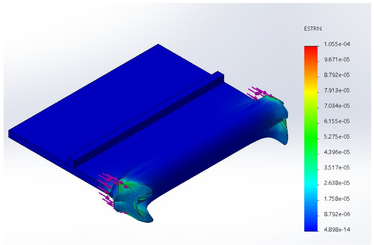

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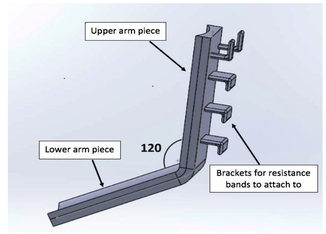

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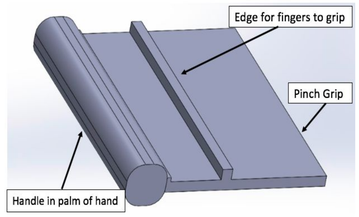

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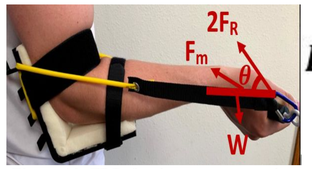

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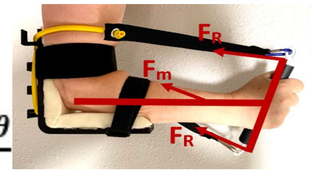

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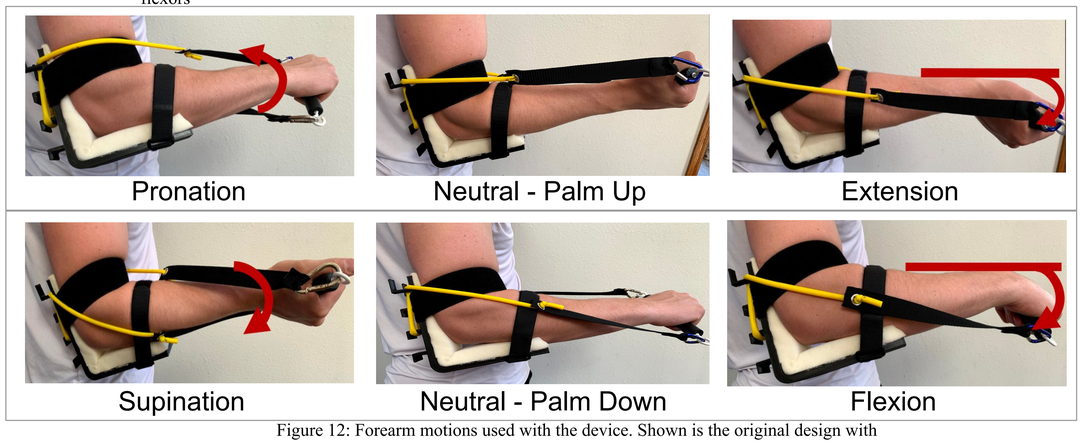

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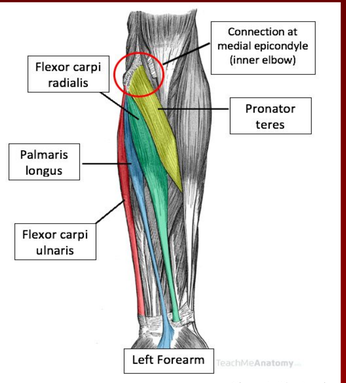

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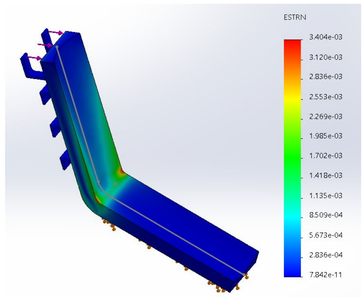

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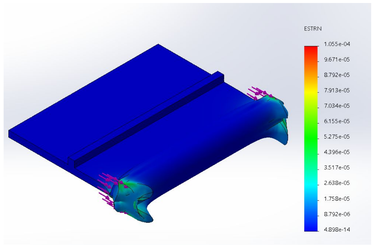

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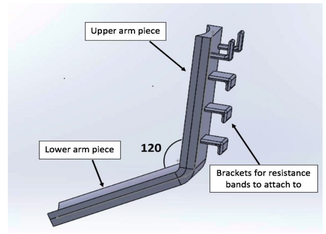

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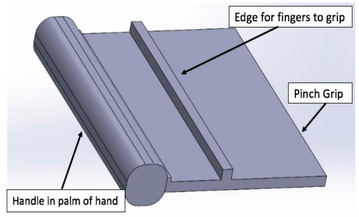

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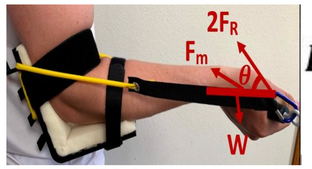

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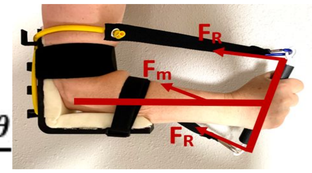

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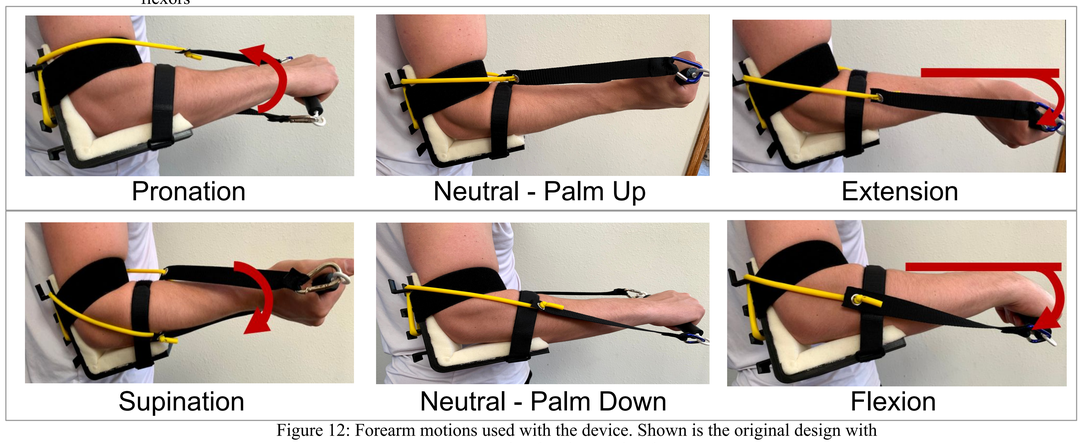

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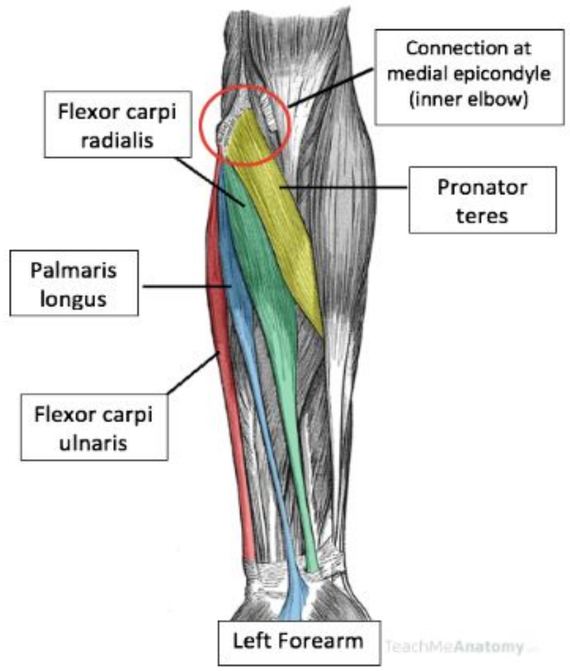

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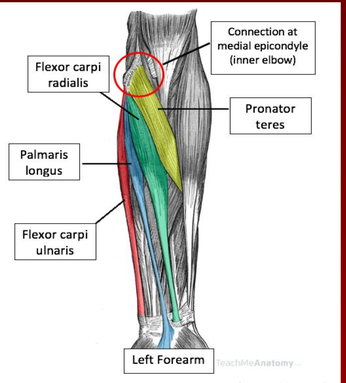

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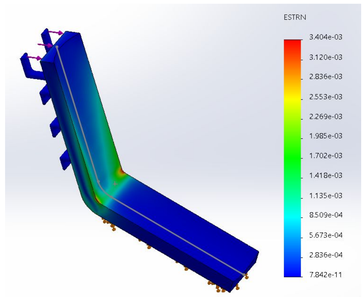

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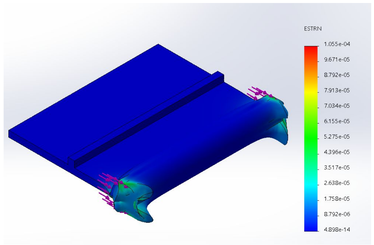

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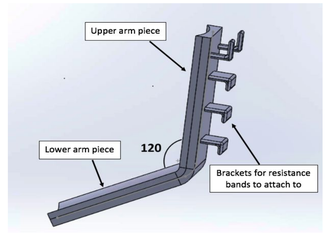

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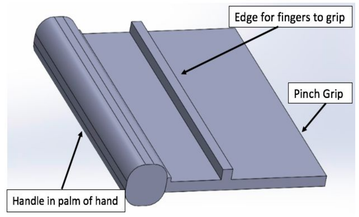

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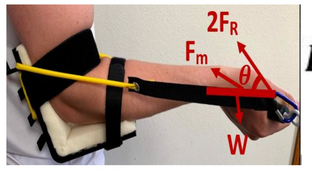

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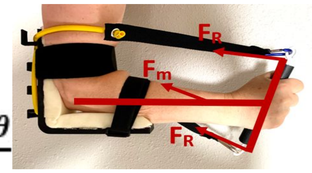

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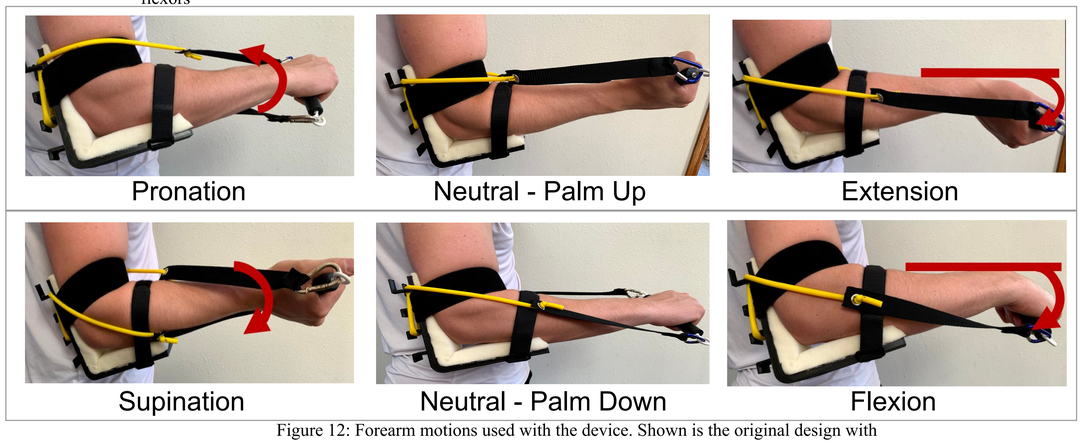

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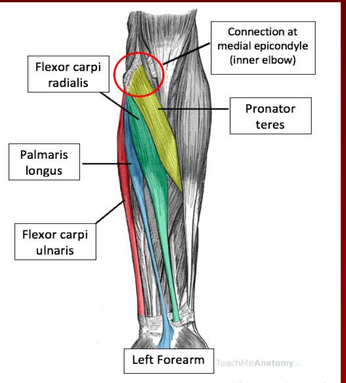

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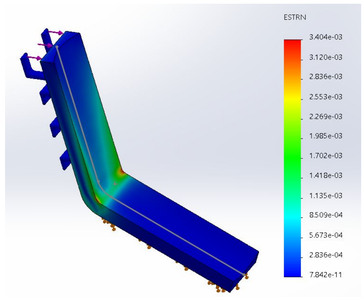

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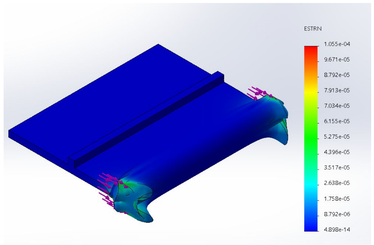

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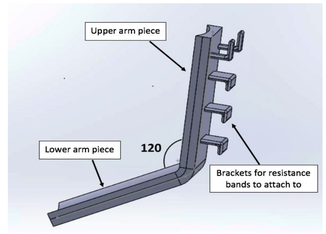

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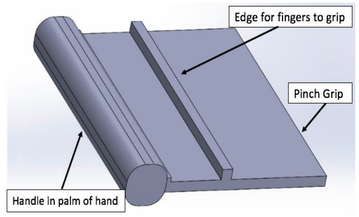

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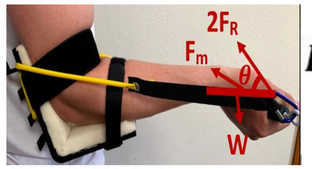

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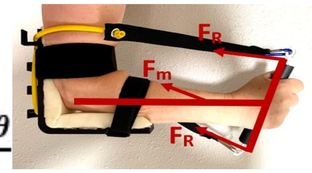

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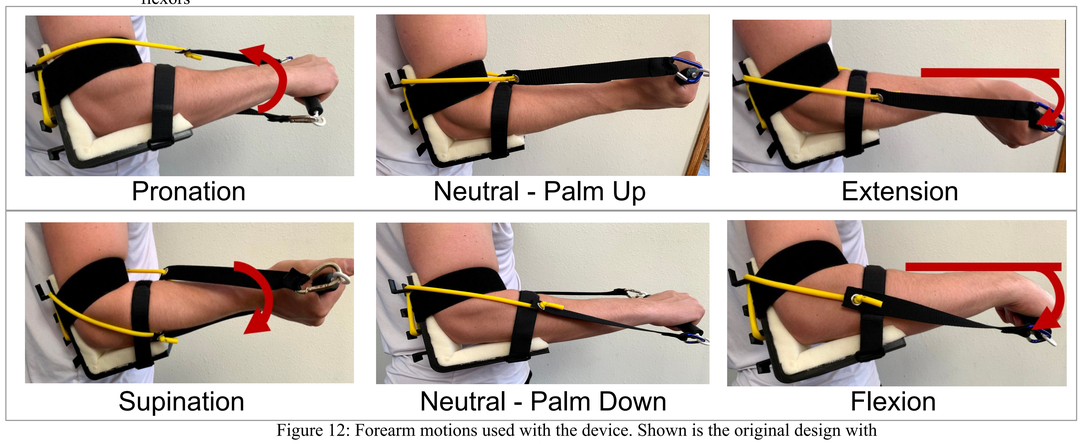

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CLIMBER’S FOREARM TRAINER

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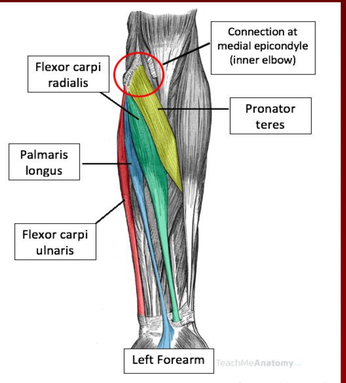

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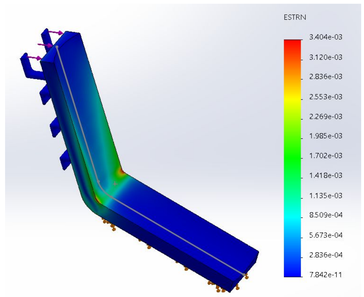

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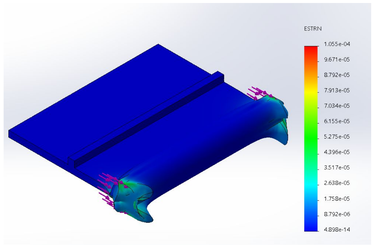

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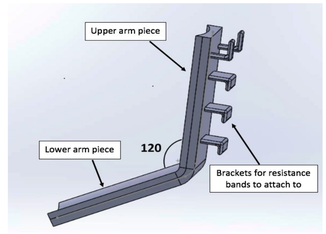

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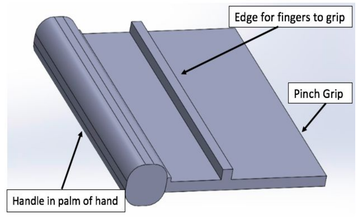

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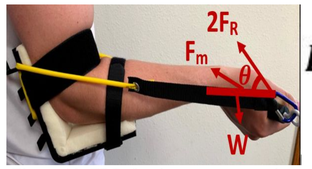

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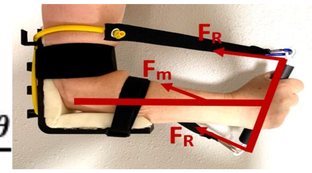

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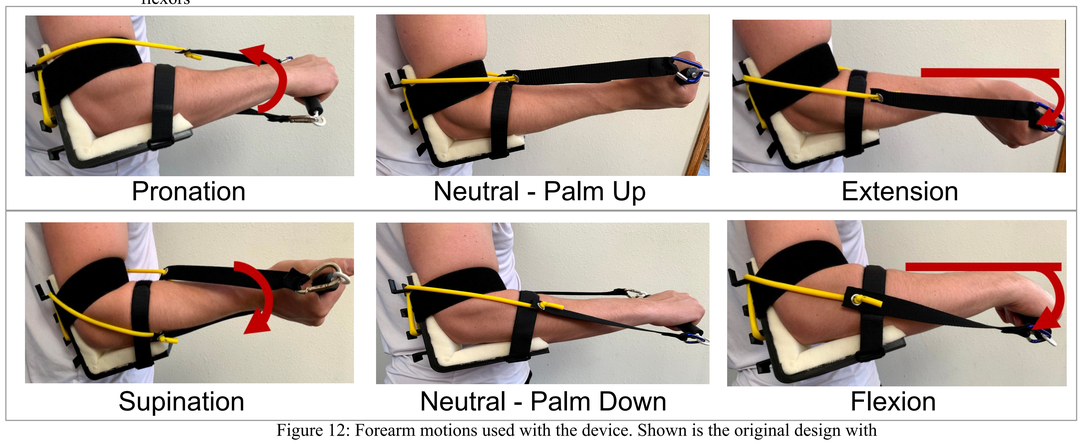

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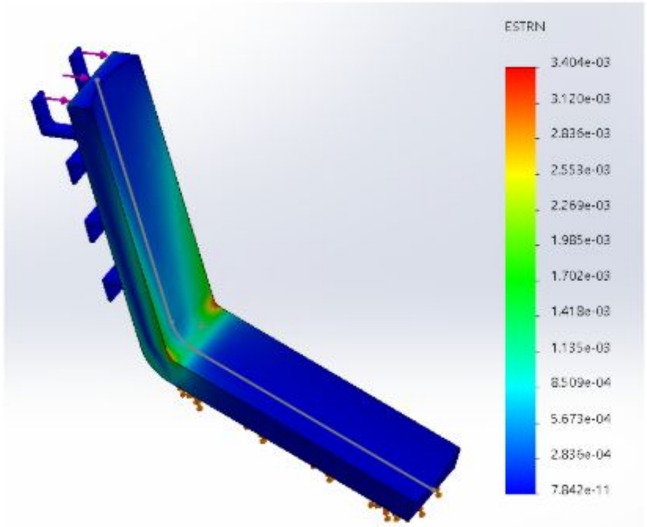

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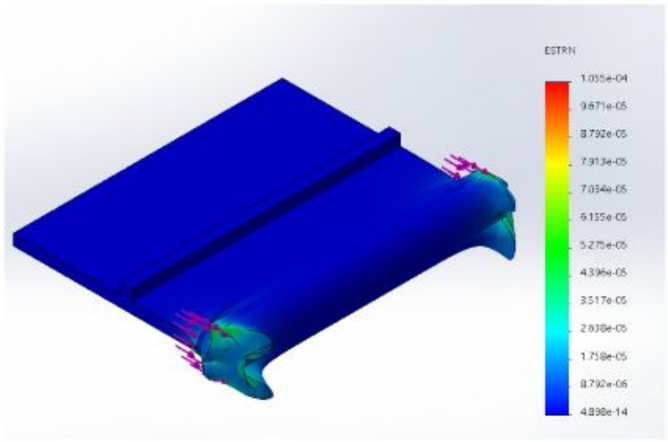

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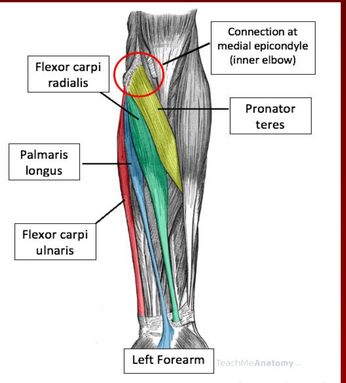

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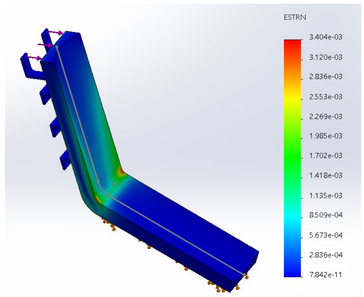

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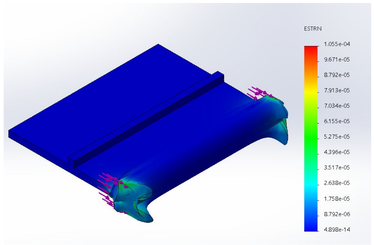

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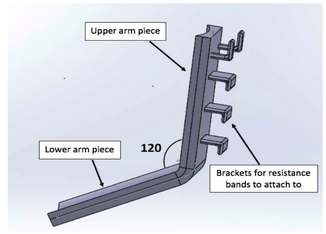

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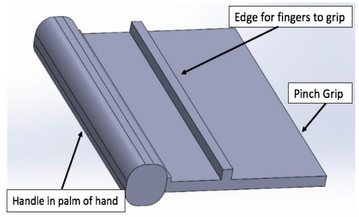

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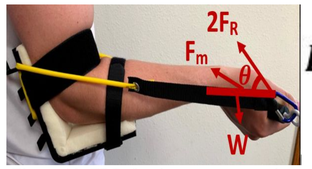

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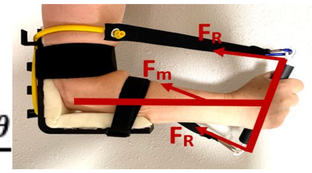

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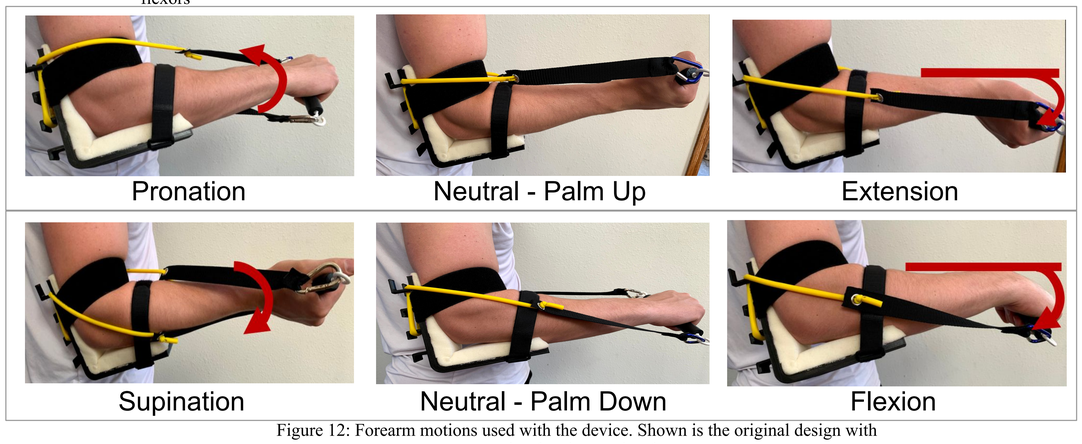

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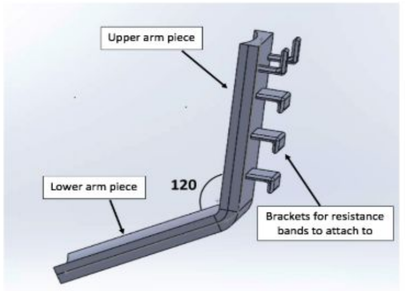

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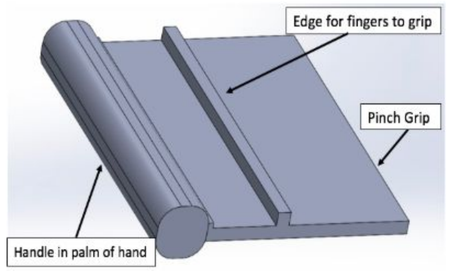

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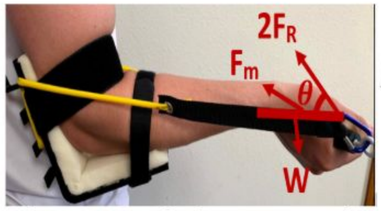

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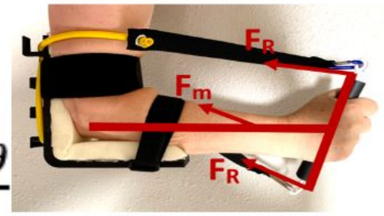

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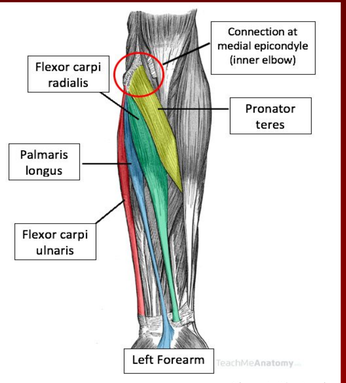

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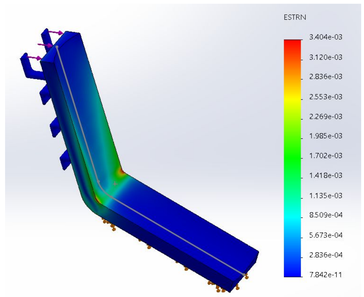

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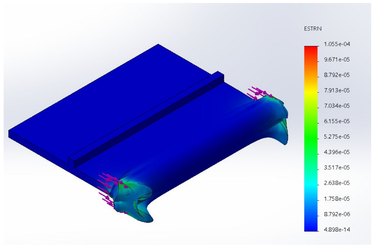

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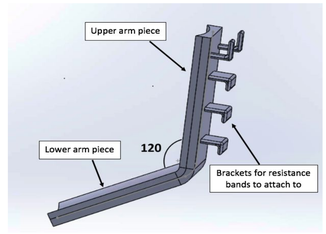

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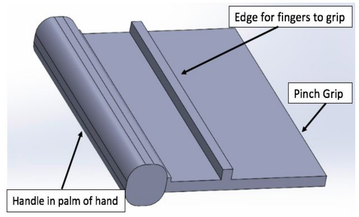

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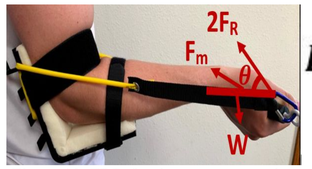

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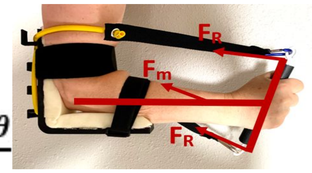

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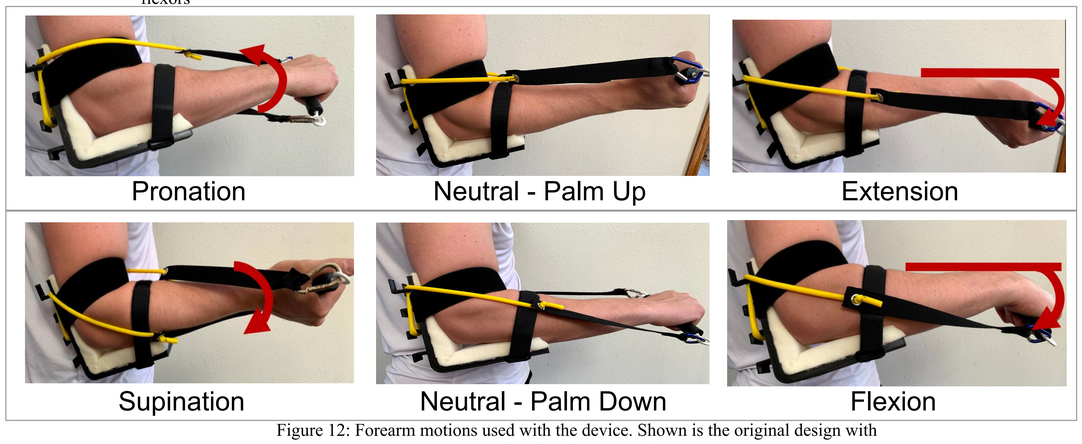

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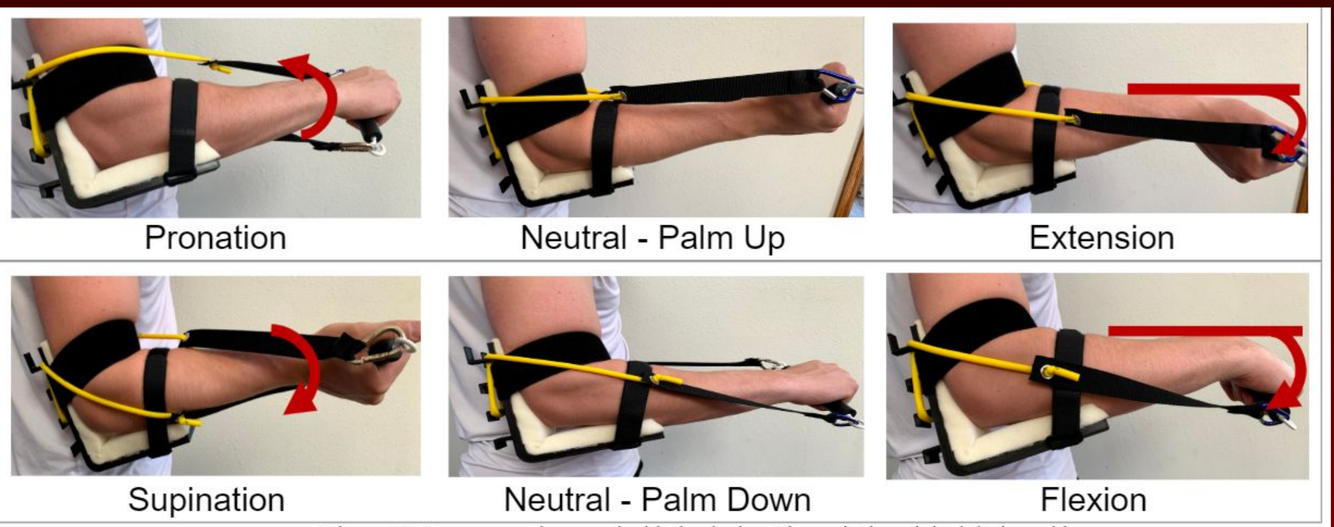

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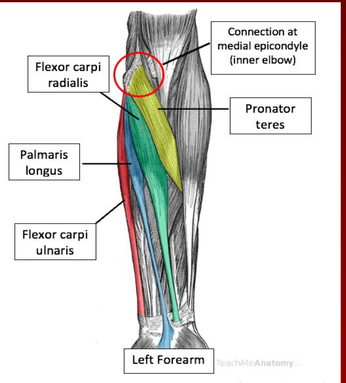

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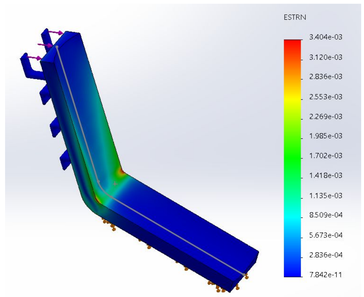

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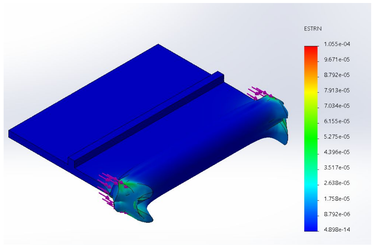

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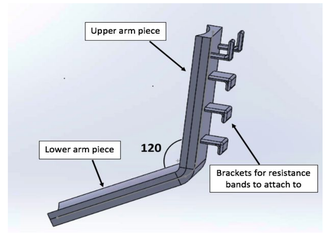

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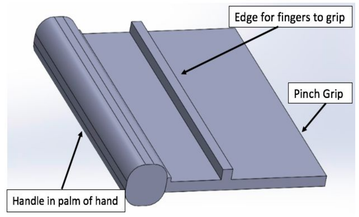

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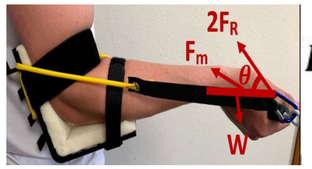

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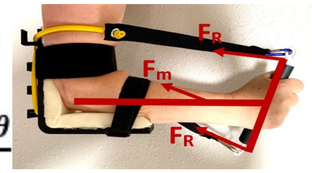

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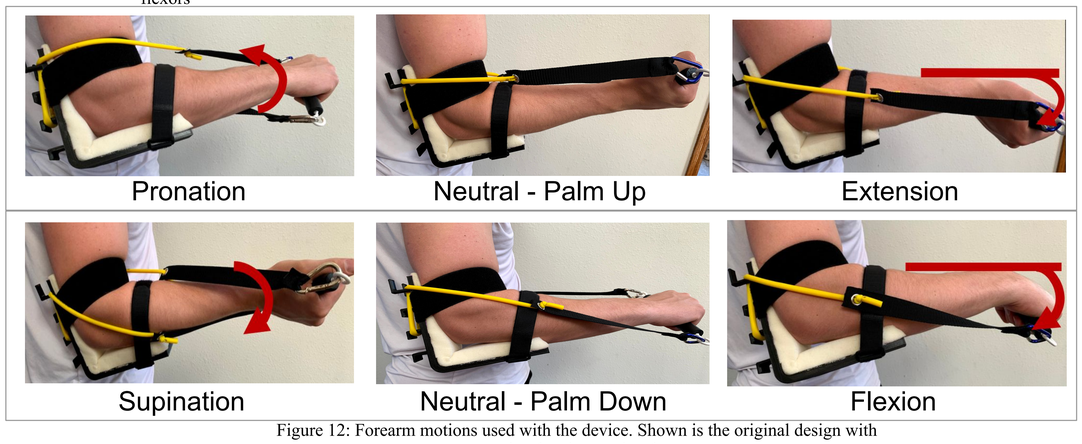

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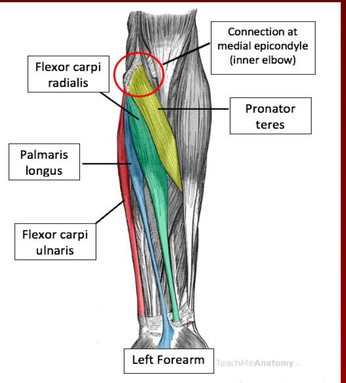

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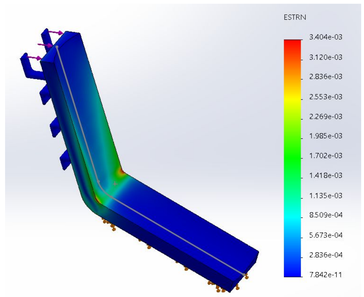

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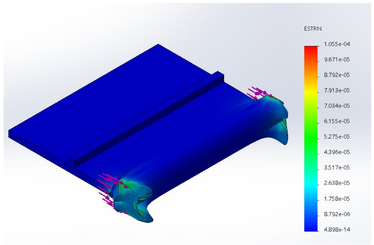

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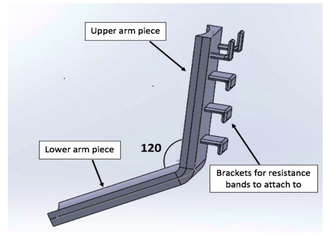

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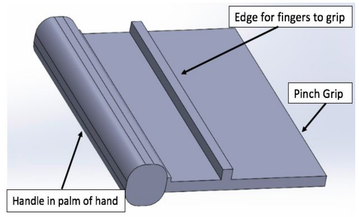

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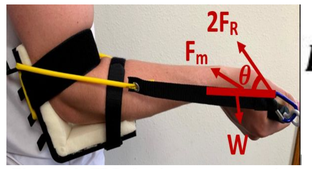

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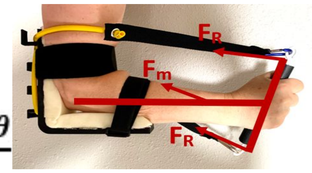

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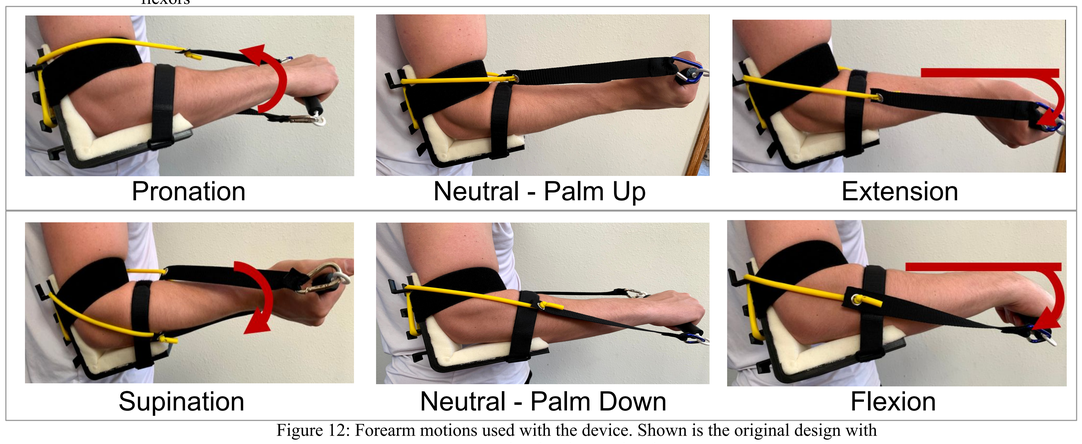

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- 4 major forearm muscles [1]
- Pronator teres is the muscle of focus
- Movements:
  Pronation of hand
  Flexing of the elbow

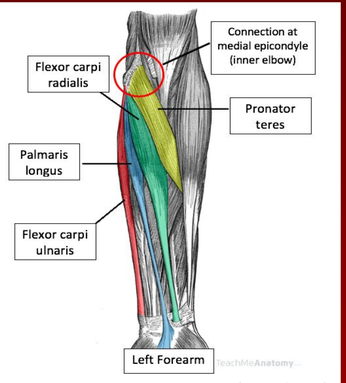

Figure 1: The 4 main muscle groups attached at the medial epicondyle. [4]

- 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]

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
- Adaptable to different sized forearms and hands
  - 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

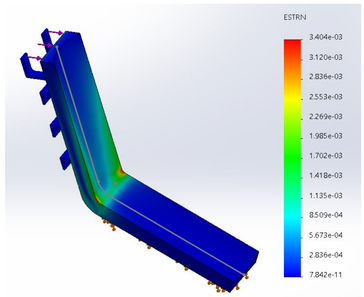

Figure 5: Strain representation of base design under resistance band load

FEA of Handle Design

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

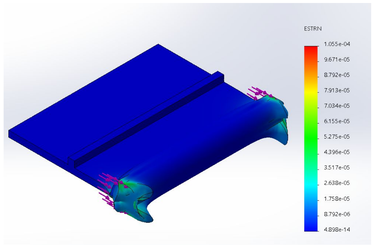

Figure 6: Strain representation of handle design under resistance band load

Conclusion

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

Final Design

Figure 7: Original design with updated resistance bands

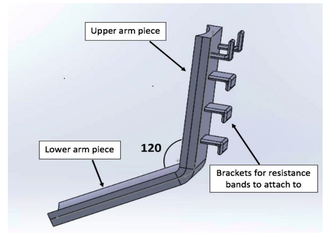

Figure 8: Proposed design of back piece

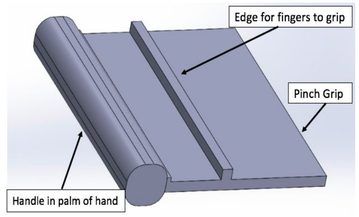

Figure 9: Proposed handle design for grip strengthening

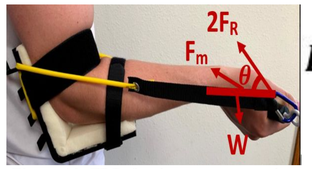

Figure 10: FBD for the extensors and flexors

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

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

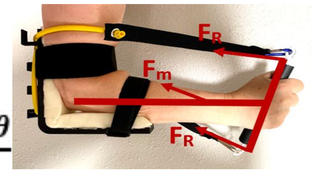

Figure 11: FBD for the pronator teres

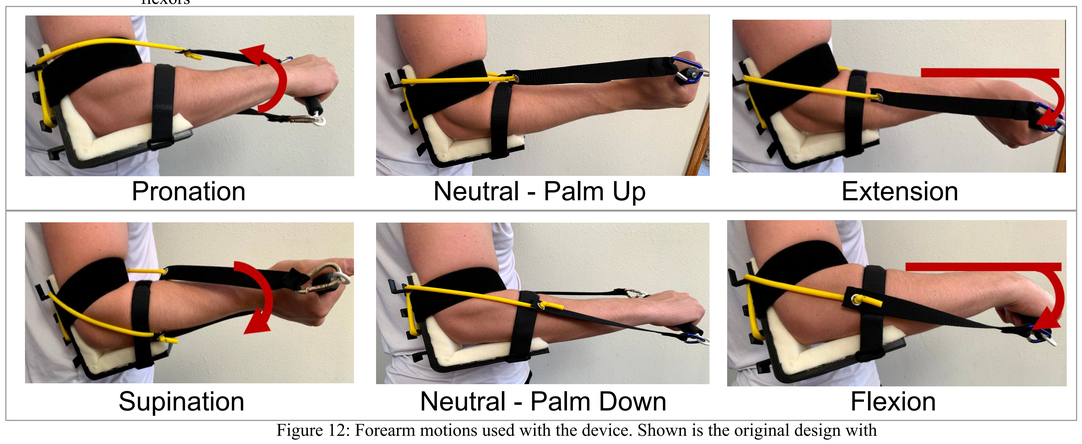

Figure 12: Forearm motions used with the device. Shown is the original design with updated resistance bands.

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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