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Custom Fabricated Devices To Assess Rodent Muscle Health

Joel Pingel[1] (Honors Capstone), Luke Stoneback[2] and Lindsey Lepley Ph.D., ATC[2]
[1]Department of Biomedical Engineering, [2]School of Kinesiology

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Personal Introduction

Joel Pingel - jpingel@umich.edu

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Outline

- Lab and Project Background
- Introduction
- Problems Addressed
- Methods
- Results
- Discussions and Conclusions
- Acknowledgements

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Lab and Project Background

Lab and Project Background

[1]

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HONORS PROGRAM
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Introduction

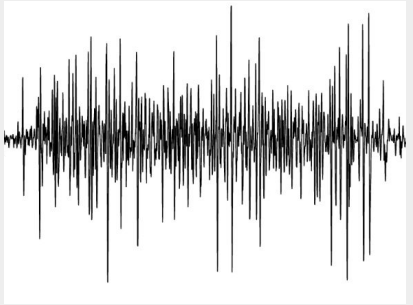
Introduction

- ACL Injury Background
- Aims of the CORL
- Capstone Focus

Problems Addressed

Problems Addressed - EMG Electrodes

- Electromyography (EMG) signal strength is a measure of muscle health
- Commercial rodent electrodes are expensive ($305 per electrode[3]) and have great lead time (6 weeks delivery)
- Custom, biocompatible rodent EMG electrodes were needed



Example EMG signal [4]

Problems Addressed - Dynamometer Knee Orthosis

- A dynamometer is a machine that is able to measure the force and torque a muscle produces

- Quadriceps strength recovery is best quantified by measuring knee extension torque

Clinical dynamometer [5]

Problems Addressed - Dynamometer Knee Orthosis

- During initial data acquisition, the rodent's leg was not stable
- A method to constrain any accessory motion was needed

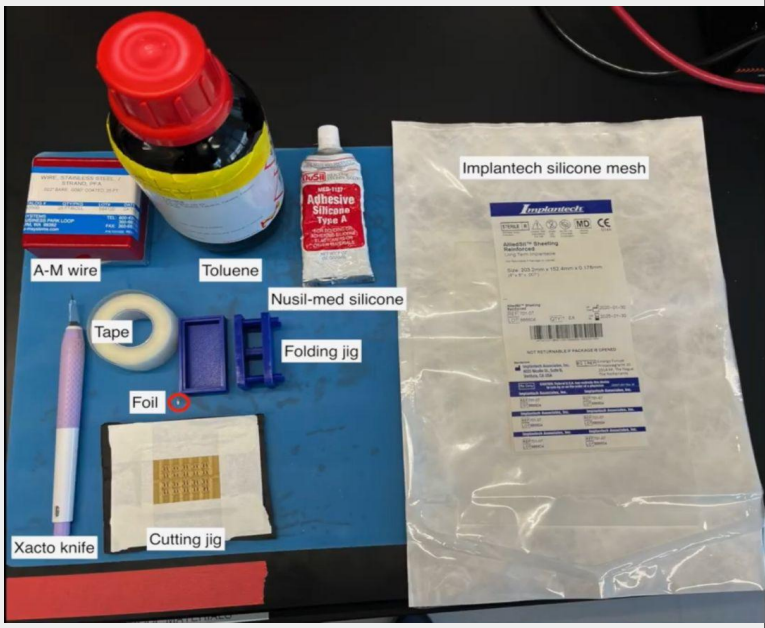
Dynamometer pre-Capstone

Methods

Methods - EMG Electrodes

- Senior lab members taught a small team how to create the biocompatible electrodes

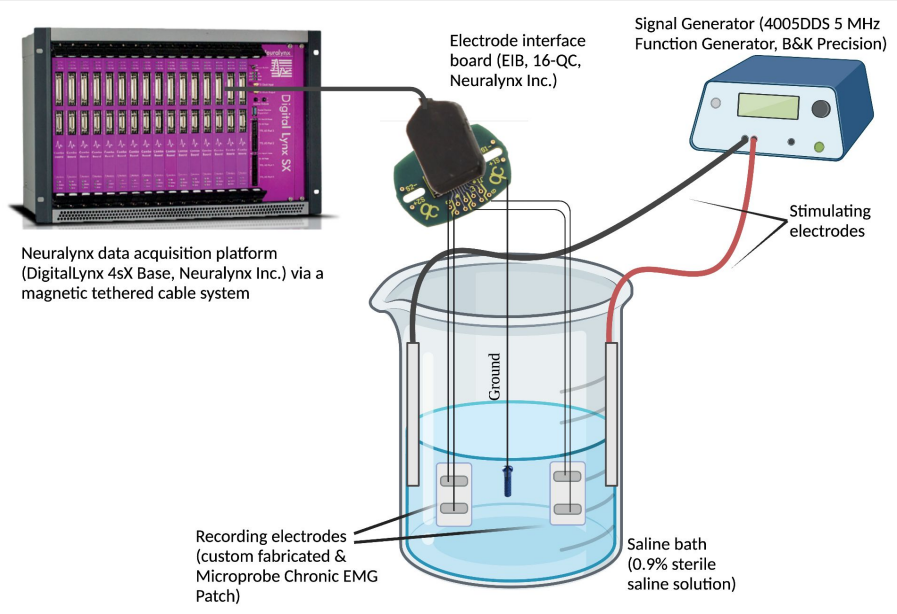
- After producing initial electrodes, a standard operating procedure to fabricate and test them were developed



Electrode materials [6]

Methods - EMG Electrodes

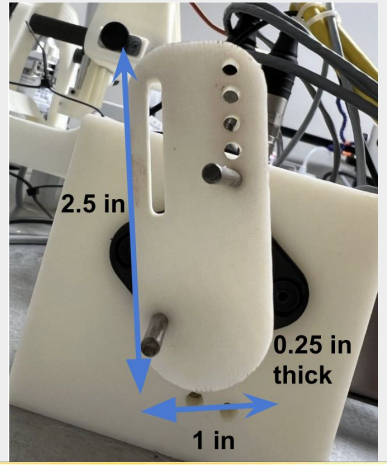
- To compare the custom electrodes to the commercial option, ex vivo testing was performed
- Different waveforms were sent to both electrodes and the correlation was measured

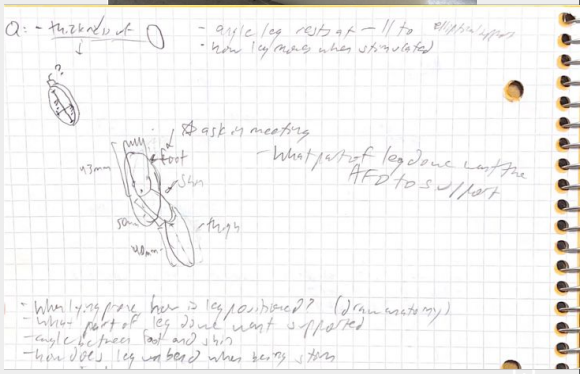


Ex vivo testing of electrodes [3]

Methods - Dynamometer Knee Orthosis

- **Root cause analysis was performed to identify the problem and guide design**
  - Realization of the problem
  - Background research
  - Measuring dimensions of the existing system and rodent anatomy
  - Making design recommendations





Pre-design work

Results

Results - EMG Electrodes

- A proprietary electrode fabrication process was developed
- Using this method, nearly 100 electrodes were hand-fabricated over the course of three weeks

A. Place silicone mesh on cutting jig and perforate with X-acto knife.

B. Place foil into folding jig and use the folding jig to fold foil into U-shape.

C. Insert U-shaped foil into the perforated silicone mesh. The mesh should contain 12 foils for 6 bipolar electrodes.

D. Remove the mesh from cutting jig and fold one arm of the U-shaped foil flush with the mesh.

E. Denude wire and weld to the remaining upright foil arm and fold foil arm flush with the mesh.

H. Align denuded wires and apply silicone (1g) - toluene (75 g) mixture to seal electrode and set for 72 hours.

G. Denude wire and weld to the remaining upright foil arm and fold foil arm flush with the mesh.

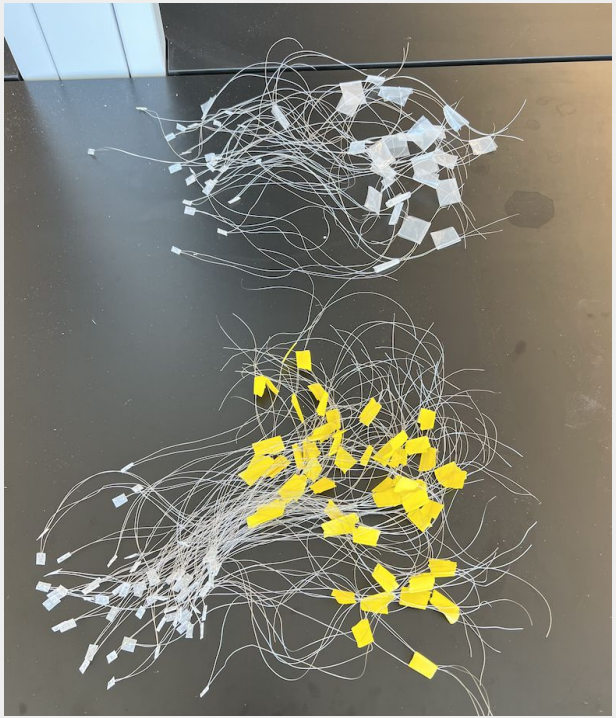
H. Align denuded wires and apply silicone (1g) - toluene (75 g) mixture to seal electrode and set for 72 hours.

I. Divide silicone mesh sheet into 6 individual electrodes measuring "10 x 5" mm and clean in ultrasonic bath

Fabrication process flow chart [3]

Results - EMG Electrodes

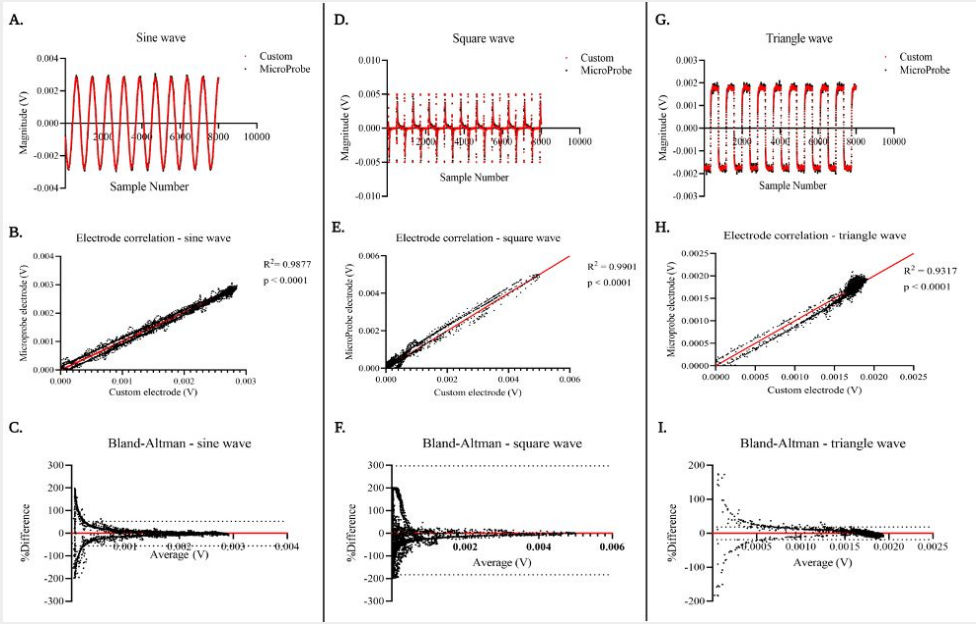
- **Total cost per electrode: $32.70**
  - **~90% cost** reduction relative to commercial alternative
- **Time to produce batch of ~50: <1 week**
  - Potential to produce **300 electrodes** during 6-week commercial lead time



Two of the final batches of electrodes

Results - EMG Electrodes

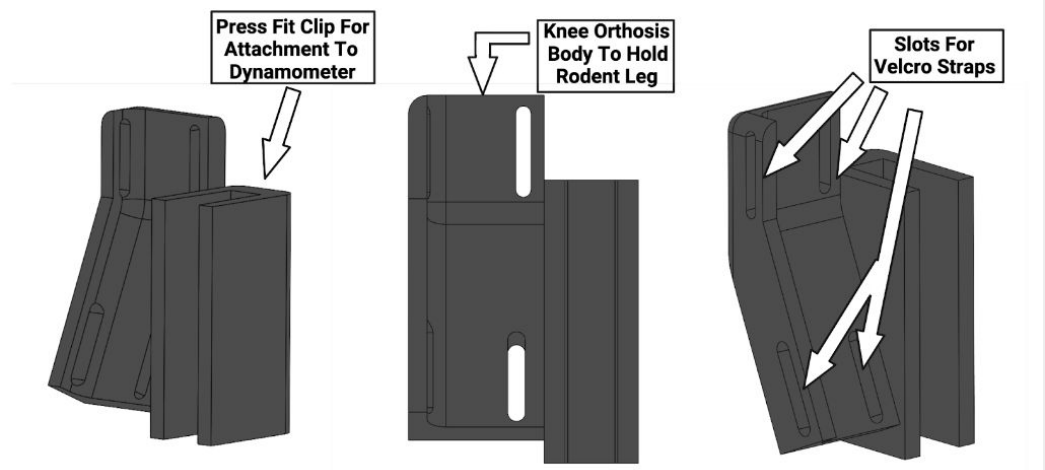
- Different waveforms were sent to both electrodes and the correlation was measured
- Data showed similar performance and high correlation between custom and commercial electrodes



Correlation data [3]

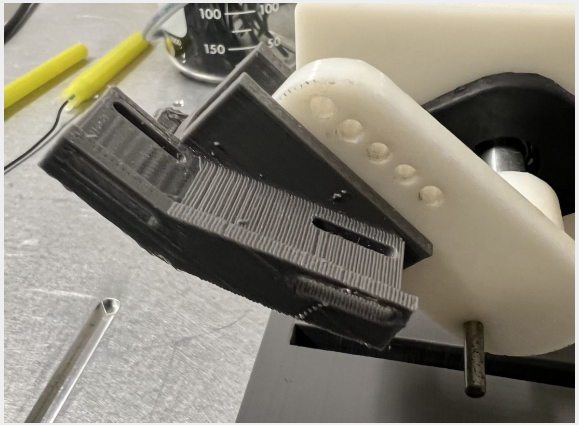
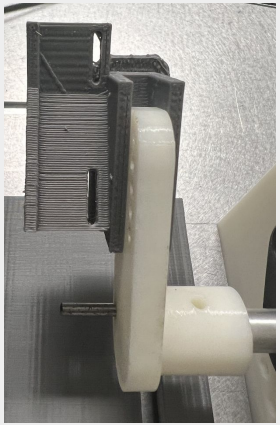
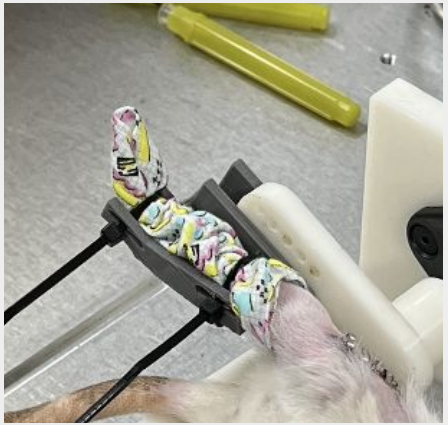
Results - Dynamometer Knee Orthosis

- **SolidWorks design of knee orthosis to restrain undesired leg movement**
  - Simple press fit clip attachment to existing system
  - Knee orthosis body to position rodent's leg for testing
  - Slots for velcro straps to immobilize lower limb



Labeled views of the final design of the knee orthosis

Results - Dynamometer Knee Orthosis


3D printed model in use

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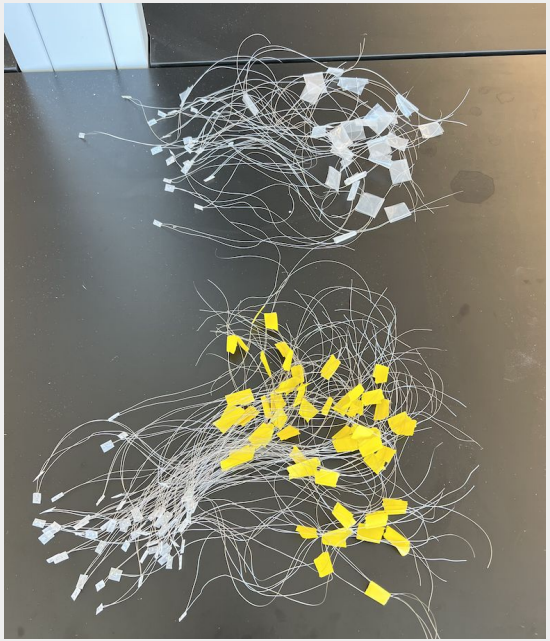
Discussion and Conclusions

Discussion and Conclusions - EMG Electrodes

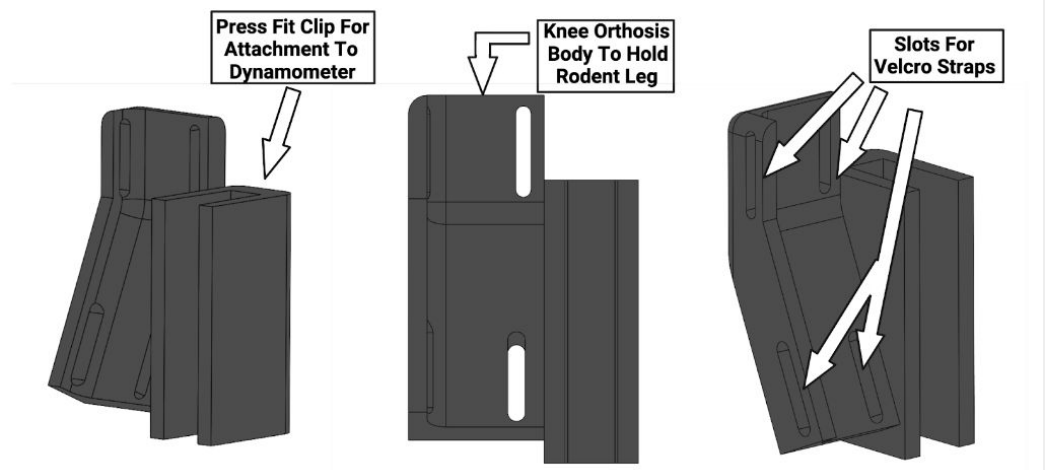
- The CORL now has biocompatible electrodes to collect EMG data
- Reliable electrodes can be made on-demand, quickly, and at very lost cost to the lab
- A standard operating procedure exists to train future members of the CORL and other labs



Two of the final batches of electrodes

Discussion and Conclusions - Dynamometer Knee Orthosis

- The dynamometer can now be used to reliably collect data about the quadriceps
- This design is easily used, manufactured through 3D printing, and is readily accessible for other labs to utilize



Labeled views of the final design of the knee orthosis

Acknowledgements

Acknowledgements

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- Thank you to Dr. Lindsey Lepley, Luke Stoneback, Grant Gueller, Akhil Ramesh, and the Engineering Honors Program for their support during my Capstone Project.

References

[1] Adapted from Comparative Orthopaedic Laboratory lab meeting slides
[2] Logo Provided by Engineering Honors Program with permission for use
[3] Stoneback L, Fullano GD, White MS, Naaz S, Lepley LK. Development of a low-cost biocompatible EMG electrode: metrics of performance and instructions for fabrication. In preparation.
[4] https://link.springer.com/chapter/10.1007/978-981-13-9097-5_1
[5] https://www.google.com/url?q=https://innorenew.eu/equipment/isometric-bilateral-knee-dynamometer/&sa=D&source=editors&ust=1682358241905378&usg=AOvVaw1ke-PI7T3-tBks8PmVltRr
[6] https://www.youtube.com/watch?v=O9aJCMkGKSA

Thank You!

Joel Pingel - jpingel@umich.edu