Progress Report # 3

UW Adapted Fitness: Grip Strength Improvement Mechanism

Client: Dr. Kecia Doyle

Advisor: Prof. William Murphy

Team: Simon Nam (Team Co-Leader and BSAC)

Sarah Kendall (Team Co-Leader)

Nicolas Maldonado (Communicator)

Owen Noel (BWIG)

Joey Dringoli (BPAG)

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Problem Statement

A longtime Adapted Fitness client and mechanical engineer has worked consistently on stimulating his hand with lesser grip strength. The client would like a custom mechanism that would help an adapted fitness client improve his grip function and enable him to better grip on daily objects and workout equipment.

Brief Status Update

We are currently working on a design for the grip enhancing device. Each group member brainstormed a detailed design and three designs were chosen to be evaluated in the design matrix. We also met with our client and saw the device that we will improve upon.

Summary of Weekly Team Member Design Accomplishments

- TEAM
  - Prepared and discussed 3 different possible designs based on the specified criterias and requirements delivered by our client
  - Worked on the design matrix.
- Simon
  - Researched more with the focus on developing a viable mechanism to improve grip strength for a patient with stroke
  - Came up with a potential design with incorporating ideas initially written for proposal of the project prior to selection day

- Worked on additional possible design with a different mechanism; hand-drawn and listing all the specifications and features that heavily integrates electromagnetic force principles.
- Sarah
  - Meet with the adapted fitness client on Thursday to discuss the goals and expectations for the project.
  - Brainstormed a design for the grip-assist device.
  - Worked on the criteria aspect of the design matrix.
- Nicolas
  - Continued researching for one of our designs
  - Drew rough draft and final product for presentation
  - Contacted the client and coordinated meeting times
- Owen
  - Came up with and drew a design option for the design matrix
  - Uploaded Progress Report and PDS
- Joey
  - Wrote and defined some of the criteria on the design matrix
  - Presented my preliminary design to the team; although it did not make it to the matrix it still offered insight into alternative solutions
  - Meet with adaptive fitness client via Zoom to understand his desires and past solutions

Weekly/Ongoing Difficulties

After meeting with our client on Thursday, we determined that the client would rather us improve upon their device than fabricating a new one. Our PDS and design matrix were centered around the creation of a new gripping device, so we will have to review those documents, as the client would prefer we alter their current design.

Upcoming Team and Individual Goals

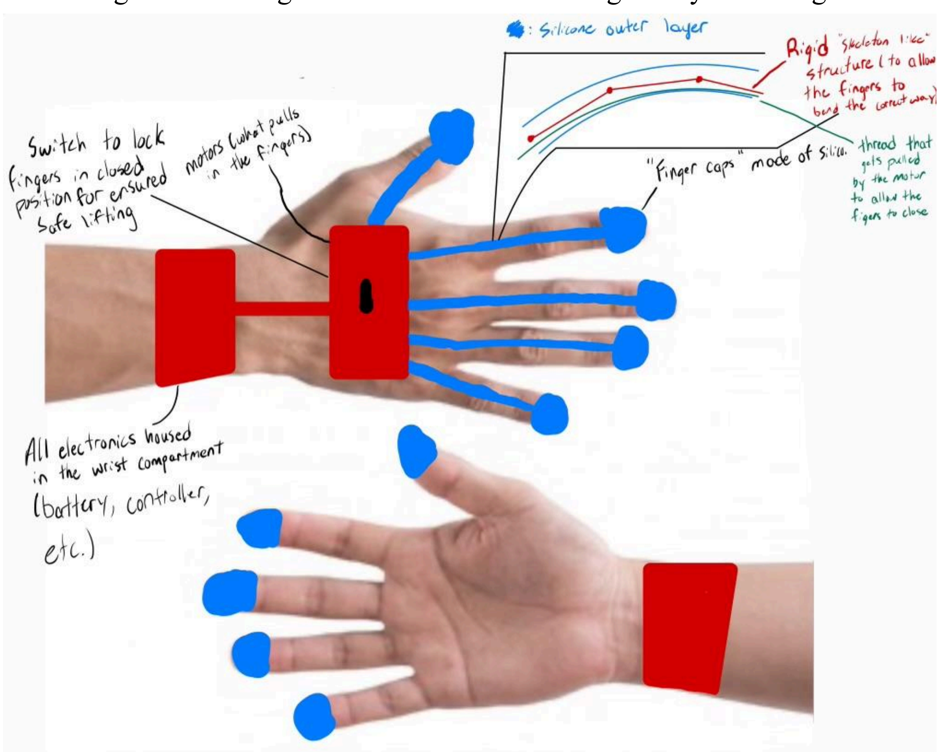
- TEAM
  - Prepare for the preliminary presentation to present design ideas
- Simon
  - Engage more with the client to discuss further development of the design
  - Begin prototyping and plan about obtaining necessary materials and fabrication methods
  - Prepare for the preliminary presentation occurring in person
- Sarah
  - Prepare for the preliminary presentations.
  - Remain in contact with the client and attempt to schedule an in person meeting so we can see the existing device.
  - Research EEG waves and the possibility using brain waves to control hand movements
- Nicolas
  - Continue research

    - Make a final design for our product incorporating all positive aspects of each design.
    - Continue to communicate to with client
- Owen
    - Begin working on the preliminary presentation
    - Continue research on materials
    - Continue to upload documents to the website and update website as needed
- Joey
    - Begin working on the preliminary presentation PDF, slideshow, and oral presentation
    - Get updated on what happened at the BPAG meeting (missing due to schedule conflict)

Design Matrix

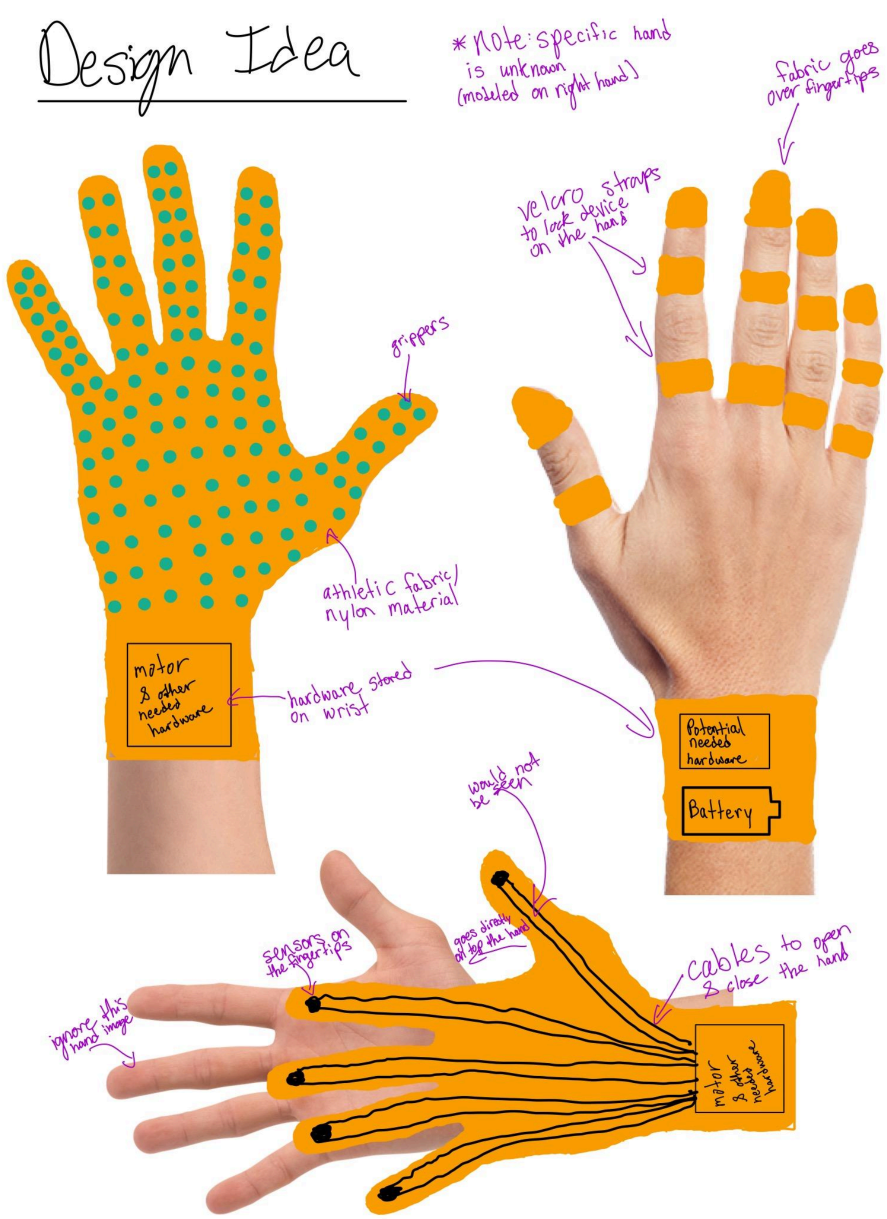
Design 1: Skeleton Glove

The first design uses an outline of the joints in the hand and is designed with physical activity (predominantly weightlifting) in mind. Using a system of electronics located in the wrist, the silicone fingers and fingertips will be pulled by a thread connected to a motor allowing the fingers to close around whatever object the user is holding. This grip can be locked in place using a switch on the back of the hand. The fingers will be made of rigid plastic sections outlining the skeletal structure of the user's fingers allowing them to bend similarly to the typical hand: each knuckle is capable of independent movement. After the user places their hand inside the silicone layer and moves their fingers into the skeletal frame, the synthetic threads connected to the motors will rest beneath the fingers; awaiting the initial pressure from the user to begin contraction. This motor would be charged with a reusable battery. This design emphasizes maintaining a natural finger structure without needing a fully covered glove.



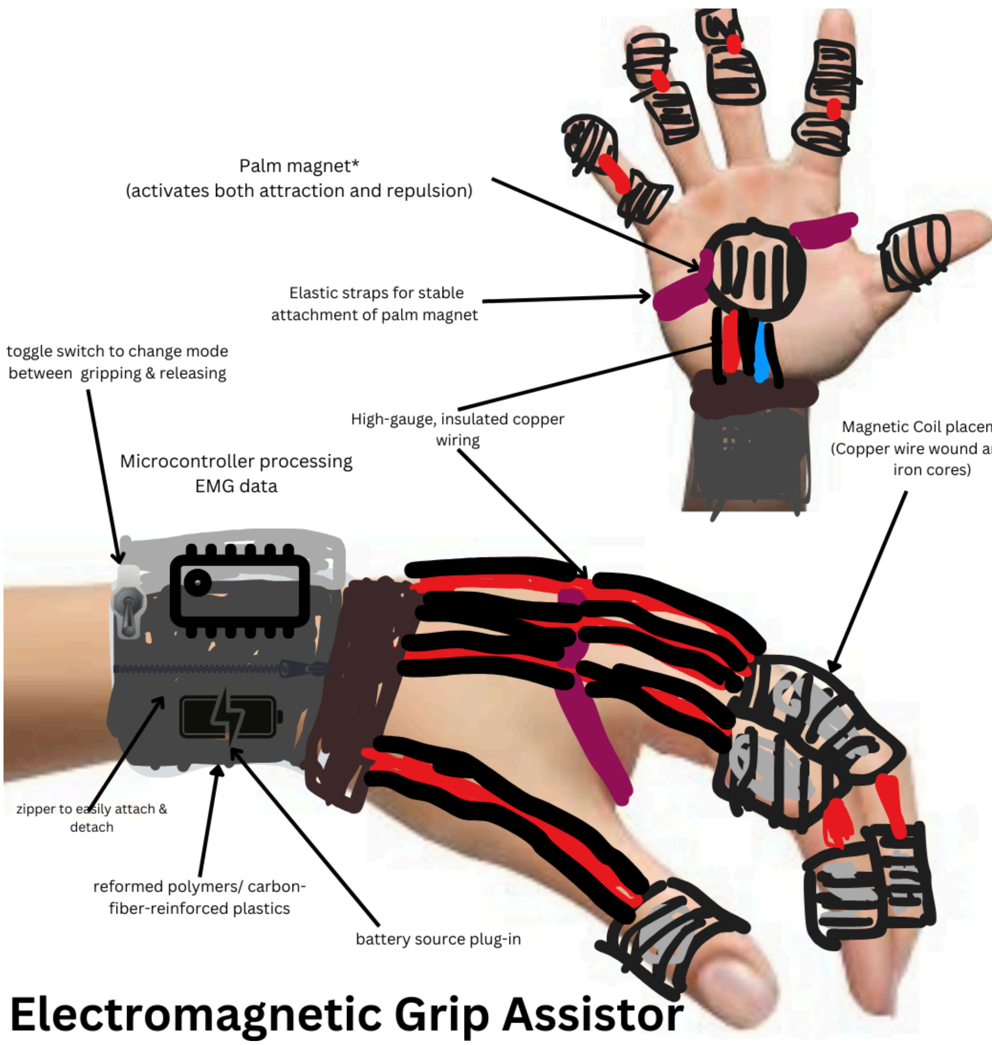
Design 2: Palm Glove

This design uses a motor system with wire cables located on the palm side of the hand to assist the user in closing their hand. The palm would be entirely covered in an athletic, breathable nylon material and have small grippy circles similar to the ones used in socks for maintaining balance. To fasten the device to the user there would be several velcro strips placed near the knuckles and along the wrist that could be easily fastened using the opposite hand. On the inside of the material, there will be sensors placed at each fingertip to determine if the user is attempting to grip or release their hand. While gripping, the motor in the wrist will activate contracting the cables and causing the finger to curl. When releasing, the cables will loosen; slowly helping the user extend their fingers once again. This design emphasizes maintaining a secure grip with maximal discreteness.



Design 3: Electromagnetic Grip Assistor

In this design, electromagnets would be embedded in the glove at key locations in the finger joints and palm. When activated, the magnets could either attract (to assist gripping by pulling fingers toward the palm) or repel (to resist or assist in opening the hand) depending on the mode. The design would also involve EMG sensors to monitor muscle activity and control the strength and timing of the electromagnetic forces. This adaptive system would provide varying levels of assistance depending on the user's needs. This device would have the electronics located on the wrist with a simple switch for determining if the user is gripping or releasing. This design can be slipped on or off using a zipper to attach at the wrist and would be powered via rechargeable battery. This design emphasizes both gripping and retracing of the fingers and user feedback.



Criteria (Weight)	Design 1: Skeleton Glove		Design 2: Palm Glove		Design 3: Electromagnetic Grip Assistor	
Effectiveness (25)	4/5	20	3/5	15	4/5	20
Safety (20)	5/5	20	5/5	20	3/5	12
Variety of Use (20)	4/5	16	2/5	8	4/5	16
Unassisted Use (15)	4/5	12	5/5	15	3/5	9
Sterilizability (10)	5/5	10	3/5	6	3/5	6
Cost (5)	4/5	4	4/5	4	2/5	2
Discreteness (5)	3/5	3	5/5	5	2/5	2
Total (100)	85		73		67	

Effectiveness (25):

The purpose of the device is to improve the client's grip strength. Effectiveness refers to how successful the device will be in improving grip strength, considering the device's material, design, and biosensor feedback accuracy.

Both skeleton glove and electromagnetic grip assistor have scored 4/5 for effectiveness because of their overall satisfactory ability to deliver the main objective for the client to improve grip strength over time. The silicone fingers encompassing around the client's fingers will allow flexible movements of grip in a secured manner. The attractiveness between the magnets of the fingers and palm will also cause gripping in a controlled way. Through consistent training with both designs equipped and availability of live biofeedback makes them more suitable and desirable for the client for continuous usage and further improvement. The two designs also provide enough security and stability for the client to easily grip without much disturbance or disorientation to effectively achieve the objective. On the other hand, the palm glove scored 3/5 because of its potential risk involved in damage of the design while gripping in motion because of its heavily one-sided configuration of the device's material coverage on the entire palm.

Safety (20):

The device will directly interact with the patient, therefore, it must be safe to use. Safety considers the placement and storage of all electronic elements of the device and how easily the device components can be released from the grip in urgent, unexpected situations.

The skeleton glove scored 5 out of 5 due to its dedicated focus on safety. This design ensures that all electronic components are located in the wrist, which minimizes exposure to sensitive areas of the hand. The skeletal framework is also designed to maintain a natural hand structure, and the grip can be easily released via a switch on the back of hand that offers an option to quickly release in urgent situations. Palm Glove also scored 5 out of 5 with its electronics similarly stored in the wrist, durable materials and velcro fastenings that can be easily detached. This also ensures safe and fast operation of removal if needed. Electronic Glove Assistor scored 3 out of 5 by its complex addition of electromagnetic system and attachment of EMG sensors. Despite providing much adaptive system, this setup could potentially introduce hazards, such as direct interference from electromagnetism, making it slightly less safe and reliable than the simpler and more biomechanically focused designs of the other two designs.

Variety of Use (20):

Variety of use defines the ability of the device to adapt to the shape and size of the object that will be gripped and refers to the setting in which the device will be used. The device should allow gripping of a variety of objects in both everyday and exercise settings.

Skeleton Glove scored 4 out of 5 due to its flexible design that accommodates various motions of hand and different kinds of object shapes. The motorized thread system allows precise control over the grip, making it adaptable to objects in different dimensions which is applicable for both physical training and daily activities, with the small exception of weightlifting limiting its full versatility. Electromagnetic Glove Assistor scored 4 out of 5 too, as its electromagnetic system offers adaptive assistance for gripping objects of various scales. Furthermore, the EMG sensors allow for customization based on user needs, making it suitable for a wide range of setups for training purposes. However, its complexity makes it not the most ideal candidate for general applicability. Palm glove scored 3 out of 5, because it primarily focuses on providing grip assistance with limited flexibility. The use of wires and the focus on secure grip may reduce its functionality to adapt to objects of varying sizes especially in training setting, which makes its level of versatility significantly lower compared to other designs

Unassisted Use (15):

The client is a hemiplegic stroke survivor, requiring assistance for most everyday activities. The glove should give the client independence for gripping and releasing objects. The device should be simple to put on and use, requiring little external assistance.

The palm glove ranked the highest for unassisted use because the client would slip the entire hand through the electronic wrist storage, and then could strap in their fingers using their dominant hand. The act of putting this glove on could occur independently as the fingers must only lay flat to be put on. The skeleton glove would be simple for the client to put on unassisted, as the finger would be popped into the exo-skeleton, which would occur with the use of their non-paralyzed hand. The electromagnetic grip assistor would require external assistance to put on because the client’s hand would have to fit into the glove, rather than the glove fitting around the hand.

Sterilizability (10):

The device will be used for exercising and everyday tasks, which requires the device to be easily disinfected or cleaned. Sterilizability considers how easily the device’s material will be cleaned.

The skeleton glove received the highest ranking for sterilizability because it would be fabricated using silicone, which can be sanitized using disinfectant spray. None of the electronic aspects of the device would get wet during sterilization, as they are embedded in the wrist bracelet and silicone fingers. The palm glove’s non-slip material could be cleaned using a machine washer, however, the electronic aspects would have to be removed prior to cleaning. All of the electronic aspects of the electromagnetic grip assistor are exposed, making sterilization of the device more difficult as it can not be sprayed with disinfectant or machine washed.

Cost (5):

The budget for the project is currently unknown, however, the device should be fabricated using as small of a budget as possible. The client wants the device to be available to all patients, regardless of financial situation, so the cost should remain low.

The skeleton glove received a ⅘ ranking for cost because the materials used to fabricate the glove are relatively budget friendly. The fingers and exterior of the hand would be fabricated from 3D printed silicone and the microcontroller would utilize an Arduino, which are materials readily available in the MakerSpace. The palm glove would require ordering of non-slip fabric and similar electronic elements, but would be within the budget. The electromagnetic grip assistor would be the most expensive design as magnets, iron cores, and copper wires would quickly become expensive making the glove inaccessible to lower income clients.

Discreteness (5):

Discreteness refers to how the device interacts with the hand. The device's appearance should be relatively inconspicuous and should not impede the client's grip strength.

The palm glove received the highest ranking for discreteness because it would be fabricated from thin non-slip material that is relatively weightless. Since the glove only encompasses the palm and fingertips, it leaves the majority of the hand exposed making it inconspicuous compared to the other designs. The skeleton glove design consists of an exo-skeleton on the exterior hand and a bracelet containing the electronic components, which could contribute to the device's weight, making it difficult for the patient to lift their paralyzed arm. The electromagnetic grip assistor is the least discrete design, as the palm magnet, iron cores, and microcontroller contribute to the design's bulkiness.

Project Timeline

Project Goal	**Deadline**	**Team Assigned**	**Progress**	**Completed**
Background Reading and Prep for First Client Meeting	9/12/2024	All	Complete	Yes
PDS Draft 1	9/19/2024	All	Complete	Yes
Design Matrix w/ at least 3 ideas	9/26/2024	All	Complete	Yes
Preliminary Presentations	10/4/2024	All	In Progress	No

Preliminary Deliverables (Report, Notebook, Peer Eval)	10/9/2024	All	Not yet started	No
Final Poster Presentation	12/6/2024	All	Not yet started	No
Final Deliverables	12/11/2024	All	Not yet started	No

Materials & Expenses

n/a