UW Adapted Fitness: Grip Strength Improved Mechanism

Preliminary Report

BME 200/300

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October 8th, 2025

Abstract

Grip Strength is a vital indicator of overall muscle function. It is essential for daily activities and maintaining independence. As humans age, grip strength naturally declines. Additionally, individuals recovering from stroke or traumatic brain injuries often experience impaired control and precision in their grip motion. This project aims to design and fabricate a safe, affordable, and user friendly, device that assists with both hand flexion and extension while improving grip strength over time. This device targets older adults and rehabilitation patients who seek to regain full function in their hand. After evaluating three design concepts, the final design consists of a half glove made from a modified work glove, fitted with silicone finger rings reinforced by carbon steel wire. Adjustable rubber bands connect the rings to a 3D printed central connector via small metal S hooks. This allows customizable tension levels to change between different hand strengths while maintaining simplicity and reliability without complex electronics. The glove is secured with an adjustable velcro wrist strap and can be worn independently by the user. Prototype testing will assess the range of motion, comfort, amplification, adjustability, safety, and durability. Preliminary designs indicate the glove effectively supports finger extension and allows for independent use. This device demonstrates strong potential as a low cost rehabilitation tool for hemiplegic patients. Future work will refine material choices, complete fabrication, and evaluate performance through multiple tests.

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Introduction

Grip strength devices are necessary in today's society to help strengthen the overall hand muscles in human beings. Grip strength is such an imperative part of human life and is used in everyday functions to get humans through simple daily tasks. Our device targets the demographics of older men and women, as it is common for grip strength to decrease as humans age [1]. Grip strength affects the muscle function throughout the entire body, so it is important that grip strength stays strong throughout a human's life. Additionally, our device targets rehabilitation patients recovering from a stroke or any traumatic brain injury. Control and precision grip force is impaired in people with a traumatic brain injury [2]. Our device will allow these patients to relearn the motion of extending their hand from a closed fist.

Several grip strength mechanisms are currently available on the market. At the UW Adapted Fitness Center, the primary grip device that is being used is called Active Hands [3]. This device straps a patient's hand to a machine or weight and enables them to have a stable and controlled grip. The device acts as a glove. fastening around the wrist, over the fingertips, and around the object using Velcro straps. Active Hands is used in patients who have disabilities or are practicing rehabilitation of their grip flexion, facilitating the relearning of proper gripping motions. Another current grip mechanism being used is a grip trainer [4]. This device is a spring hand gripper, centered around a central spring that provides resistance when the user squeezes inward on two metal or plastic handles. The resistance serves to strengthen the hand, fingers, and forearm muscles. The device is commonly used for rehabilitation, improving grip strength, flexion, and enhancing hand endurance. A more experimental design is a robotic hand. This design targets hand extension rather than flexion. In this system, the patient inserts the hand into a glove while maintaining a fist position. The device is powered by a motor to extend the hand from a balled position to an extended position [5]. There are wires down the fingers of the hand to pull the hand open, and it is powered by a battery, a control board, and a motor.

Some individuals who face challenges with grip strength that limit their ability to perform daily tasks and participate in exercise are clients of the UW Adapted Fitness program. Current tools in the Conway Adapted Fitness space are not tailored to our clients' needs, creating a gap in training effectiveness and slowing their path to rehabilitation [2]. This project aims to design a safe, affordable, and user-friendly mechanism to support targeted flexion grip training, improve independence, and enhance the client's overall fitness experience.

Figure [1]: Active Hands grip mechanism used at the UW adapted fitness center [3]

Figure [2]: Grip trainer used at the UW adapted fitness center [4]

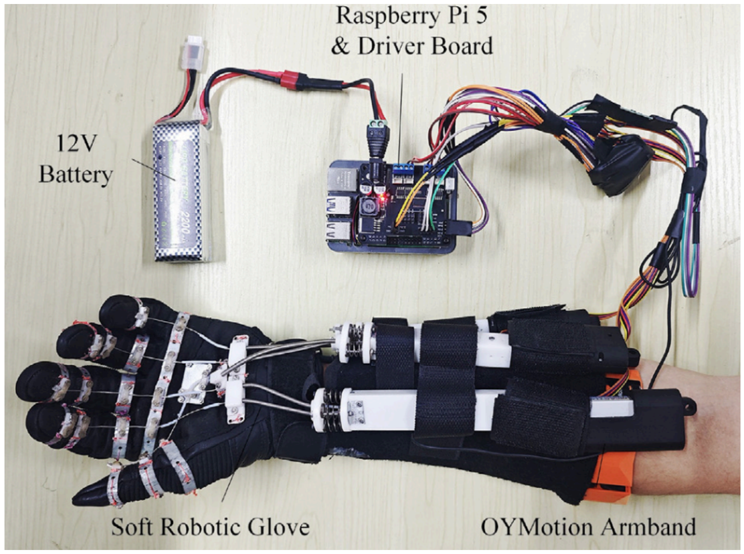


Figure [3]: Soft robotic glove to test grip strength [5]

Background

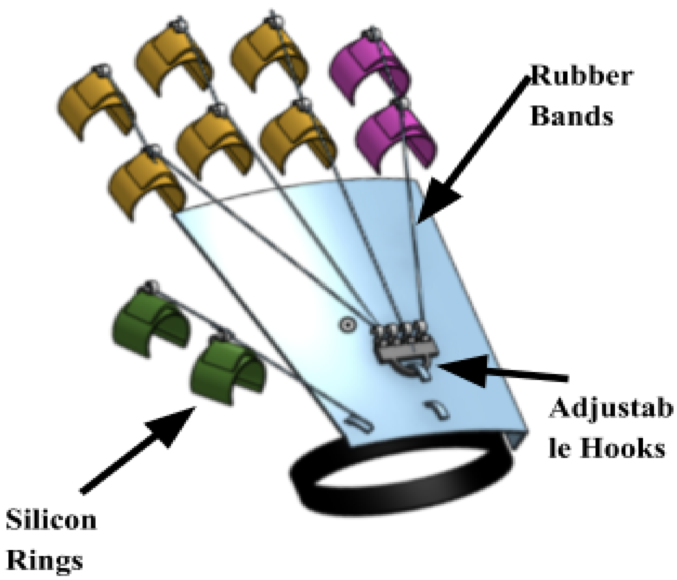
The skeletal muscles are what cause movement in the human body. The muscles that control grip strength specifically are in the forearm of the body [6]. Specifically, the anterior division of forearm muscles plays the most important part in flexing joints. Two muscles in the hand that play a key role in grip strength are the flexor carpi radialis, which flexes the hand and fingers, and the flexor carpi ulnaris flexes, which adducts the hand. These are two muscles that are extremely involved in grip strength and function [7]. Additionally, the exor digitorum supercialis is the main muscle that specifically targets the extension of the hand, which is the main muscle target of our project. All of these muscles travel down the forearm and onto the hand, and are not solely muscles just in the hand. The muscles that are extrinsic on the forearm are what control most of the grip strength in the human hand. These are the main muscles that need to be targeted for our project.

When researching for this project, our team began by expanding our knowledge of the human hand's anatomy to understand better how to approach creating a device that focuses on the flexion and extension of the hand muscles. After we had a better grasp of the anatomy, we moved on to understanding how strokes and traumatic brain injuries present in patients, and also their path to recovery. We researched both strokes and TBIs because they present very similarly to one another, and there is far more literature on stroke rehabilitation. We also researched competing designs to gauge the other products available to consumers. This allowed us to figure out what worked well and what did not, and apply those findings to our final design. Now that we have chosen our final design, we have turned our attention to researching sweat-resistant biomaterials that can be easily sanitized. The device must also be lightweight and provide as much comfort to the client as possible.

Our client was a professional skier before he suffered a traumatic brain injury, resulting in him being hemiplegic (having paralysis or weakness) on the right side of his body. The resting state of his right hand is currently a fist, and the goal of our design is to work on opening his hand specifically to assist him if he falls and needs to get back to his feet by himself.

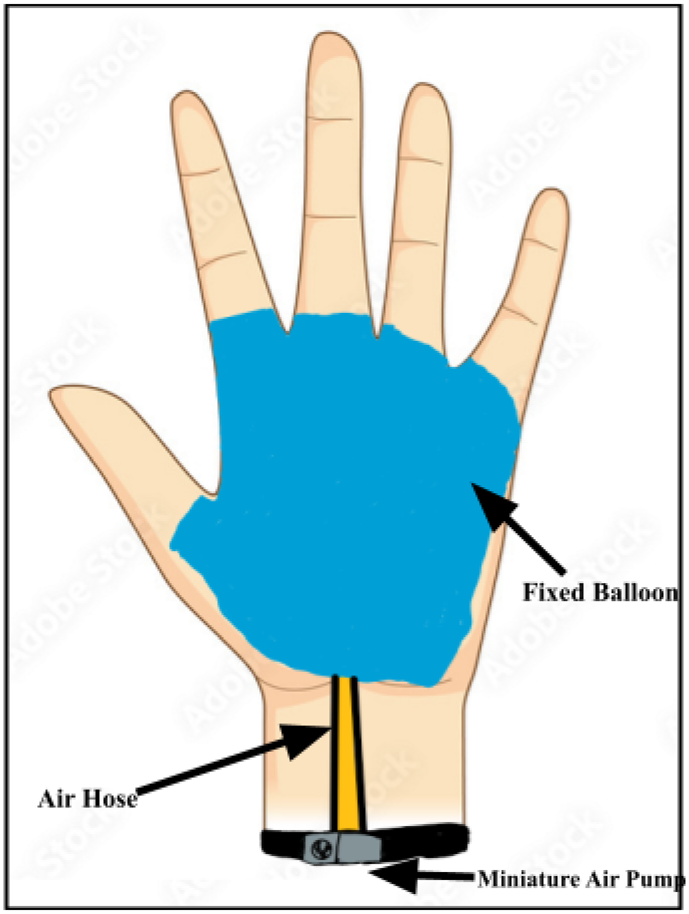
The client's requirements for the device were that it must be easy to put on, it must be adjustable so as to fit multiple hand sizes and grip strengths, it must allow quick and safe release of objects in case of emergency, and it must be easy to sanitize for frequent use. With these criteria in mind, we began to formulate design ideas to best meet the specific needs of our client. (See full PDS in Appendix 1)

Preliminary Design



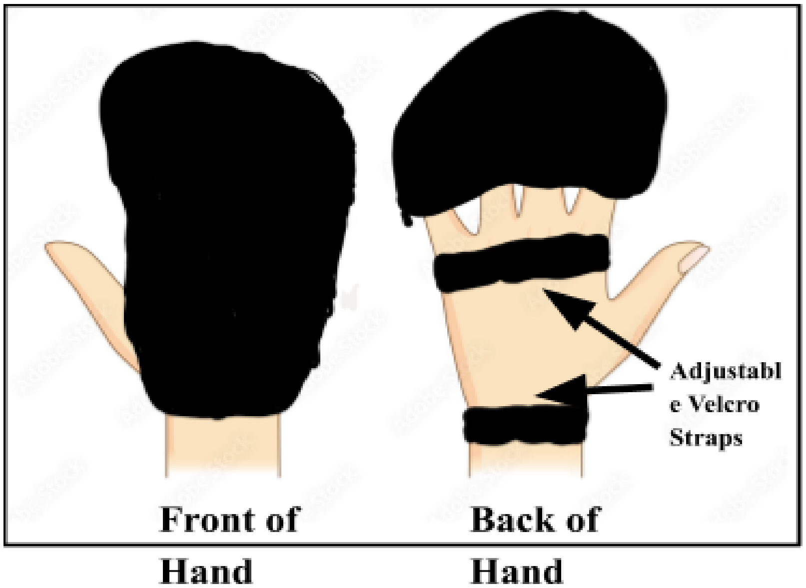
Hooks & Bands

This design utilizes a system of high tension elastic bands to assist with hand extension by gently pulling the fingers back into an open position. Each band provides controlled resistance and is hooked at a central connection point located on the back of the hand. When the central point is pulled backward, the tension in the bands increases, extending the fingers outward from a clenched position. The central connector can then be hooked onto the back of the glove to maintain the hand in an open configuration, allowing the user to rest without actively exerting force. The elastic bands are attached to open silicone rings that fit around each finger. The rings are designed with a small gap that allows them to be slipped onto the user's fingers without requiring the hand to be opened first, an essential feature for patients with limited finger mobility due to stroke or neurological impairment. The open ring structure provides both stability and ease of use while distributing tension evenly along the fingers to prevent discomfort.



Balloon Glove

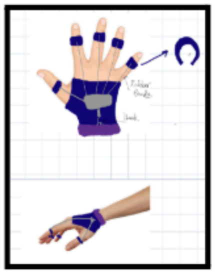
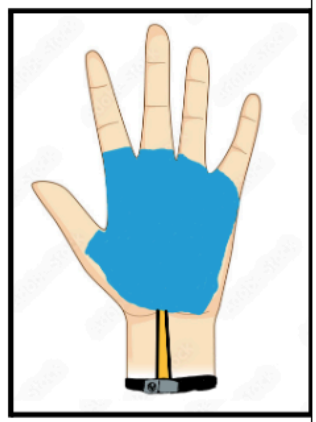
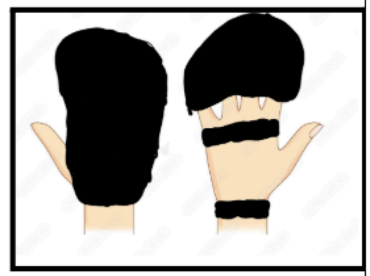
This design uses a deflated balloon shaped like the lower section of the hand. The way this device would open the hand is by inflating the balloon to expand outwards from the palm and push against the inner surface of the fingers which will cause the hand to open from its original clenched position. The balloon component would be fixed to the palm of the glove and secured using rubber clips inside the gloves lining. This positioning would ensure that the balloon maintained the correct shape and orientation while it is inflated, to attempt to mimic natural finger motion. Airflow would be controlled by an air hose that connects the air balloon to a compact electric pump that would be located on the velcro wrist strap. This creates an overall, lightweight and portable solution with this device.



Hinge Mitten

This design focuses on the user's hand enclosed within a soft, supportive mitten structure that helps maintain alignment and comfort during operation. The mitten is secured with an adjustable strap that runs over the top of the hand and wrist, ensuring the hand remains properly positioned throughout motion of the hinge. Beneath the palm of the hand lies a mechanical hinge mechanism that begins in a closed, locked position when the device is at rest. In this starting state, the user's hand naturally wraps around the hinge in a fist like posture, mirroring the hand's natural resting grip. The hinge is electronically connected to a compact power source along with a simple control board that regulates the motion sequence. When activated, the hinge mechanism is powered to extend and "snap open," converting stored mechanical energy into motion that gently pushes the fingers outward. This controlled movement transitions the user's hand from a clenched fist to an open, extended position of about 180 degrees.

Preliminary Design Evaluation

		Design 1: Hooks & Bands		Design 2: Balloon Glove		Design 3: Hinge Mitten	
							
Criteria	**Weight**	Score (Max 5)	Weighted Score	Score (Max 5)	Weighted Score	Score (Max 5)	Weighted Score
Range of Motion	25	5	25	2	10	3	15
Patient Comfort	25	2	10	3	15	4	20
Amplification	20	4	16	2	8	2	8
Adjustability	15	3	9	4	12	4	12
Safety	10	3	6	5	10	4	8
Cost	5	4	4	2	2	3	3
Total	**100**	70		57		66	

Range of Motion:

One of the most important criteria for this project is the maximum Range of Motion that can be accomplished with the design. In this context, the Range of Motion criteria refers to the maximum angle that is formed from the knuckle bone of the finger to the tip of the finger to test the flexibility of each device. The Range of Motion is important to the device because it will assist us in evaluating the effectiveness of each design. For this reason, Range of Motion is weighted 25/100 in our design matrix, as it directly reflects the design ability to meet core goals of the project.

The Hooks & Bands design scored a 5 out of 5. The range of motion that is provided with each band with the ability to increase the tension by using the hooks greatly puts this design above the rest. The mobility of each ring being attached to each individual finger allows for much more range of motion which adds to this design.

The Balloon Glove scored a 2 out of 5. The design uses an inflating balloon to initially get the hand to an open position but after fully expanded, the user's hand will not be able to reach the maximum range of motion. In addition, it may raise the fingers unevenly, further limiting flexibility.

The Hinge Mitten scored a 3 out of 5. By using a flat hinge, it moves the entire hand and fingers upward together, achieving an open-hand position. However, this design only allows motion in one direction and prevents natural gaps from forming between the fingers, limiting its overall flexibility.

Patient Comfort:

Patient comfort is very important to this project as it is being designed to improve the quality of life of a specific patient. The final product should be comfortable enough that the patient actually wants to use it frequently. Comfort is a difficult quality to quantify, especially since we do not know the exact materials we are using yet. Comfort is weighted at 25/100

We rated the Hooks & Bands design a 2 out of 5. The high tension bands could cause some discomfort by pulling the glove and the patient's wrist forward. The glove will most likely have to be made of some hard material like plastic in order to hold the bands with tension. This can be adjusted for with padding underneath but still gives this design a low patient comfort rating.

The Ballon Glove design was rated a 3 out of 5 for patient comfort. This design does not open the hand all the way, this would most likely be more comfortable for the patient, but it does sacrifice functionality. The balloon glove would fit to the patient's hand slowly as the balloon expands. The wrist device that inflates the balloon would be somewhat heavy and uncomfortable so this design was rated as our middle comfort option.

The Hinge Mitten design received the highest comfort rating of 4 out of 5. This design would open slowly and evenly which would be very comfortable for the patient. The design does not require the patient to put on a glove like the other two designs, this is important since the patient cannot open their hand unassisted. The mitten would also be padded on the top to provide more comfort to the patient. The only reason this design is not rated a 5 is because the patient must grip the mitten by opening their hand slightly.

Amplification:

Refers to how effectively the device multiplies a small input (like a pull, inflation, or hinge motion) into a larger, useful opening movement of the patient’s fingers. Since the patient has limited voluntary motion, the device must provide mechanical or powered assistance to amplify that motion into meaningful finger extension. Amplification was weighted 20/100.

The Hooks & Bands design scored a 4 out of 5. The high-tension elastic bands provide strong amplification because a small amount of pulling force translates into significant finger extension. This makes it highly effective at magnifying limited input into large finger movements. However, the strong forces may feel uncomfortable or unnatural if not carefully tuned.

The Balloon Glove design scored a 2 out of 5. The inflatable balloon gradually pushes the hand open, but the amplification is weak since most of the “input” comes from the balloon expansion itself rather than a small motion being multiplied. The effect is more gentle and progressive, but it doesn’t provide a powerful amplification of motion.

The Hinge Mitten design scored a 2 out of 5. The hinge mechanism is powered electronically, so the “amplification” is not mechanical but rather dependent on the motor/hinge. It can open the hand, but the movement is more of a direct action rather than an amplification of a small patient input. Because of this, the score is lower than Hooks & Bands.

Adjustability:

Another important criteria for the project is the adjustability of our design. This criteria refers to the ability of our design to fit users that are not our client and work easily for hands that are bigger or smaller. Aspects that affect the adjustability include the flexibility of materials that we use and if the size is adjustable. Adjustability is important because if our design works well for our client, it has the potential to work well for other TBI and stroke patients that are hemiplegic. However, the focus of this project is on helping our specific client, which is why we have Adjustability weighted 15/100.

We rated the Hooks & Bands design a 3 out of 5 because while the rubber bands are flexible, we were concerned that the rings that go around the clients fingers are a specific size. On smaller hands, the rings would simply slip off and be useless, while on larger hands the rings wouldn’t even be able to be put on.

We rated the Balloon Glove design a 4 out of 5 because it is a pretty adjustable design. The glove that we plan to pair with the balloon would be attached to the wrist with velcro, meaning that it would be able to fit on hands of all sizes. Additionally, the balloon is able to be blown up as much or as little as needed, which also helps with adjustability.

Finally, we rated Hinge Mitten a 4 out of 5 as well. We discussed the similarities between the Hinge Mitten and a tool used for a large number of clients in UW Adapted Health that allows stroke patients to grip rehab machines. It is another adjustable design because it utilizes velcro and a design less tailored to a specific person because it is larger and would work on hands of different sizes.

Safety:

Another key factor to this project is the safety of the design for the patient. This criteria means that the design will be safe for the patient to use and protect the user from any further injuries that could result from the design itself. This criteria is important because we want the patient to be able to use the mechanism comfortably without the worry or risk of further injury. The area of focus for this project is the hand, which has many sensitive tensions and ligaments. It is imperative that our design isn’t too powerful where it rips or tears any of the muscles in the hand, and it is comfortable on the user's hand without any sharp edges. Since the safety of the design is necessary for success, we rated it a 10/100.

We rated The Hooks & Bands design a 3 out of 5 for safety because some of the features of the design have room for potential injury. For instance, rubber bands have the potential to snap if they have too much stretch and tension. If this occurred, the bands would snap onto the patient's hand resulting in potential injury. Additionally, the hooks added onto the fingers of the base would most likely be made out of metal. If metal is not sawed down and smoothed, it has the potential to be sharp which would be harmful to the patient. Because of these two features of the design, we ranked it a 3 out of 5.

We ranked The Balloon Glove design a 5 out of 5 for safety because there are few features that would cause this design to be unsafe. The design would be centered around a balloon or inflatable object, which is a squishy and comfortable feature. Additionally, we would use velcro to attach the balloon to the hand, which is a material that is extremely safe and comfortable.

Lastly, we ranked The Hinge Mittens a 4 out of 5 because the design is relatively safe but has a few features that could be slightly risky. The mitten and strap over the top of the hand is extremely safe and will be made out of safe and comfortable material. However, the hinge could be slightly unsafe because it will be snapped upward electronically. We need to make sure that the hinge doesn't have too much power and open snap too quickly. This could result in the hyperextension of the finger. However, once we complete many tests and find the right amount of energy needed, the design will be extremely safe.

Cost:

In all designs, minimizing cost is always a goal. For this project, the budget is currently unknown but ensuring the cost is as low as possible makes the device more inclusive for many groups. Though cost is important to the design, it is not a core goal which is why it is weighted 5/100.

The Hooks & Bands scored a 4 out of 5. This is because the cost of the hooks are quite minimal as well as the rubber bands that will be holding most of the design together. A glove will also be modified to fit the main part of the hand which will have little cost all together.

The Balloon Glove scored a 2 out of 5. Sourcing a balloon of the correct size and shape could be more costly, and the miniature air pump required adds a significant expense compared to other designs.

The Hinge Mitten scored a 3 out of 5. Its main components are a glove with Velcro and a denser hinge material. While not overly expensive, the hinge makes it slightly more costly than the Hooks & Bands design.

Final Design

Out of our three options the Hook and Bands design had the highest overall score of 70. This design performs well in the range of motion, amplification and cost categories, which are all very important to this project. Ultimately we choose this design because of its simplicity and effectiveness when it comes to amplification. The changeable rubber bands allow this design to be easily modified for different hand strengths and the lack of complex electronics makes the glove more intuitive for the client to use and less prone to failure. The client will be able to put on the glove unassisted using the overhand glove design and open rings. This would not be possible for the other designs. We currently have rough dimensions of the clients hand that we are using for the size of the glove and rings. The glove will be 6.5 cm wide and 12 cm long. The thumb ring will have a circumference of 5.4 cm, the index, middle and ring finger rings will have a circumference of 5.5 cm and the pinky ring will be 6.5 cm. The wrist band circumference will be 17.5 cm. The rubber bands will reach from the center of the hand to the bottom segment of each finger and shorter bands will reach from the bottom segment to the middle segment.

Fabrication

Materials

The half glove will be made using a work glove, this soft material will be easy to cut into the shape we need and will be comfortable for the client, while still being stiff enough to not be pulled forward by the bands. We will use silicone rings with a metal wire inside. This will allow them to slip on over the fingers with relative ease, while not easily coming off when the bands pull at them at an angle. For the hooks we will use small metal s-hooks, we can attach these to the rubber bands using heat shrink tubing. The hooks will meet at a central connector that we will 3D print using PLA filament.

Methods

1. 3D Modeling: the entire glove will be modeled but specific detail will be given to the hook connector. This is the only part we are currently planning on 3D printing, but the rest of the model is still important to make sure this piece makes sense in the context of the device.
2. The Half Glove: The glove will be constructed using a right-hand work glove with the finger and palm section cut off. The hook and band wrist strap will remain on the glove to secure it to the clients hand. This wrist strap will have a circumference of 17.5 cm to match with the clients wrist.
3. Hand Hooks: 3 metal s-hooks will be sewed to the back of the glove. The first two will be on the center of the glove with one further up than the other to allow for adjustability. These hooks will be used to hold the hook connector. The final hook will be for the thumb since it will need to be pulled back at a different angle than the other fingers.
4. Hooks and Bands: To attach the hooks to each end of the bands we will be using heat shrink tubing around the base of each s-hook and the both ends of each rubber band. This will allow the bands to be grabbed and attached easily by the client.
5. Rings: We will use stiff silicone rings and cut out the bottom section of each ring. These alone will not hold their shape well enough to keep the rings on the clients fingers so we will need to feed carbon steel wire through each ring and shape them into open rings. Carbon steel wire is flexible enough to be bent but will still retain its shape once we form it into rings.

Figure[8]: Work gloves with hook and loop wrist strap

Testing and Results

The prototype will be tested across several key criteria, including range of motion, comfort, amplification, adjustability, safety, and durability. There should be showing that the glove allowed substantial extension, approaching a near open-hand position. Comfort will be evaluated during 15 minutes of simulated daily tasks, with participants providing feedback on pressure, skin irritation, and wearability. A force gauge measurement will confirm that the relatively small input tensions produced significant finger extension, validating the intended amplification effect. The glove was also fitted to hands of varying sizes, demonstrating adequate adjustability, though finger ring sizing posed a limitation. Safety will be assessed through over-stretching and cycling of the elastic bands, which will reveal no immediate hazards, while durability tests involve repeated open-and-close motions, indicating that the prototype could withstand repeated use without loss of function.

Additional usability tests adapted from previous prototypes were also performed. Grip strength was measured with a dynamometer before and during weekly use of the device (with the glove removed during testing) to track long-term improvements. Ease of use will be evaluated by asking participants to put the device on using only their dominant hand and rate the process on a 1–10 scale; results may indicate that while the device could be donned independently, finger loops required extra adjustment. Everyday task testing involved observing the client perform activities such as gripping objects, holding a handle, and releasing items, followed by self-evaluation of usefulness.

Discussion

Overall, the Hooks & Bands glove effectively supports finger extension for hemiplegic patients while remaining lightweight and easy to use. Compared to earlier design concepts, this prototype will achieve a greater range of motion and adjustability without relying on bulky hardware. Comfort testing highlighted the need for additional padding or alternative band materials to reduce localized pressure, but overall scores indicated acceptable usability. The amplification tests will confirm the core design principle, showing that low tension could translate into meaningful hand extension. While rubber band snapping remains a potential safety concern, medical-grade elastics or protective sheaths could mitigate this risk. Possible limitations of this device include a small sample size, approximate force measurements, and a lack of flexion support, which may be important for comprehensive rehabilitation. Nonetheless, the device demonstrates strong potential as a low-cost, accessible alternative to complex robotic gloves, with future improvements aimed at enhancing comfort, adjustability, and long-term durability.

Conclusions

The client requested a device that assists with the opening and closing of the hand, as well as the rehabilitation of grip strength over time. The device must be easy to put on, and the client must be able to put on and operate it independently. The material of the device must be lightweight, easy to sanitize, and comfortable for the client. The final design consists of a system of silicone rings that attach to multiple sections of the client's fingers. From there, rubber bands of different elasticities attach to the rings and meet in the center of the hand on a joiner. The joiner is then able to hook onto hooks of varying distances from the fingers, pulling back the rubber bands and extending the fingers. The rings allow the device to be put on without the client's hand being forcibly opened, allowing him to put on the device independently. The silicone and rubber bands are easy to disinfect, and the adjustability of the design will allow the client to be comfortable during rehabilitation.

Our future work will focus on finalizing materials and beginning the fabrication of our grip strength device. We have determined the materials for most aspects of the device, but choosing a comfortable, safe, and easily cleaned material for the ‘half glove’ that will rest on the back of the client's hand will take further research, as well as trial and error. Additionally, the budget will need to be determined by the client so we can order materials without going over budget. We will purchase materials through Shop UW to make the ordering process simple. Moreover, after we complete the construction of our prototype, we will perform the aforementioned testing procedure. Our team will document the successes and failures of our product and make adjustments to the prototype accordingly before the final presentation.

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Appendix

Appendix I: Product Design Specifications

Function

The device must assist the user with impaired hand function by enhancing their ability to open and close the hand with greater strength and control. It should assist to initiate movement when needed and resistance to build muscle strength during rehabilitation. The device should promote dexterity, independence in daily activities, and measurable progress in grip strength over time.

Client requirements

- The device must be easy to put on and remove.
- Adjustable to fit different hand sizes and grip requirements.
- Must allow safe and quick release of objects in case of emergency.
- Must be easy to sanitize for frequent use

Design requirements

1. **Physical and Operational Characteristics**
    a. **Performance requirements**
        i. The most important performance requirement of the device is to improve the client's grip strength, the goal being to achieve full strength after having suffered a traumatic brain injury.
        ii. The device must also be easy to take on and off without assistance.
        iii. Must transmit and store grip strength information to track the progress of the client over time.
    b. **Safety**

    i. The device must be made with materials that do not irritate the skin, and fit comfortably on the hand
    ii. Must allow for quick release of objects in case of emergency

c. **Accuracy and Reliability**
    i. Device must be versatile and allow the user to perform multiple tasks with objects of different sizes and shapes
    ii. Device must report feedback accurately and consistently, allowing the client to understand progress or setbacks in their grip strength training

d. **Life in Service**
    i. The device should be reliable for at least one year with regular use. Components should be replaceable for ease of repair.

e. **Shelf Life**
    i. The lifespans of any sensors or electronics used should be considered
    ii. If a battery is required it should be replaceable and removable for storage

f. **Operating Environmen**t
    i. Product will be used in a gym during workouts/physical therapy sessions
    ii. Durability should reflect this: sweat-proof, breathable, flexible

g. **Ergonomics**
    i. Glove should be comfortable for the client to wear when working out
    ii. The glove needs to be put on by a person with limited hand mobility

h. **Size**
    i. The device should be around the size of the client's hand. The device will need to cover up to the fingertips of the hand and around the palm of the hand.
    ii. The average size of a male hand is length of about 7.6 inches and a width of 3.5 inches so our design will be in similar dimensions.

i. **Weight**
    i. The weight of our object should be light and should not put an immense amount of pressure on the clients hand. The client has mobility issues with extending open his hand, so the object can’t be too heavy because that would make it extremely difficult for the client to learn how to use the tool.

j. **Materials**
    i. The materials that we choose to use will have to be comfortable and durable. The client will have to wear this product while working out and potentially for everyday use, so it is necessary that it is comfortable material. The materials will also have to withstand and last during strenuous activities.
    ii. There will also need to be a power source so materials like batteries and wires will be necessary so the object can move and pull the hand open.

k. **Aesthetics, Appearance, and Finish**
    i. The product will be worn frequently, so it should be clean and have good aesthetics. Additionally, it should not have anything sharp or unsafe protruding for the device because the client could get injured. Objects like wires and batteries should not be shown on the device and should be concealed appropriately.

2. **Production Characteristics**
    a. **Quantity**
        i. Only one final device will be needed to be fabricated with the option of being scalable for mass production.
    b. **Target Product Cost**
        i. Current competing devices range from $90 to $400. Low cost materials and modular design should be implemented to reduce replacement costs.
3. **Miscellaneous**
    a. **Standards and Specifications**
        i. The device must adhere to basic safety and usability standards for assistive and fitness devices, prioritizing user comfort, ergonomics, and injury prevention. Where applicable, guidelines from the Americans with Disabilities Act (ADA) and ASTM standards for fitness equipment will be referenced. The mechanism should also follow university safety protocols for electronics and mechanical design.[1]
    b. **Customer**
        i. The primary customer is Dr. Kecia Doyle, representing UW Adapted Fitness. The client is a longtime Adapted Fitness participant with a specific need for grip strength improvement in one hand. The device should be tailored to his abilities, preferences, and fitness goals, while also providing value for broader adapted fitness applications.[update when we meet John(patient)]
    c. **Patient-related concerns**
        i. The client's comfort, safety, and motivation are central to the design. The mechanism must not cause pain, strain, or unintended injury during use. Ease of use, adjustability, and the ability to operate independently (when possible) should be taken into consideration. The design should accommodate variability in grip strength and hand dexterity.[update when we meet John(patient)]
    d. **Competition**
        i. Commercial grip-strength trainers exist (spring-loaded hand grippers, therapy putty, squeeze balls), but they are not customized for adapted fitness clients with asymmetric grip ability or integration into workout routines[2]

References

[1] ASTM International, ASTM F3021-17(2023): Standard Specification for Universal Design of Fitness Equipment for Inclusive Use by Persons with Functional Limitations and Impairments. West Conshohocken, PA, USA: ASTM International, 2023. [Online]. Available: https://www.astm.org/f3021-17.html

[2] Flint Rehab, "9 Best Physical Therapy Tools for Hands: Improve Strength, Mobility, and Function With Rehab Tools at Home," *Flint Rehab*, July 21, 2025. [Online]. Available: https://www.flintrehab.com/physical-therapy-tools-for-hands/. [Accessed: Sept. 18, 2025].

Appendix II: Expense Table

Item	Description	Manufacturer	Mft Pt#	Vendor	Vendor Cat#	Date	QTY	Cost Each	Total
Category									
Rubber Bands	Staples Economy 64 Rubber Bands, 3 ½" x ¼", 95 Pack	Staples	28611-CC	Staples	143297	10/8/2025	1	$5.79	$5.79
S Hooks	¾ in. S-Hooks (for band attachment)	Grainger	U17380.000.0075	Grainger	2ZDK2	10/8/2025	1	$4.39	$4.39
Carbon Steel Wire	Carbon steel wire	Grainger	501	Grainger	15V227	10/8/2025	1	$18.24	$18.24
Glove	Glove to embrace the hand	Grainger	902L	Grainger	26H497	10/8/2025	1	$19.99	$19.99
Silicone Rings	Silicone Ringers for the joints of the hand	MSC	ZMSCS 70109	MSC	2047694	10/8/2025	10	$3.30	$33.00
3D Printed Band Center	3D print bands for around joins of finger					10/8/2025	10	$2.00 hour	$16.00
Heat Shrink Tubing	Heat shrink tubing around the rubber bands	Grainger	CPO18706	Grainger	3KH56	10/8/2025	1	$15.51	$15.51
								TOTAL:	**$97.41**