BME Design-Spring 2020 - Brittany Glaeser
Complete Notebook

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KAITLIN LACY

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Team Contact Information

Brittany Glaeser - Feb 26, 2020, 12:10 PM CST

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Project description

ZOE SCHMANSKI - Feb 25, 2020, 6:21 PM CST

Course Number:

BME 301

Project Name:

Climber's Forearm Trainer

Short Name:

forearm_trainer

Project description/problem statement:

Many climbers may develop a condition known as Climber's Elbow in which the tendons between the pronator teres and forearm muscles to the medial epicondyle of the elbow develop micro-tears that accumulate over time. Currently, there are stretches available to climbers to help ease the discomfort and delay the onset of this injury. A device is needed to help build muscle strength in the forearm to help prevent this injury or at least slow its progression. The device will include adjustable resistances that will allow the user to increase the amount of force as the muscles grow. An adjustable resistance will also allow the device to be used for other athletes; not just climbers. The forearm trainer should also be able to strengthen as many of the forearm muscles as possible. The device also needs to be portable enough so that it can be used in a variety of applications.

About the client:

Dr. Chris Vandivort is an Emergency Physician at UW-Health. In his free time, he likes to climb, and he has developed Climber’s Elbow in the past. This led him to be in need of a device to help prevent and rehabilitate Climber’s Elbow.

2020/02/07 Initial Client Meeting

KAITLIN LACY - Feb 21, 2020, 4:45 PM CST

Title: Initial Client Meeting

Date: 2/7/2020

Content by: Kaitlin Lacy

Present: Brittany Glaeser, Kaitlin Lacy, Zoe Schmanski, Jonathon Murphy

Goals: Discuss the goals of this semester with our client, and confirm details of the project.

Content:

Our client would like us to include an element of grip strength into the device to allow it to be a more all-inclusive piece of equipment for climbers. There are currently grip strengthening devices on the market, but these devices involve more flexion than extension, so the client would like us to focus on extension. The devices currently on the market are also limited on their range of motion, so he would also like the team to try and include a larger range of motion in the grip strengthener. The angle of the L-piece needs to be changed for better comfort, but does required to be adjustable as previously thought. It could be still be included in the final design if the team still thinks it offers a benefit to the consumer. Finally, the team discussed the option of laser cutting the device out of plastic to allow for smoother plastic pieces. This would reduce the amount of friction generated in the device and would allow for a more professional finish.

Conclusions/action items: Start brainstorming grip devices that follow the client's requests. Discuss the details of the meeting with Dr. Puccinelli.

2020/02/27 Discussion of Proposed Final Design with Client

KAITLIN LACY - Apr 28, 2020, 10:25 PM CDT

Title: Discussion of Proposed Final Design with Client

Date: 2/27/2020

Content by: Kaitlin Lacy

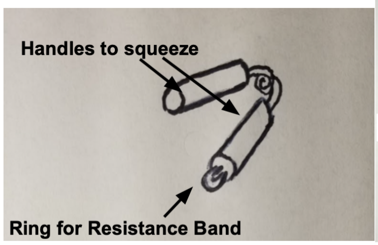
Present: Entire Team

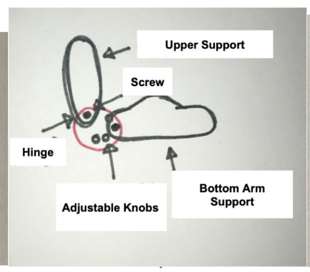
Goals: Explain our proposed ideas to the client to obtain his feedback and suggestions as well as approval to move forward with the design.

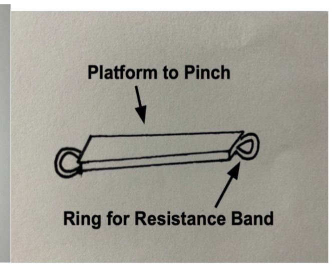
Content:

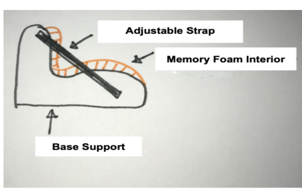
The team met with the client over FaceTime to discuss the initial designs from the preliminary presentation. The pictures below are included below for reference. Discussion about the designs was brief, but he seemed to like the pinch grip which was the top design before the meeting. He really liked the idea of incorporating a way to have exercises for grip training with a full range of motion, but agreed that an isometric exercise might be a potential alternative.

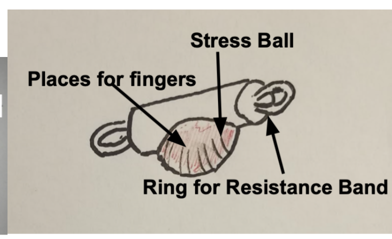
The straps design was the other preferred design for the base piece; however, he did not seem very concerned about adjusting the angle of the design. It may be possible to choose a set angle instead of finding a way to change the angle as this could introduce a potential failure point of the device.











Figures 1-5: Sketches of the five preliminary designs - Gripper, Hinge, Pinch Grip, Straps, and Stress Ball Grip respectively.

Conclusions/action items: The team will move forward with the pinch grip, but will continue to brainstorm ways to incorporate a dynamic movement with the training such as adding clips. The straps design could move forward to the proposed final design, but more brainstorming will be done to decide whether or not an adjusted angle will be needed.

KAITLIN LACY - Apr 28, 2020, 10:10 PM CDT

2020/02/07 Initial Advisor Meeting

KAITLIN LACY - Feb 09, 2020, 7:40 PM CST

Title: Advisor Meeting 2/7/2020

Date: 2/7/2020

Content by: Kaitlin Lacy

Present: Brittany Glaeser, Kaitlin Lacy, Jonathan Murphy, Zoe Schmanski

Goals: Discuss previous semester work and goals for the current semester

Content:

As the design from last semester was successful in isolating the intended forearm muscles, this semester's design can build off of it to improve certain features and add new functions. One possibility discussed was looking for existing equipment that may be larger to find features and functions that could be applied to this device.

The dates for progress reports was changed to Monday night or early Tuesday mornings. The group also has the option to send PowerPoints and posters ahead of time for review as long as they are sent by the Wednesday before being used.

Some points about IDR submission were clarified. The group has one year from disclosure to file. A thorough patent search will need to be performed as well as making sure that the device is new relative to existing patents and is not obvious. The IDR should be filed some time after preliminary designs are decided upon.

Conclusions/action items: Meet with client to obtain the prototype and solidify goals for the semester. Brainstorm some preliminary designs pertaining to increasing grip strength for the next advisor meeting on Tuesday. Send progress report on Monday.

2020/02/11 Initial Design Ideas - Advisor Meeting

KAITLIN LACY - Feb 25, 2020, 11:07 PM CST

Title: Second Advisor Meeting

Date: 2/11/2020

Content by: Kaitlin Lacy

Present: Entire Team

Goals: Discuss design ideas with our advisor.

Content:

During this meeting, the team presented the design ideas that had been discussed over the weekend. Several ideas were mentioned, including using individual resistance bands on each finger that could provide resistance in flexion and extension of the fingers. Stress balls and grip strengtheners that use springs to provide resistance in flexion were also discussed.

We decided to abandon extension motions and just focus on flexion as there are plenty of flexion devices on the market. The grip strengthening component will be built into the handle, and we discussed possibly having the resistive element elsewhere other than the directly in the handle.

The device currently is not very user-friendly, and is actually very complicated to use. We need to improve the ease of use, and this means we will need to complete two design matrices (one for handle and one for usability).

Conclusions/action items: Most of the ideas discussed exist on the market, so we need to come up with more unique design ideas. For our advisor meeting next week, we need design matrices, criteria, and designs. We need to update the PDS with more specific and measurable components. Finally, we should consider talking to climbers about our device.

2020/02/18 Discussion of PDS - Advisor Meeting

KAITLIN LACY - Feb 26, 2020, 2:57 PM CST

Title: Third Advisor Meeting

Date: 2/18/2020

Content by: Kaitlin Lacy

Present: Entire Team

Goals: Discuss preliminary design ideas, design matrices

Content:

Changes to the PDS were discussed and are listed below.

PDS: add forearm lengths/widths

-ensure buckles are different than pre-existing devices

-angle comfort to 99% of people (not a changing angle)

-possibly use thermoformed material?

For the presentation of the PDS, we need to include very specific values in SI units. After going over the design matrix, we decided that the inclusion of the straps should not be considered, just the actual base design part and way to adjust the angle. Possibly consider the geometry/size/weight/bulkiness in the matrix. Also differentiate them between no sides, sides, and rounded sides. We do not need to do CAD drawings for the preliminary presentation.

The pinch grip is not a unique design and Dr. Puccinelli would like us to consider brainstorming a design that would be different than ideas on the market.

Conclusions/action items: Finish presentation and send it Dr. Puccinelli by Wednesday. Change the PDS based on evaluation. Consider the comments made about design matrices and change them if necessary. Rehearse the presentation, and prepare for Friday.

2020/03/03 Proposed Final Design - Advisor Meeting

KAITLIN LACY - Apr 28, 2020, 10:45 PM CDT

Title: Advisor Meeting Discussing Proposed Final Design

Date: 3/3/2020

Content by: Kaitlin Lacy

Present: Entire Team

Goals: Discuss feedback from presentation with Dr. Puccinelli as well as steps to take moving forward.

Content:

We received feedback from our presentation and discussed how to make our future presentations and reports better. After sharing the feedback our client gave on pinch grip and our idea to add clips, Dr. Puccinelli suggested that we make our own through 3D printing. He suggested looking at several suppliers, including Templeman Company and Lee Spring, to purchase springs from as well as a possible idea of incorporating some kind of dial to tighten the springs in order to adjust the resistance.

As far as fabricating the back piece, we discussed ways to improve other than just 3D printing. Thermoforming the final product after using 3D printed prototypes would be a way to create a sleeker looking device. Dr. Puccinelli also suggested solvent smoothing, and encouraged us to look for a resource on the design page for more information. It involves using a chamber of acetone vapor to smooth out any roughness on the part. He also warned us to be careful with this process and not leave it in for too long to prevent degradation of the part.

Finally, he suggested we talk Dr. Wille in order to discuss the impacts of adjusting the angle of the device.

Conclusions/action items: Complete CAD drawings by next week as well as finalize a way to attach the bands. Start ordering parts that have been finalized. Continue to brainstorm ways to incorporate the clips into the device and change their resistance.

2020/03/10 Discussion of Deliverables - Advisor Meeting

KAITLIN LACY - Apr 28, 2020, 11:02 PM CDT

Title: Advisor Meeting Discussion of Deliverables

Date: 3/10/2020

Content by: Kaitlin Lacy

Present: Brittany Glaeser, Marissa Harkness, Jonathon Murphy, Zoe Schmanski

Goals: Discuss feedback. on preliminary deliverables and progress on design.

Content:

The deliverables were a good start, but there are several areas that need to be improved. More detail needs to be provided in terms of the discussion that goes on during team meetings and documentation of items discussed that. were decided against still needs to be included. Overall, more of an engineering approach needs to be applied to the notebooks including calculations and more details about the design process.

For the design, Dr. Puccinelli likes the two designs, the straps design and the pinch grip, but was wary about the ability to produce the straps design through 3D printing. The idea of the design involves bending the back piece slightly in order in change the angle; however, this could introduce strains that could compromise the integrity of the device.

Conclusions/action items: Discuss the straps design in more detail to determine whether or not 3D printing would still be a viable option. Work on making changes to the notebook and continue to order parts as they've been finalized. Update CAD drawings as needed.

2020/03/24 Transitioning to Online - Advisor Meeting

KAITLIN LACY - Apr 29, 2020, 12:31 PM CDT

Title: Advisor Meeting Transitioning to Online

Date: 3/24/2020

Content by: Kaitlin Lacy

Present: Brittany Glaeser, Marissa Harkness, Jonathon Murphy, Zoe Schmanski

Goals: Discuss changes to the course as classes have moved online.

Content:

This meeting centered around the changes to the course now that classes have moved online for the remainder of the semester. Show and tell as well as the poster presentation are cancelled, and presentations will likely be given through BBC or a similar platform. As engineering buildings are closed, no more fabrication and testing can occur, so most of the semester will. center around theoretical and future work. Finite Element Analysis can be conducted on SolidWorks to yield some data on the durability of the device and provide some feedback in terms of failure. FBDs and theoretical calculations will now be an important part of the analysis of the device. With the current uncertainty, the team needs to be flexible and be willing to work around many complications. However, we should be in good shape to finish the semester with a theoretical prototype for our client.

Conclusions/action items: Work on updating CAD drawings and FBDs of the device. Continue to research as a large portion of the project will now rely on research.

2020/04/06 Discussion of FEA and Presentations - Advisor Meeting

Brittany Glaeser - Apr 06, 2020, 12:42 PM CDT

Title: Advisor Meeting

Date: 4/6/2020

Content by: Brittany Glaeser

Present: Team

Goals: Determine next steps for the semester

Content:

- Complete FBD so forces and attachment points can be used for FEA
- PLA is not a material that can be used for FEA in solidworks
    - Can use a material such as ABS as it is very common for 3D printed objects
- For the handle design, we need to decide on the length of the flat portion so that it can fit a wide variety of hand sizes
    - Jonathon had the idea to maybe create different lips along the flat portion so different sized hands have different gripping locations
- Presentations are coming up
    - For presentations it can be a prerecorded video
        - Powerpoint will allow us to have a voice over for the different slides
    - The presentations can be done by zooming in on different portions of the poster or by "cutting up" the poster and placing them on different slides

Conclusions/action items:

The next step for our team will to finish the FEA testing plan and decide if ABS is the plastic we would want to use. The team will also meet to determine what other things need to be done for the presentation.

References:

2020/04/13 Review of Goals for Semester - Advisor Meeting

Marissa Harkness - Apr 13, 2020, 11:14 AM CDT

Title: Advisor Meeting - Review To Do List

Date: 4/13/20

Content by: Marissa Harkness

Present: Team

Goals: To review our to do list and get feedback from Dr. Puccinelli

Content:

Below is the meeting template

1. Testing
    1. Finite element analysis within SW
    2. Hypothetical testing methods
        1. Survey we would have asked
        2. MTS testing
2. Poster presentation
    1. Divvy up sections similar to prelim presentation
        1. Create poster
        2. Create slides
    2. Include old photos and new SW design
    3. Determine if there is an extension to include a video recording on the slides
3. Modify handle design
    1. FBD/mathematical approach/calculations based anthropometric data
4. Pinch grip
    1. Research for importance of static vs dynamic
    2. Find spacing for different finger lengths
5. SW
    1. Location of strap holes
6. Notebook
    1. Meeting notes (1 meeting w/ Pucc)
    2. Testing plan
    3. FBD/mathematical approach/calculations based anthropometric data
    4. Create a doc on things we would have bought or included in design
    5. Summarize what our ideal design would have looked like
    6. Detailed fab plan of what we would have done

            1. Consider writing about injection molding

    7. Future work

7. Refund

8. Deliverables

    1. Final notebook

    2. Final report

    3. Peer evals

Meeting Summary

- Determined our testing plan was appropriate enough for the scope of the semester
- Need to look into a way to video record over our google slides for the poster presentation
- Research spacing between different finger lengths and determine how we will accommodate for this within our design
- Consider including a write-up of injection molding in our fabrication plan
    - Potential method of implementation on a larger scale
- Ask client for a refund for our material expenses

Conclusions/action items:

- Find a way to video record on our presentation slides
- Research finger spacing
- Research injection molding
- Ask client for refund
- Look into protoloab for reviewing our SW design

2020/04/20 Feedback on Poster - Advisor Meeting

Brittany Glaeser - Apr 22, 2020, 9:27 PM CDT

Title: Advisor Meeting - Poster Feedback

Date: 4/20/20

Content by: Brittany

Present: Entire Team

Goals: To receive feedback on the poster and receive answers for any other questions the team has

Content:

- A scale on the FEA should be enlarged so that the forces are readable
- For the FBD, it should not include numbers just variables
- The red in the movement photos should be thicker
- The design criteria should remove any of the obvious ones and others should be quantified more
- FBD should be shown in parallel to show the muscle groups
- References and headings can be made smaller to fit more
- There should be more labels on the solidworks
- There should be a total cost on the poster
- If we don't use a video in the presentation, we should include a picture with a name
- Poster should be uploaded by 10:00 am on Friday

OTHER:

- We should keep a detailed expensive list
    - Maybe add a status column to state whether it was ordered or if we have it or if it is to buy in the future
- All detailed testing protocols should be listed in an appendix of our final report
    - Testing that has not yet been completed should be stated in the future work

Conclusions/action items:

References:

2020/04/27 Discussion of Final Report - Advisor Meeting

Brittany Glaeser - Apr 28, 2020, 10:59 PM CDT

Title: Advisor Meeting

Date: 4/27/20

Content by: Brittany

Present: Team

Goals: Determine what needs to be done for the final report

Content:

- FBD location
  - Should be placed in testing
- N vs. Kg
  - Doesn't matter which we use
  - Should be consistent
  - Kg is a mass
- Citing Christa
  - BME 315, slides, year, personal meeting, and Dr. Christa Wille
- Justification of criteria
  - In the future can combine for the two matrices because they have similar reasonings
  - Can ignore for now
- Constrasting
  - Photoshop
  - Constrast before labels
- FEA scale
  - Change so that it is easier to read
  - Change the units so that they are not in scientific notation
- Discussion
  - Use the discussion for actual numbers and testing for the framework
- Need to determine if we want the design to continue on

Conclusions/action items:

Things to be done: report, lab archives, peer evals, client eval, upload to website

References:

2020/02/16 Preliminary Design Brainstorming - Team Meeting

KAITLIN LACY - Apr 29, 2020, 12:51 PM CDT

Title: Team Meeting

Date: 2/16/2020

Content by: Kaitlin Lacy

Present: Entire Team

Goals: Discuss design ideas, create design matrices, and assign roles for the preliminary presentation.

Content:

We discussed and came up with the following design ideas and matrices.

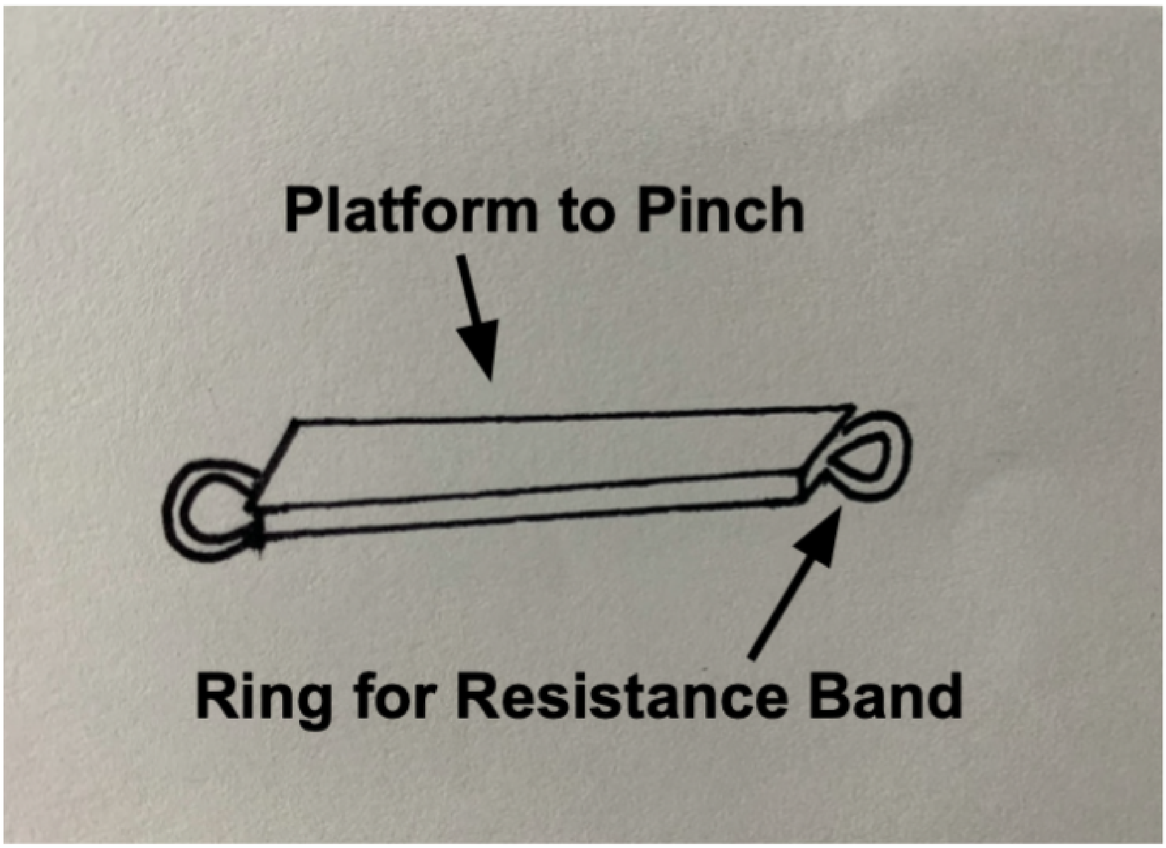


Figure 1: Pinch Grip

This would allow for variable resistance as altering the resistance of the bands would change the resistance of the grip, and it would be easy to fabricate. However, this device only incorporates isometric training while the client was very enthusiastic about the idea of incorporating a full range of motion into climbing exercises. The user would simply grip this like any other pinch grip and perform the suggested exercises from last semester.

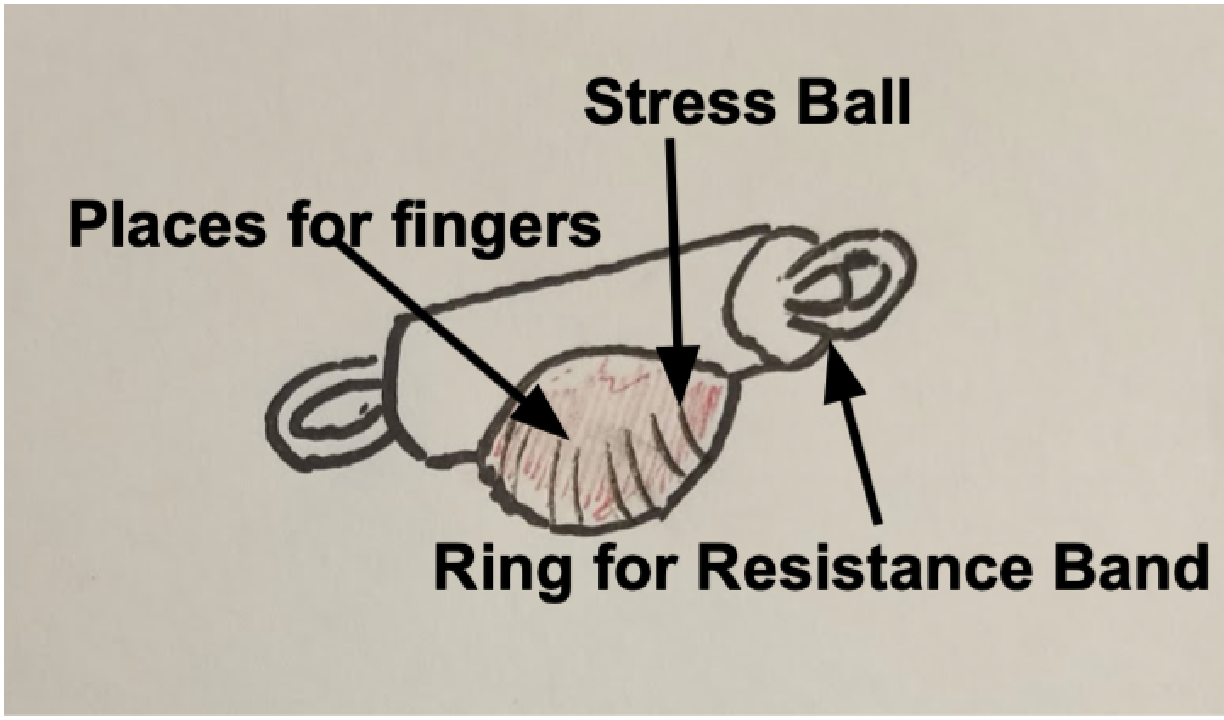


Figure 2: Stress Ball

This device incorporates a stress-ball-like component that would provide resistance when flexing the fingers. There would be grooves in this component to make finger placement more intuitive, and the user would grip the handle to perform the suggested exercises. However, it could be difficult to change the resistance of the training, so incorporating a way to change out the stress ball would improve this design.

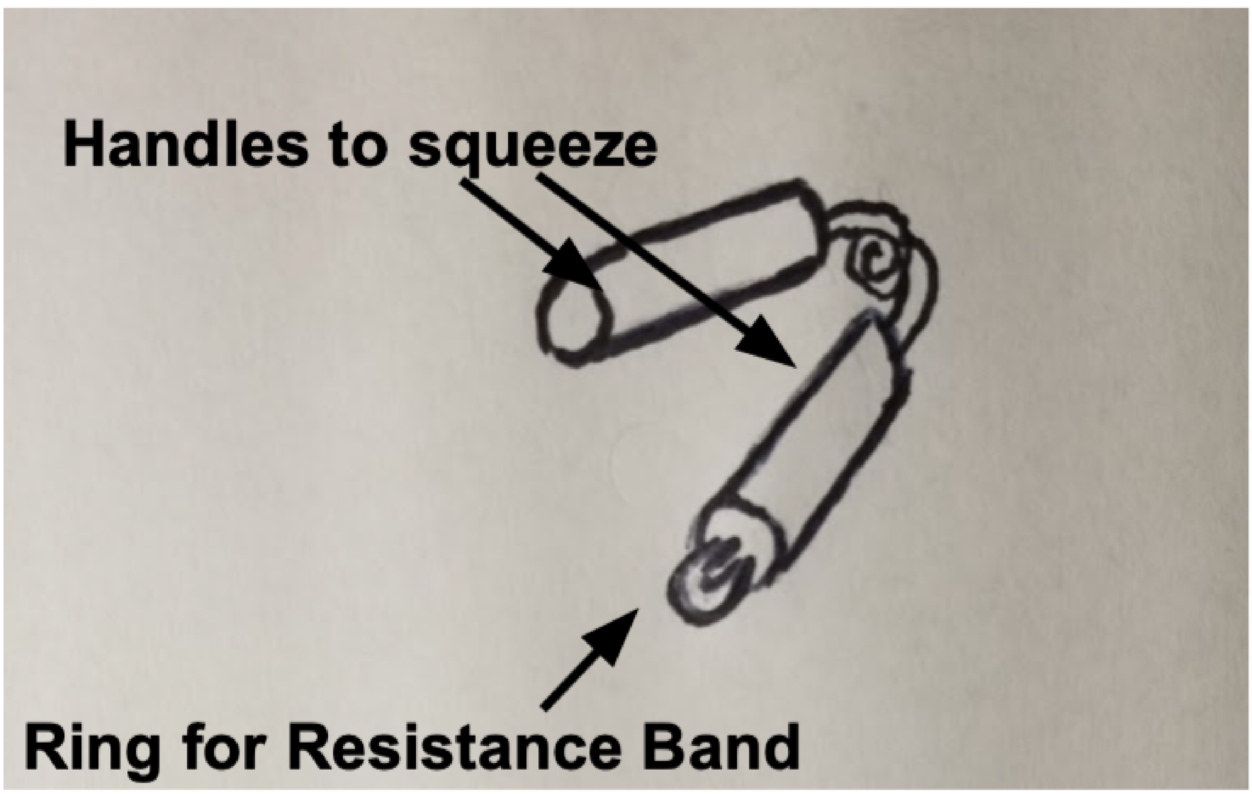


Figure 3: Gripper

The Gripper design would incorporate an already existing grip training device. Normally, the user squeezes the handles together, and the spring provides resistance. One of these handles would be modified to allow the resistance bands to attach, so the user could only grip one handle in order to perform the forearm strengthening exercises with the rest of the device. If grippers with different resistances were found, swapping them out could be a way to change the resistance of the device, but this could get expensive.

See Grip Design Matrix in Design Process Folder. All three devices would be incorporated into the handle of the device.

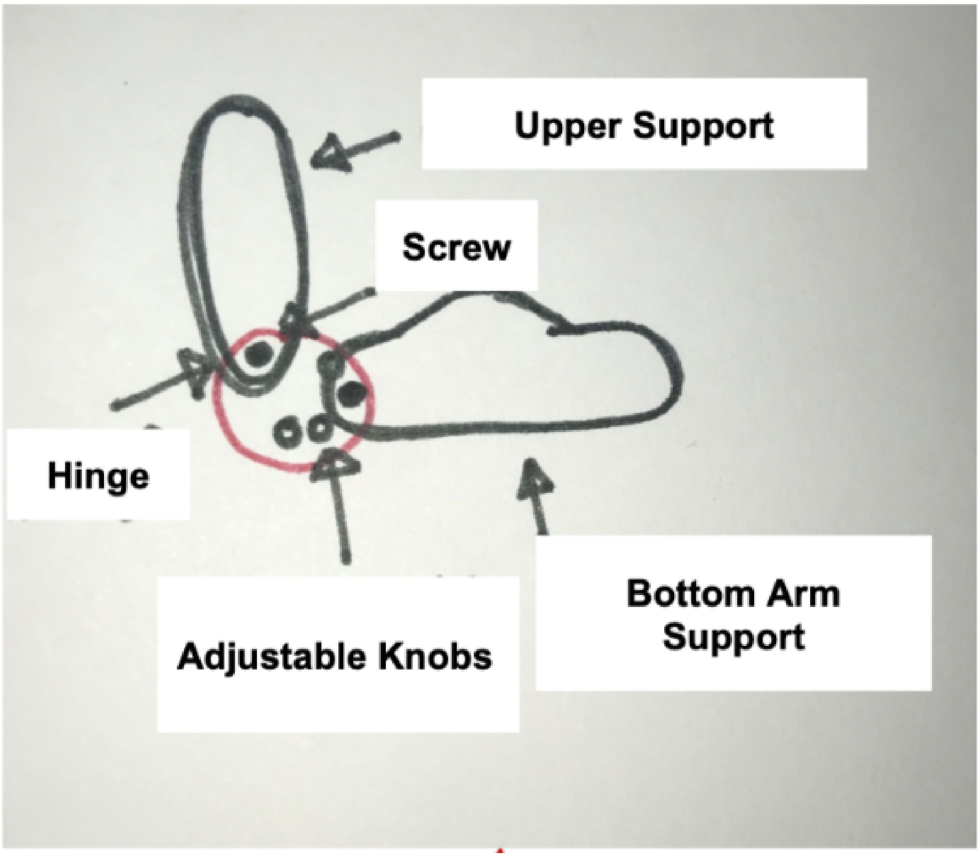


Figure 4: Hinge Design

The hinge design would add an adjustable knob that would allow the user to change the angle of the device. The forearm would be held in place by walls to prevent sideways motion.

This design would allow an easy way to adjust the angle of the device that would be intuitive for a user while the walls would provide much needed stability. This could potentially be difficult to fabricate and may not provide as fine of adjustments as the strap design. However, discussion with the client could provide insight as to how much control the user should have in. changing the angle and the scale of the adjustments.

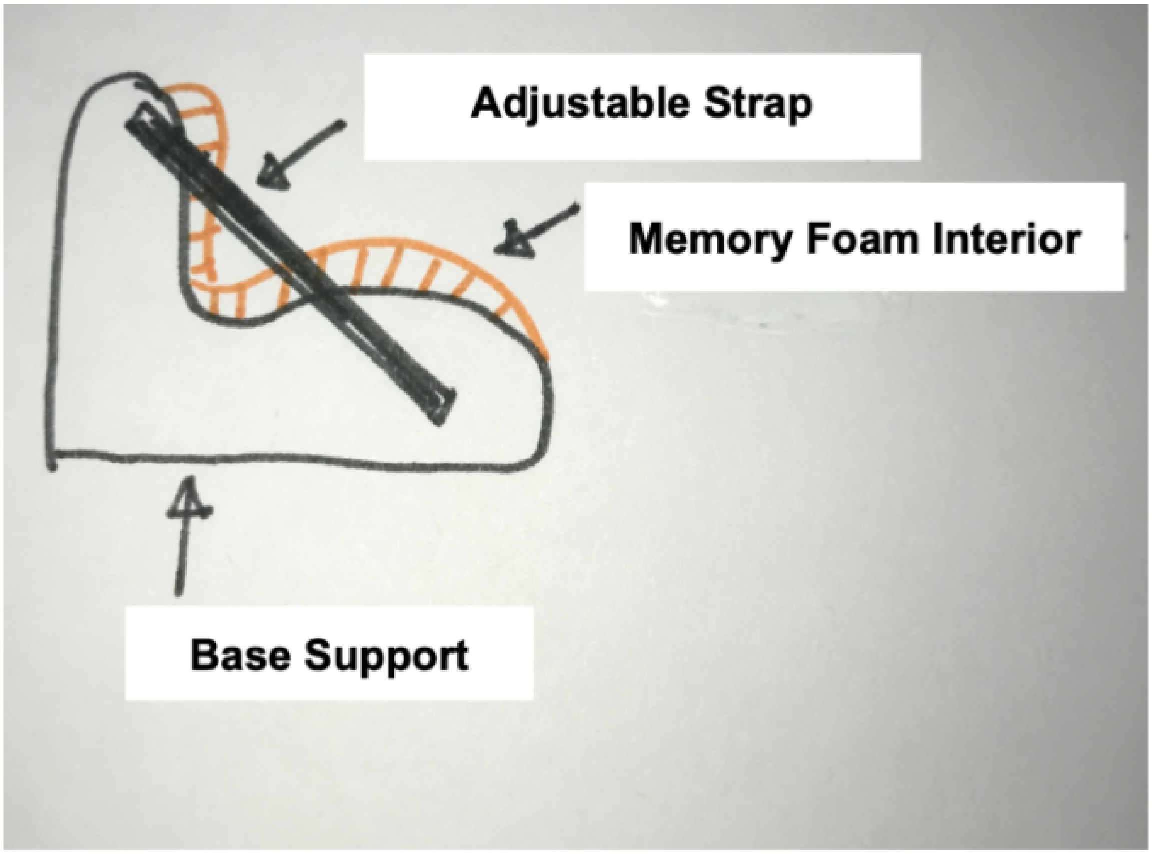


Figure 5: Straps Design

The Straps idea was taken from the adjustable braces that have a strap that changes the angle of the device. We would incorporate a more rigid piece instead of a strap to prevent motion around the elbow. It would also incorporate straps similar to roller blade straps that would replace the velcro currently on the device. It would also feature curved walls that would increase the stability of the arm in the device.

This device would not provide the large changes in angles like the hinge design could which may or may not be beneficial depending on feedback from the client. However, the straps would provide a much easier way to secure the device, and it would likely be easy to fabricate and incorporate into the existing design.

See Base Design Matrix in Design Process Folder

Conclusions/action items: Discuss design ideas with Dr. Puccinelli. The grip designs would be familiar to the climbers based on equipment they've already used and would most likely be intuitive to use. The team is planning on continuing with the Straps design and the Pinch grip, but will continue to research and see if there are ways to improve either design.

2020/02/26 - Materials and Fabrication Meeting

KAITLIN LACY - Apr 28, 2020, 10:09 PM CDT

Title: Materials and Fabrication Meeting

Date: 2/26/2020

Content by: Kaitlin Lacy

Present: Entire Team

Goals: Discuss brainstormed ideas as well as methods of fabrication and materials.

Content:

Prior to this meeting, everyone researched specific aspects of materials and design/fabrication. One topic of brainstorming was finding a way to incorporate a dynamic movement onto the pinch grip. The client is very interested in having a full range of motion with the strengthening exercises. Adding some kind of resistive clip was discussed, and ways to incorporate varying resistances was debated. By attaching all of the clips together, they could be switched out easily for another set of clips with a different resistance. There was a set of clips used to strengthen grip, but the expense of the clips ultimately led everyone to agree on. finding a way to fabricate clips ourselves. 3D printing them would be a possibility, and carefully choosing the springs in the screws would allow for control over the resistance.

As far as the fabrication of the pinch grip itself, we discussed either 3D printing it or using a sheet of plastic such as PLA. One idea brought up was to add some sort of raised edge to prevent the fingers from sliding off. This would prevent easy fabrication with a plastic sheet, so we ultimately chose to go with 3D printing for the initial prototype. Once the dimensions and design are tweaked to the liking of our client, we could potentially thermoform the pieces or look into companies. or resources on campus to make a more polished prototype. Another idea was to use FlexSeal or something similar in order to even out some of the roughness of printing and make a more aesthetically pleasing product.

New resistance tubes were found that will be less bulky and easier to adjust with the hooks on the back. There is a potential way to attach them onto the device through some cone-shaped inserts that would allow the length of the tubing to be adjusted. If this doesn't work, there is a potential to attach the bands using carabiner clips.

Conclusions/action items: We will continue to brainstorm how to attach the clips onto the pinch grip as well as ways to improve the appearance of the final prototype. Finalize the method of attachments for the resistance tubes, and set. up a meeting with the client to discuss our updated ideas with him.

2020/03/12 Team Planning for Online- Team meeting

ZOE SCHMANSKI - Apr 09, 2020, 3:54 PM CDT

Title: Team meeting before spring break

Date: 3/12/2020

Content by: Zoe

Present: Team

Goals:

Determine what needs to be done during spring break for the next deadlines

Content:

1. Finished material orders and placed order

2. Began SolidWorks

3. Create FBD

4. Create testing plan

Conclusions/action items:

Enjoy spring break :)

References:

2020/04/02 Discussion SolidWorks and FBDs - Team Meeting

ZOE SCHMANSKI - Apr 09, 2020, 4:01 PM CDT

Title: Team Meeting altered for distance learning

Date: 4/2/2020

Content by: Zoe

Present: Team

Goals:

Move project to completely online and more theoretical

Content:

1. Moved SolidWorks to Onshape for sharing and editing

2. Decided in Finite element analysis testing for design

3. Continue FBD drawing

4. Email Christa for help with simplifying the FBD

5. Altered handle design sketch to create in SolidWorks

6. How are we attaching straps? Screws

Conclusions/action items:

Email Christa before next meeting

References:

2020/04/09 Goals for Rest of Semester - Team meeting

ZOE SCHMANSKI - Apr 09, 2020, 3:50 PM CDT

Title: Team Meeting

Date: 4/9/2020

Content by: Zoe

Present: Team

Goals:

Create a to do list of all that needs to be accomplished

Content:

1. Testing
    1. Finite element analysis within SW
    2. Hypothetical testing methods
        1. Survey we would have asked
        2. MTS testing
2. Poster presentation
    1. Divvy up sections similar to prelim presentation
        1. Create poster
        2. Create slides
    2. Include old photos and new SW design
3. Modify handle design
    1. FBD/mathematical approach/calculations based anthropometric data
4. Pinch grip
    1. Research for importance of static vs dynamic
5. SW
    1. Location of strap holes
6. Notebook
    1. Meeting notes (2 meetings w/ Pucc, 1 team meeting)
    2. Testing plan
    3. FBD/mathematical approach/calculations based anthropometric data
    4. Update materials and expenses
    5. Create a doc on things we would have bought or included in design
    6. Summarize what our ideal design would have looked like
    7. Detailed fab plan of what we would have done
7. Refund

8. Deliverables
    1. Final notebook
    2. Final report
    3. Peer evals

Conclusions/action items:

Divide up the list and discuss with Dr. P on Monday.

Begin final testing and poster presentation.

References:

2020/04/16 - Dr. Wille Team Meeting

Marissa Harkness - Apr 17, 2020, 7:49 PM CDT

Title: Dr. Wille Team Meeting

Date: 4/16/2020

Content by: Zoe and Team

Present: Team

Goals: Document meeting about FBDs and Pinch Grip

Content:

Include in FBD

- simplifications
    - force for flexors and extensors
- wrist joint axis of rotation
- weight of the hand
- weight of arm
- force arrow for muscle acting across the wrist (protonator teres extensors or flexors)
- angle
    - device sits at elbow
        - the muscles aren't acting across elbow
        - pick a position of elbow that is comfortable not necessary
- Will the angle effect the bicep?
    - primary action of bicep is elbow flexion and forearm supination
    - we are targeting pronator teres, pronation is involved so bicep not involve
    - angle not effecting bicep
    - bicep most active at 90 degree angle
        - change angle away from 90 degrees to make the bicep less active
        - optimal angle range
            - fully extended - small moment arm (less effective bicep)
            - 135 degrees - do not go larger than that
- modeling forearm muscles
    - cut at wrist, axis of rotation
    - have hand and wrist in FBD
    - at cut have wrist reaction forces
    - weight of hand
    - force from wrist
        - extension arrow offset pointing up
        - look up the moment arm distance - same plot she showed us of the elbow but at the wrist
        - oppose tension of band
- 3 FBDs
    - wrist flexor and extensor - sagittal plane
    - pronator teres - rotational moment on transverse plane

Pinch Grip

- advantages of static versus dynamic gripping
    - dynamic
        - more realistic in physiological standpoint
        - train muscles in same way as using them
    - static
        - value in static, isometric exercise
        - activating muscles without moving
- include justifications and arguments for why we chose it
    - isometric training reduces fatigue over long term
        - also pain mitigating / tolerable
        - makes sense for our use with the climber's elbow treatment

Conclusions/action items:

Sketch the FBDs and send to Dr. Wille to look over

Use the plots Dr. Wille provided as guidance

References:

2020/04/23 - Dr. Wille Team Meeting

JONATHON MURPHY - Apr 29, 2020, 12:48 PM CDT

Title: Dr. Wille Team Meeting

Date: 4/16/2020

Content by: Jonathon and Brittany

Present: Jonathon and Brittany

Goals: confirm FBDs

Content:

Previous communication through email gave us moment arm information via Dr. Willie.

FBD of flexor/extensors

- take moment about wrist
- use data provided via email for MA

Pronation FBD

- transverse plane
- moment about x axis as well

Conclusions/action items:

pronator teres FBD should be in transverse plane, sum of M about x axis

Use the tables for actual numbers

References:

Previous Semester Notebook

KAITLIN LACY - Jan 24, 2020, 5:33 PM CST

Title: Previous Semester Design

Date: 1/24/2019

Content by: Kaitlin Lacy

Goals: Upload team notebook from last semester so those unfamiliar with the project can see the project that was made.

Content:

See attachment below

Conclusions/action items: Make sure the entire team is updated on necessary aspects of the project from last semester.

KAITLIN LACY - Jan 24, 2020, 5:28 PM CST

BME Design-Fall 2019 - Brittany Glaeser
Complete Notebook

PDF Version generated by

KAITLIN LACY

Table of Contents

Final_Notebook-CFT.pdf(14.2 MB) - download

Base Design Matrix

Brittany Glaeser - Feb 22, 2020, 4:15 PM CST

Title: Base Design Matrix

Date: 2/16/20

Content by: Brittany

Present: Team

Goals: To evaluate the designs for the base design matrix

Content:

Criteria	Design 1 "The Original"		Design 2 "Hinge"		Design 3 "Straps"	
Ease of Use (25)	3/5	15	4/5	20	5/5	25
Comfort (25)	3/5	15	5/5	25	4/5	20
Adaptability (20)	5/5	20	5/5	20	4/5	16
Ease of Fabrication (15)	5/5	15	2/5	6	4/5	12
Safety (10)	5/5	10	5/5	10	5/5	10
Cost (5)	5/5	5	5/5	5	5/5	5
Total (100)	80		86		88	

Figure 1. Base design Matrix

Ease of use: Ease of use was determined most important for the design matrix. The team wants to make sure that the device is easy for the user to use with minimal instruction needed. The design also needs to be easy enough for the user to place the device on by themselves without assistance from anyone else. The "Straps" design was considered the easiest to use because the straps would already by placed through the loops so the user would simply slide their arm in and tighten the straps. Also, it had the easiest component to adjust the angle that didn't require screws.

Comfort: Comfort was also considered important because we wanted the design to be comfortable to the user so the user would want to exert as much force as possible without causing pain or discomfort. The hinge design was the highest scoring because it allowed for a larger angle range than the other design. This was important because with the original design from the previous semester it was found that the 90 degree angle was uncomfortable and your arm naturally wants to extend. Each user may have a different preference for angle comfort so the "Hinge" design would allow them to adjust as needed.

Adaptability: Adaptability was also considered important because the device needed to work for a large variety of people. The design would still need to allow for varied strength and the size of the arm pieces would also need to fit a larger variety of people. Both the "Original" and the "Hinge" design was considered to be the most adaptable. This was due to the fact that there would be no curved edges/side supports that would be inconvenient for someone with different widths of forearms.

Ease of Fabrication: Ease of fabrication was to ensure that we would be able to fabricate the device with our own capabilities and that we have the equipment to do so. The "Original" design was considered the easiest to fabricate since the entire design was 3D printed.

Safety: Safety is important to ensure that the user would not be injured while using the device. We thought that each design would have relatively the same safety factor as the designs don't have major varying components.

Cost: The cost was also considered relatively the same since not much material would be needed to fabricate them.

Conclusions/action items:

The team will move forward with the "Straps" design due to its ease of use and relatively high comfort score. Modifications will be made to ensure that the angle adjusting mechanism will be rigid so that flexion of the elbow is not permitted. The straps across the bicep and the forearm will also be modified to ensure that it is easy for the user to use. The team was thinking of incorporating a buckle similar to that found on a roller blade.

References:

Grip Design Matrix

Brittany Glaeser - Feb 25, 2020, 2:39 PM CST

Title: Grip Design Matrix

Date: 2/16

Content by: Brittany

Present: Team

Goals: Evaluate the grip designs

Content:

Criteria	Design 1 "Pinch Grip"		Design 2 "Stress Ball"		Design 3 "Gripper"	
Ease of Use (25)	5/5	25	4/5	20	5/5	25
Effectiveness (20)	4/5	16	2/5	8	3/5	12
Ease of Fabrication (20)	5/5	20	3/5	12	5/5	20
Compatibility (15)	4/5	12	3/5	9	4/5	12
Safety (15)	5/5	15	5/5	15	4/5	12
Cost (5)	5/5	5	4/5	4	3/5	3
Total (100)	93		68		74	

Figure 1. Grip Design Matrix

The grip design matrix consisted of 3 different deigns: The Pinch Design, The Hinge Design, and the Gripper Design.

The first category of the grip design matrix was easy of use. We want the design to be easy to understand by the user so minimal instructions are needed. This important because the team doesn't want too many moving components in the design. The Pinch Grip and the Gripper design scored the highest in this category because it didn't have as many different components.

Effectiveness was how well the device meets the requirements of the client and effectively strengthen grip. The pinch grip was considered most effective because it allowed more range of motion and would activate more of the muscles associated with grip rather than just the finger muscles. It is important too to have a handle that is more similar to that of a climbing hold.

Ease of Fabrication is important as it has to be a design that we are capable of manufacturing ourselves with limited machining.This was the pinch grip because it would be a simple rectangle that can be 3D printed and the Gripper because it is made from a preexisting device.

Compatibility is how well the device will work the current design. Both the pinch grip and gripper have hooks to attach the resistance bands in an easy way.

Conclusions/action items:

The team will move forward with the pinch grip design because of the effectivness of the design and its easy manufacturing that will allow us to make modifications and approve upon the design throughout the semester.

References:

2020/04/05 - Onshape Base CAD

ZOE SCHMANSKI - Apr 05, 2020, 2:13 PM CDT

Title: Base Design using Onshape

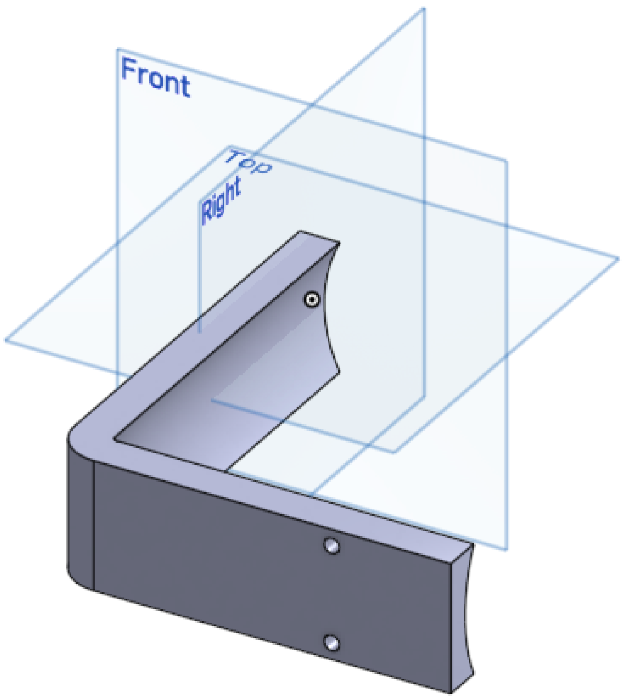
Date: 04/05/2020

Content by: Zoe

Present: Team

Goals: Document modified CAD design using online editing software called Onshape

Content:



Conclusions/action items:

Edit curvature with measurements found in research

References:

2020/04/05 - Onshape Pinch Grip CAD

ZOE SCHMANSKI - Apr 05, 2020, 2:17 PM CDT

Title: Pinch Grip Design using Onshape

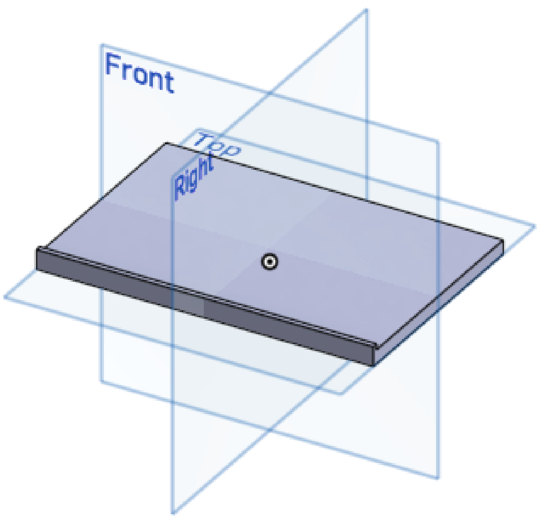
Date: 04/05/2020

Content by: Zoe

Present: Team

Goals: Document modified CAD design using online editing software called Onshape

Content:



Conclusions/action items:

Continue researching the addition of dynamic movements with resistance clips

References:

2020/04/05 - Onshape Back Brackets CAD

ZOE SCHMANSKI - Apr 05, 2020, 2:20 PM CDT

Title: Back Brackets Design using Onshape

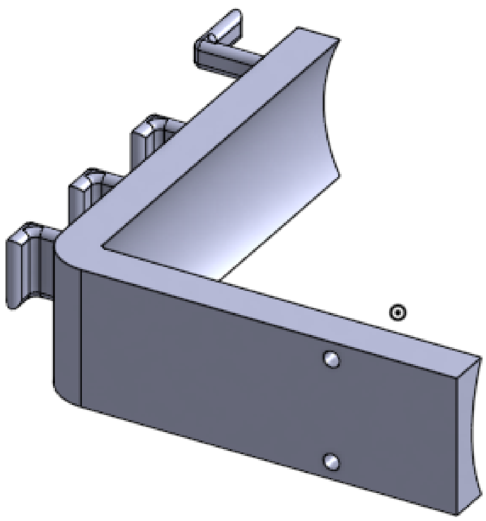
Date: 04/05/2020

Content by: Zoe

Present: Team

Goals: Document modified CAD design using online editing software called Onshape

Content:



Conclusions/action items:

Evaluate the new smaller resistance bands ordered and how they will attach

References:

2020/4/7 - SolidWorks Model of L-Piece with Increased Angle

KAITLIN LACY - Apr 28, 2020, 4:30 PM CDT

Title: SolidWorks Model of L-Piece with Increased Angle

Date: 4/7/2020

Content by: Kaitlin Lacy

Goals: Increase angle that the arm will be held at to aid in user comfort.

Content:

An angle of 110 degrees was chosen to make the design more comfortable for the user. This angle may be changed with future research on muscle activation or feedback on user comfort.

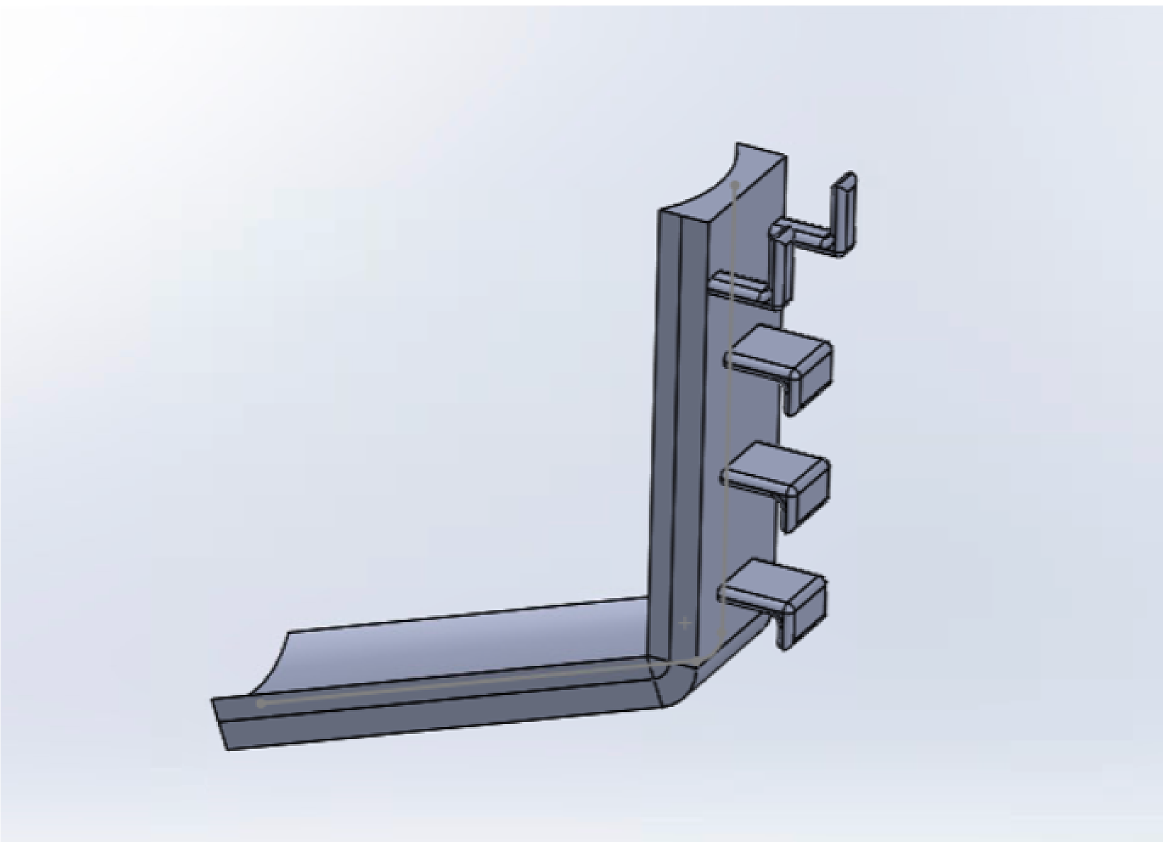


Figure 1: Drawing of L-Piece that includes an angle of 110 degrees.

Conclusions/action items: Research the impact of the angle of the arm on increasing strength during training. Consider asking Dr. Wille about this.

2020/04/13 - Updated Pinch Grip with Finger Indentations

KAITLIN LACY - Apr 29, 2020, 12:22 PM CDT

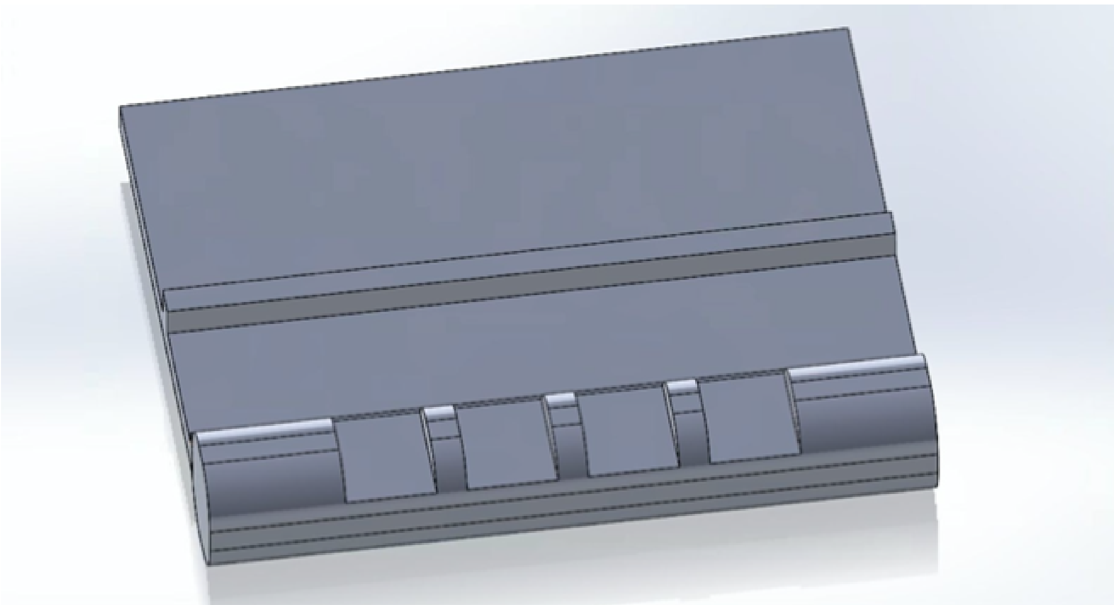
Title: Updated Pinch Grip with Finger Indentations

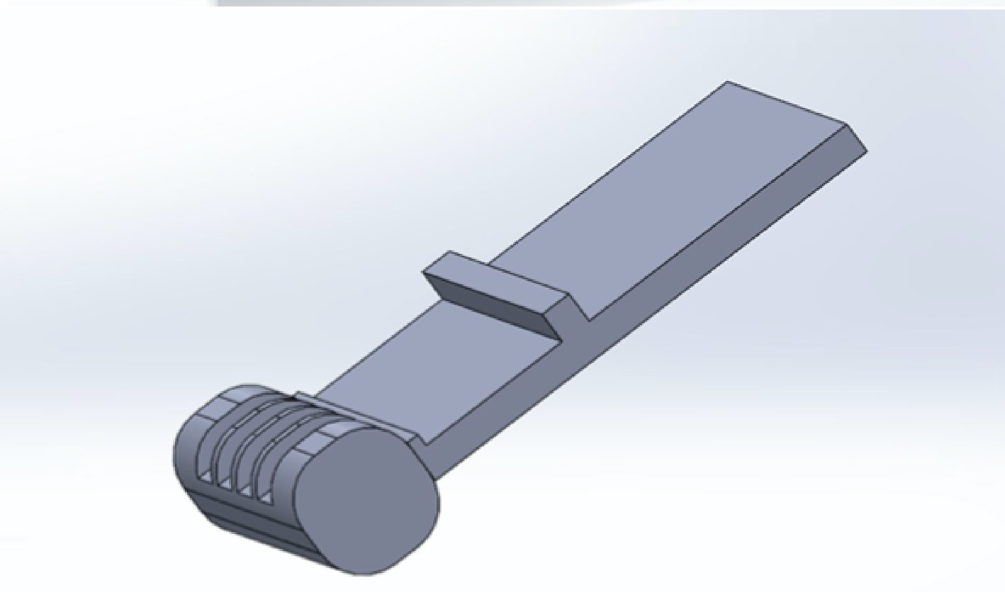
Date: 4/13/2020

Content by: Kaitlin Lacy

Goals: Update the design of the pinch grip to make it more intuitive to use.

Content:





Figures 1 & 2: Updated SolidWorks design of the pinch grip.

Team discussion revealed the possibility that users may not immediately understand the intended use of the grip. One possibility to improve the usability of the device is including the notches for fingers as seen above. This gives the user a visual idea of where their fingers should be, and from there they can more easily figure out to put the pads of their fingers along the ridge in the middle of the device with their thumb wrapped below the handle.

Conclusions/action items: More research needs to be done on finger size and spacing to confirm that the size and position of these notches would work for a variety of users.

Final Design Models

Brittany Glaeser - Apr 26, 2020, 2:22 PM CDT

Title: Final Design Models

Date: 4/26

Content by: Brittany

Present: Britt

Goals: To show representative pictures with ideas for the final design

Content:

Figure 1. Mock up of final design - changes made on original design

UPDATES TO ORIGINAL DESIGN

- New resistance bands - less bulky than original design
- Nylon straps were added to the resistance bands
    - Easier attachment of bands to the handles
    - Ideally would give us more opportunity to design an idea for tightening the bands without the hooks in the back to slim down the device (ex. tension straps)
    - Allow for the attachment of carabiners
- Carabiner Hooks on the handle
    - Allows for easy removal of the resistance bands from the handle
    - Hook eye screws were used to clip the carabiners on

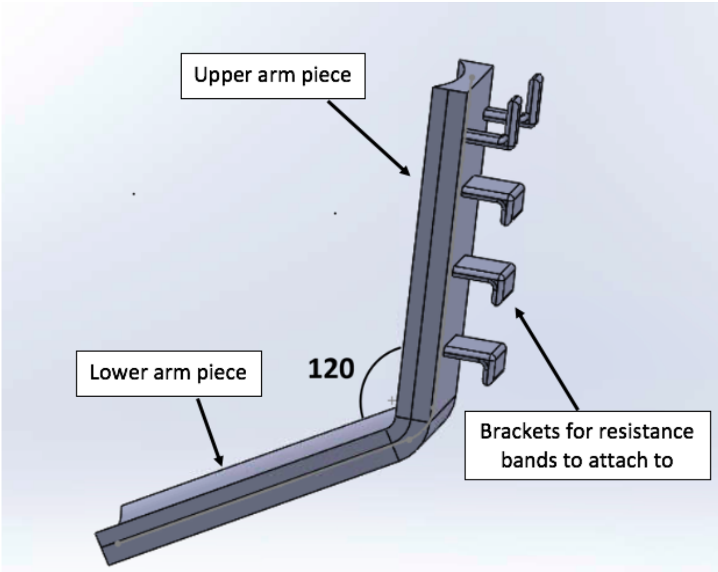


Figure 2. Updated CAD of final design

UPDATES FROM ORIGINAL DESIGN

- The angle was increased from 90 to 120
  - More comfortable for the user
  - Moves bicep out of the optimal zone to limit its activation
- Curved edges
  - Help prevent the users arm from moving laterally that could cause an unstable design
- Buckle Straps - NOT PICTURED
  - Easier attachment by the user
  - More comfortable
  - More aesthetically pleasing

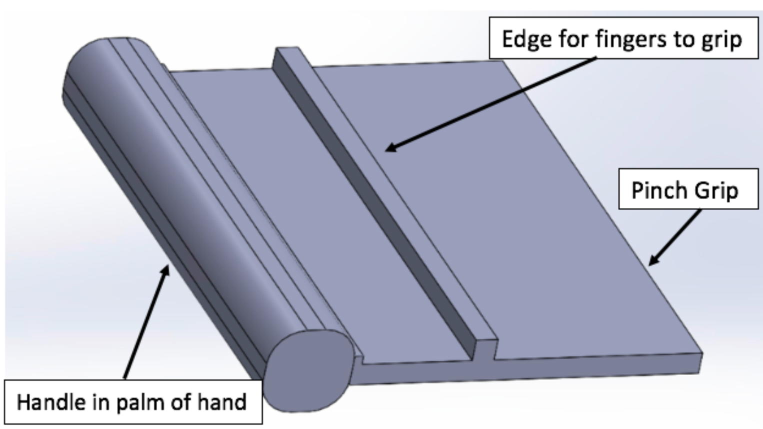


Figure 3. Updated CAD of handle design

UPDATES FROM ORIGINAL DESIGN

- Smaller aperture of the fingers
  - Increase grip at a smaller aperture since it was found that this is a weaker grip position
- Static Design
  - Ideal for rehabilitation purposes
- Pinch Grip
  - Similar to that of a hangboard for increasing strength of digital flexors
  - Also will strengthen forearm muscles
  - Could be similar to that of a climbing hold

Conclusions/action items:

The above designs will be incorporated into the final report. The main ideas behind the updated design are increasing user comfort as well as ease of use. The design also now incorporates a grip component that was ideal for the client.

References:

Future Work

Brittany Glaeser - Apr 26, 2020, 7:08 PM CDT

Title: Future Work

Date: 4/26

Content by: Brittany

Present: Britt

Goals: Determine ideas for future work

Content:

- Testing of the device
  - MTS
  - EMG
  - Survey
- Tightening Mechanism
  - Hooks are took bulky and non-intuitive
  - Something similar to a tension strap on a backpack
- Printing the design
  - Prototype can be 3D printed
    - Looked into flex seal to make it more durable and more aesthetically pleasing
  - Look more into injection modeling as this seems like a suitable idea for a final design
- Modify the handle
  - Potentially a design where the pinch grip or flat part is removed so it is more of a simple handle
    - Would allow the user to focus on forearms and not grip
  - Having varying angles of grip so the user can decide what is best for them or allow them to train with different angles
    - Could be important because climbing holds differ and isometric training strengthens muscles mainly at the angle at which training is done
- Look into ideas for a cover for the design
  - Likely removable to be cleaned
- After the survey testing, it will be clearer if the design is suited for a large variety of people or if the design dimensions will need to be changed
- It would also be beneficial to look into the resistance bands of higher resistances so those can also be tested and incorporated into the design

Conclusions/action items:

The future work will help improve the device overall. Many modifications were determined this semester but to ensure that the device is commercializable, more modifications could be made. The ideas for the future work will be placed into the final report.

References:

Materials and Expenses

Marissa Harkness - Apr 25, 2020, 8:03 PM

Item Name	Part Number	Link	Description	Vendor	Cost	Quantity	Su
Theraband Professional Latex Resistance Tubing	B0037IUXFY	https://www.amazon.com/TheraBand-Resistance-Professional-Exercise-Physical/dp/B0037IUXFY/ref=asc_df_B0037IUXFY/?tag=hyprod-20&linkCode=df0&hvadid=198076111901&hvpos=&hvnetw=g&hvrand=15866532437678886062&hvpone=&hvptwo=&hvqmt=&hvdev=c&hvdvcmdl=&hvlocint=&hvlocphy=9018948&hvtargid=pla-349230062310&psc=1	3, 5ft tubed resistance bands to provide resistance for the device	Amazon	15.99	1	15
Alemon 2 Pieces Replacements Inline Roller Skating Shoes Energy Strap with Screws Nuts Skates Buckles Accessory	B07DVNKH3G	https://www.amazon.com/Pieces-Replacements-Skating-Buckles-Accessory/dp/B07DVNKH3G/ref=asc_df_B07DVNKH3G/?tag=hyprod-20&linkCode=df0&hvadid=312035433248&hvpos=&hvnetw=g&hvrand=18872887538718498 19&hvpone=&hvptwo=&hvqmt=&hvdev=c&hvdvcmdl=&hvlocint=&hvlocphy=9018948&hvtargid=aud-801381245258:pla-568406064936&psc=1	Two 10in straps, mounting screw included	Amazon	10.99	1	10

Hypothetical Materials and Expenses

Title: Hypothetical Materials and Expenses

Date: 4/19/20

Updated date: 4/25/20

Content by: Marissa

Present: Marissa

Goals: To write a detailed list of materials that we would have used to develop our design, as well as the associated costs

Content:

- **L-piece PLA:** This is the arm piece foundation of our entire forearm trainer design. It is positioned at a 120 degree angle. It is also where a person's arm would reside during the duratio
- **Handle/pinch grip PLA:** The handle is where the palm of the hand would be placed. The pinch grip is what the person's fingers would grasp. This addition would be used to increase g
- **Roller blade straps:** The roller blades are an intuitive, easy to use addition intended to secure a person's arm into the arm piece.
- **Body molded foam padding:** The padding conforms to the person's arm and provides added comfort within the arm piece.
- **Flex Seal:** The flex seal would be applied to the arm piece for a more sleek look. It also provides the added benefit of covering surface roughness.
- **Resistance bands:** The resistance bands vary in strength. This provides variability in the difficulty of the exercise. They can easily be switched with one another on the arm piece desig
- **Nylon webbing:** The nylon webbing would be attached to the resistance bands.
- **Hook eye screws:** The hook eye would be screwed on the circular ends of handle.
- **Carabiners:** The carabiners would be attached to the nylon webbing and clipped to the hook eye screws
- **Brass knurled inserts:** The brass knurled inserts are needed to screw the hook eye screws into the plastic. This ensures we don't damage the 3D printed PLA material.

Simplified Materials/Expenses Table

Item	Cost
L-piece/Handle/Pinch Grip - PLA	$15
Rollerblade straps	$10.99
Body molded foam padding	$38
Flex Seal	$12.39
Resistance bands	$15.99
Carabiners	$4.99
Nylon webbing	$9.99
Hookeye screws	$9.99
Brass knurled inserts	$5.99
Estimated total cost	123.33

Detailed Materials/Expenses Table

Item Name	Part Number	Link
Theraband Professional Latex Resistance Tubing	B0037IUXFY	https://www.amazon.com/TheraBand-Resistance-Professional-Exercise-Physical/dp/B0037IUXFY/ref=asc_df_B0037IUXFY/?tag=hyprod-20&linkCode=df0&hvadid=198076111901&hvpos=&hvnetw=g&hvrand=15866532437678886062&hvpone=&hvptwo=&hvqmt=&hvdev=c&hvdvcmdl=&hvlocint=&hvlocphy=9018948&hvtargid= 349230062310&psc=1
Alemon 2 Pieces Replacements Inline Roller Skating Shoes Energy Strap with Screws Nuts Skates Buckles Accessory	B07DVNKH3G	https://www.amazon.com/Pieces-Replacements-Skating-Buckles-Accessory/dp/B07DVNKH3G/ref=asc_df_B07DVNKH3G/?tag=hyprod-20&linkCode=df0&hvadid=312035433248&hvpos=&hvnetw=g&hvrand=18872887538718498198&hvpone=&hvptwo=&hvqmt=&hvdev=c&hvdvcmdl=&hvlocint=&hvlocphy=9018948&hvtargid=a 801381245258:pla-568406064936&psc=1
L-piece/Handle/Pinch Grip - PLA	N/A	N/A
Body molded foam padding	B075LFHNS8	https://www.amazon.com/Rolyan-Adhesive-Support-Self-Adhesive-Protection/dp/B075LFHNS8/ref=sr_1_1?dchild=1&keywords=body+molded+foam+padding&qid=1587863253&sr=8-1
Flex Seal	FSR20	https://www.amazon.com/Flex-Seal-Rubber-Sealant-Coating/dp/B00CD9FGNW/ref=sr_1_1?dchild=1&keywords=flex+seal&qid=1587863439&sr=8-1
Carabiners	B01L4IS4I6	**https://www.amazon.com/Tartelette-Shaped-Chain-Carabiner-Aluminum/dp/B01L4IS4I6/ref=sr_1_33?dchild=1&keywords=1.5+inch+carabiner+clip&qid=1587351743&s=industrial&sr=1-33**

Item Name	Part Number	Link
Nylon webbing	B07Q7XFG4P	**https://www.amazon.com/FANDOL-Nylon-Webbing-Strapping-Repairing/dp/B07Q7XFG4P/ref=sr_1_2?dchild=1&keywords=1%2Binch%2Bnylon%2Bwebbing&qid=1587351899&s=industrial&sr=1-2&th=1**
Hookeye screws	B07TDM1D9T	**https://www.amazon.com/AxeSickle-Thread-Eyebolt-Eyelet-Screw/dp/B07TDM1D9T/ref=sr_1_17?dchild=1&keywords=1%2Bin%2Bwide%2Bhook%2Beye%2Bscrews&qid=1587351392&sr=8-17&th=1**
Brass knurled inserts	B01IYWTCWW	https://www.amazon.com/Uxcell-a16041800ux0824-Knurled-Threaded-Embedment/dp/B01IYWTCWW/ref=sr_1_5?crid=1KGMCOVCVYDA4&dchild=1&keywords=m3+5x5+brass+knurled+insert&qid=1587864123&sprefix=brass+knurled+inse%2Caps%2C185&sr=8-5

Note: These the estimated total cost does not include tax and shipping costs.

Conclusions/action items:

We will share the estimated costs in our progress report and add the information highlighted above in our final report.

References:

N/A

2020/02/25 - Fabrication Plan

Brittany Glaeser - Apr 22, 2020, 8:11 PM CDT

Title: Fabrication Plan

Date: 2/25

Content by: Brittany

Present: Britt

Goals: Develop a plan for fabrication

Content:

The plan for fabrication would be to first create the Straps Design and the Pinch Grip design in CAD. These designs will then be 3D printing using PLA because it is very durable. Brass knurled inserts are used on the device to create screw holes, since that material is not idea for tapping. The inserts are placed by heating them with a soldering iron and pressing the heated inserts into the plastic. This allows the plastic to melt and form around the insert and when the heating element is removed, the plastic dries and the insert is held in place. The velcro straps (what we will use for now) will be screwed into the inserts along the upper arm and the forearm. Hook-eye screws will be placed at the ends of the Pinch Grip design to allow for carabiner clips to be attached for the resistance mechanism.

Conclusions/action items:

The first step will be to order the parts and begin the solidworks drawings. I recently came across thermoforming which is done on plastics and can be done in the Makerspace. Researching more and talking to the makerspace will help understand if this could be a potential for our design fabrication.

References:

2020/04/16 - Future Fabrication: Injection Molding

Brittany Glaeser - Apr 22, 2020, 8:19 PM CDT

Title: Future Fabrication: Injection Molding

Date: 4/16/2020

Content by: Zoe

Present: n/a

Goals: Summary of possible fabrication plan for the future design

Content:

1. 3D print the current SolidWorks designs until the measurements and angles are what are desired

2. Use injection molding to provide a more finished look, with softer edges and one complete device

3. Use of Protolab or other resources provided by the BME page

4. "Create a quote" on Protolab allows for the client to insert the CAD drawings for the print

5. The lab responds with the qualifications of your design, whether or not it is ready to mold or if changes need to be made

6. Also give you a quote for the price, injection molding is much more pricy then 3D printing so we would want to get it right the first time

Conclusions/action items:

Include this in fabrication / future work for the forearm trainer design

References:

Protolab website:

https://www.protolabs.com/?utm_campaign=us-ppc&utm_source=google&utm_medium=cpc&utm_content=branded-protolabs&gclid=Cj0KCQjwm9D0BRCMARIsAIfvfIa9TC1s2-5ImMUXNPpZDsmnLGZzgHhQt4B6ZfF6BmfZJahPeYTGNmgaAun4EALw_wcB

2020/04/25 Detailed Fabrication Plan

Marissa Harkness - Apr 25, 2020, 9:58 PM CDT

Title: Detailed Fabrication Plan

Date: 4/25/20

Content by: Marissa Harkness

Present: Marissa Harkness

Goals: To detail a hypothetical fabrication plan

Content:

The current plan for fabrication will begin with CAD models of both the base design, handle, and pinch grip design. The CAD models will then be used for 3D printing that will be printed using PLA (polylactic acid). Then, injection molding will be used to provide a more finished look, with softer edges and one complete device. Flex spray will then be applied to all PLA components. Rollerblade straps will be added to the base design also using the threaded inserts and corresponding screws. One will be inserted in a position to secure the upper arm and another would be inserted to secure the lower arm in place. Body molded padding would also be added in the L-piece with an adhesive glue. The sides of the handles will contain small holes where brass knurled inserts will be inserted by using a soldering iron to melt the plastic slightly. Hook eye screws will then be screwed into the inserts.The resistance bands will be looped around the hooks on the back of the base design and then the carabiner clips will be attached to the handle. The resistance bands will be tied within a nylon webbing. The nylon webbing would then be used to be attached to the carabiners which are then attached to the handle.

Conclusions/action items:

To put our detailed fabrication plan into place next semester

EMG Testing Protocol

Brittany Glaeser - Apr 22, 2020, 8:54 PM CDT

Title: EMG Testing Protocol

Date: 2/25

Content by: Brittany

Present: N/a

Goals: Create an outline for the EMG testing protocol

Content:

- Multiple team members will be tested
- Electrodes will be placed on the extensors, flexors, and bicep
    - We went to limit bicep activation
    - Extensors should be activated during supination and wrist extension
    - Flexors should be activated during pronation and wrist flexion
- The test will completed with the device, without the device (control), and with a competing design
    - The test will be completed with all the same resistance bands. The amount of tension provided will be different for each individual but this will not be an issue since the test is not testing for amplitude of force, it is only looking for the activation of the specific muscles.
- The user will do flexion, pause, supination, pause, extension, pause, pronation
    - The timing of these motions will be measured with a stopwatch for later comparison to see if the amplitude spikes occurs at the same time
- The data received can be plotted on MATLAB using subplots for easy comparison
    - The data is received via txt file
    - The data will be plotted amplitude vs. time

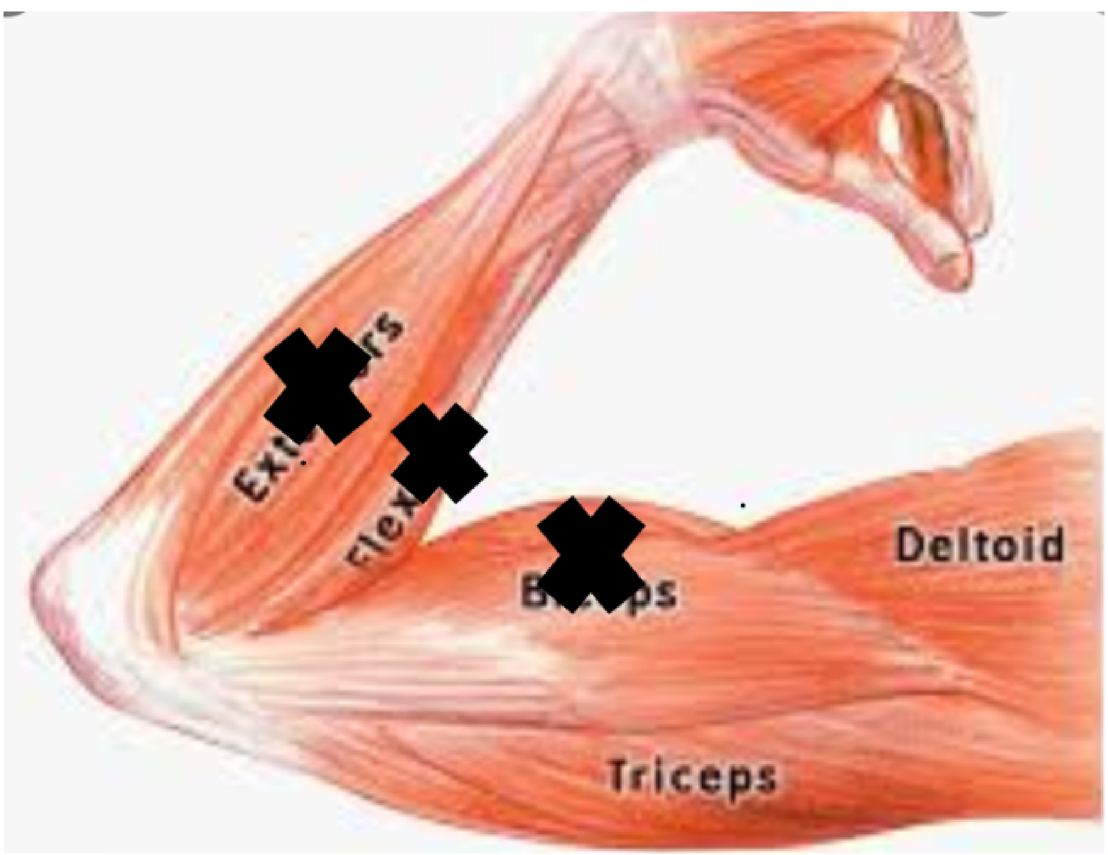


Figure 1. Black x's represent approximate locations of the location of electrodes

Conclusions/action items:

The team will first complete the prototype for this semester. Last year, we did testing at the SAPC that Dr. Christa Wille set up for us. This would be idea to go here again to have them help us with the placement of the electrodes. Also, the team should determine if we could test other individuals. The test this year should also be completed with a pre-existing device, such as a weight, to compare our device to something else.

References:

MTS Testing Protocol

JONATHON MURPHY - Apr 26, 2020, 8:13 PM CDT

Title: MTS Testing Protocol

Date: 2/25 updated 4/22

Content by: Brittany

Present: Britt

Goals: To create an outline for the MTS testing

Content:

- Resistance bands will be used in the MTS machine
    - Only new resistance bands as used ones can change the results
- The resistance bands will be cut all to the same length and loaded into the MTS machine
    - The machine will be tested until there is slight tension in the band and the gauge length will be recorded
- The test will go until fracture
    - The fracture point can be important for calculating a safety factor
    - Bands that slip will not be counted and will be redone
- The test will measure percent elongation and the force (N) exerted by the resistance band
    - Help determine how much the resistance varies with elongation

Step by Step Procedure:

1. Load program on the desktop computer
    1. In 2005 the 64-bit processor must be used
2. Obtain the 1 kN load cell and place it on the MTS machine
3. Ensure the emergency stops are set
4. Obtain the smaller set of grips
    1. The ones with the rubber padding help prevent slip of the resistance band
    2. The pin must be inserted into the grips to prevent translation and further tightened with the wrench to stop any excess movement
5. Turn on the MTS machine - the emergency stop button must be pulled out
6. The resistance bands will be cut to 3 inches in length
7. The resistance band will first be loaded into the upper grip and then the lower grip
    1. The grip must be tightened enough so the resistance band won't slip and skew the results
8. A slight tension will be added to the resistance band using the handheld controller of the MTS machine
9. At this point, the measurements of the machine will be set to 0 (zero the crosshead and the load)
10. The gauge length is then recorded
11. The play button is then pressed on the program and the test will begin in tension
    1. If the test stops before fracture, it likely indicates slip of the resistance band
    2. The program should be set up so that the test will go until fracture of the resistance band
    3. The handset must be locked in order to be controlled from the desktop
12. Once the test stops, the grips will move back to their original position and the band can be removed
    1. Each band is only tested once since pre-stretching can change the outcome of the results
13. The data file should then be saved onto the desktop for later analysis
    1. The review tab on the program will allow for one to see the data before it is saved
14. Each level of resistance band will be tested 5 times

Conclusions/action items:

The team will order resistance bands and use the 2005 lab in ECB to conduct testing. Testing can be put into MATLAB for analysis.

References:

Open Ended Testing Survey

Brittany Glaeser - Apr 25, 2020, 9:38 PM CDT

Title: Hypothetical Testing Survey

Date: 4/18/20

Content by: Marissa

Present: Marissa

Goals: To develop a testing survey that we would have asked our test subjects

Content:

We would be able to note and answer some of these questions on our own by observing the test subjects perform the exercise. However, we think it is also important to ask the subjects a list of questions to provide us with more insight about our design and ways to improve it.

Below is the list of questions that we would ask our test subject:

1. Can you point to the areas in which you feel the stretch?
2. How easy is it to grip the handle?
3. How comfortable is your grip?
4. How comfortable is the angle of your arm?
5. Do you have any critique regarding the padding?
6. Are there any areas where you feel discomfort?
7. Is the device self explanatory or did you rely heavily on the instructions?
8. Are there any aspects of the forearm trainer that were hard to understand or that you questioned?
9. Which resistance band would you choose to use when performing the exercise?
10. Do you feel as if your range of motion is at all limited?
11. How would you describe the comfort of the straps on your arm?
12. Were the straps easy to put on?
13. Do you have any critique on the appearance of the design?
14. What improvements do you think could be made to our design?
15. Do you have any questions or further remarks?

Conclusions/action items:

We would implement this list of questions when performing the tests.

The idea would be to test as many subjects as possible to obtain reliable data. The team would also like to do the survey at a climbing gym to have thoughts from other climbers as well as other gyms to ensure that our device will be adaptable to others outside of the climbing gym.

References:

Past meeting notes

FEA Testing Protocol

JONATHON MURPHY - Apr 26, 2020, 9:28 PM CDT

Title: FEA Testing Protocol

Date: 4/19/20

Content by: Jonathon

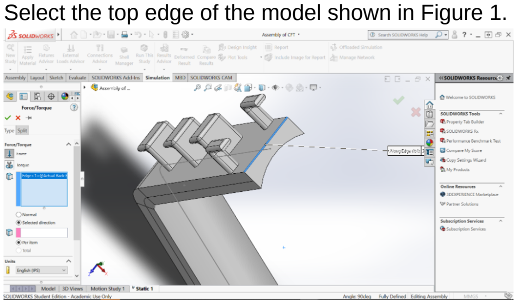
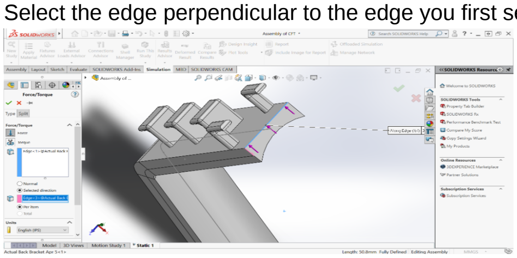
Present: N/A

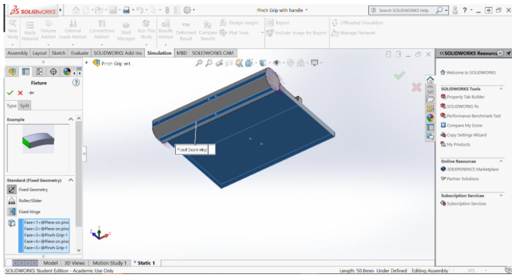
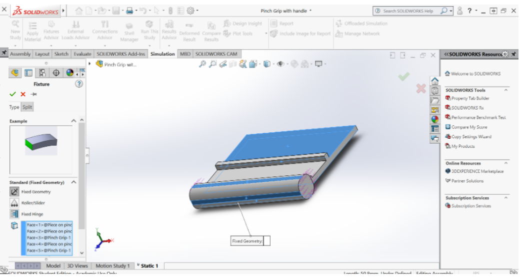
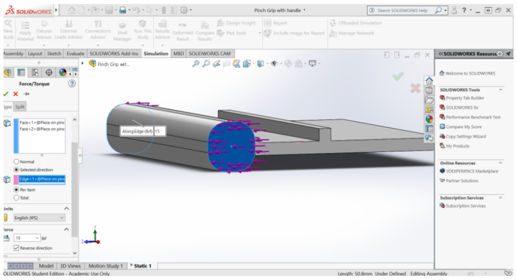
Goals: expalin FEA testing protocol

Content:

- FEA will be run through SOLIDWORKS
  - an example instruction manual created for Mechanics and Materials Lab is attached below
- the handle and base design models will be tested
  - 30 lbf will be tested as it is the largest force the device is designed for
- the analysis will confirm our design will withstand the maximum force stated in the PDS

Step by Step Procedure

1. Open SOLIDWORKS on computer
2. Open Base Design File
3. Under the "Simulation" tab select "New Study"
   - select the "Static" study and click the green check mark to complete
4. In the menu on the left, right click on "Mesh" and select "Create Mesh"
   - Adjust the slider bar to the finest mesh possible and click the green check mark to complete
5. Make sure your applied material is "ABS"
   - under "Apply Material" select "ABS" and click "Apply"
6. In the menu on the left, right click on "Fixtures" and select "Fixed Geometry"
   - Select the bottom face of the model to fix and click the green check mark to complete
7. In the menu on the left, right click on "External Loads" and select "Force"
   - Select the top edge of the model shown in Figure 1.
   - 
   - Next, select "Selected Direction"
   - Select the edge perpendicular to the edge you first selected, shown in Figure 2.
   - 
   - Under "Force" apply a 30 lbf
   - Check the direction of the force and if in the incorrect direction, select reverse direction
   - Click the green check mark to complete
8. Under the top menu, select "Run This Study"
9. Note the simulated maximum deflection
10. In the menu on the left, under "Results," select "Strain"
11. Repeat steps for Handle model with some specific changes
    - Fixed geometry is shown in Figure 3

-  
- Forces are shown in Figure 4, this time only 15 lbf (half each side)
- For "Selected Direction," select top edge, also shown in Figure 4
- 

Conclusions/action items:

Run test

References:

JONATHON MURPHY - Apr 26, 2020, 8:16 PM CDT

Laboratory 5: Finite Element Analysis

Introduction

In EMA 303 and ME 306 – Mechanics of Materials, you will learn some formulae for finding stresses and strains in various objects: cubes, prisms, cylinders, spheres, etc. We can derive these formulae because cubes, prisms, cylinders and spheres lend themselves nicely to the coordinate systems we use in Calculus and Differential Equations.

The real world, however, requires nuts, bolts, welds, notches, bearings, fittings, threads and other inconvenient geometry. For these shapes and features, there are no neat, closed-form solutions to stress and strain distributions.

Prior to the 1980s, the only solution to many of these problems was to test real parts and develop cumbersome empirical models for how stress behaves in a cylinder with a step for mounting a bearing, such as in Figure 1.

Figure 1: Shaft with shoulder and fillet.

Testing enough cylinders, with enough different diameters, with different sized steps and different loads, engineers could fairly accurately predict the stress and strain on a cylinder with a step. Repeat for plate with hole, bar with notch, etc.

As computers became faster, smaller and cheaper, Finite Element Analysis came to the scene. Effectively, FEA is a technique for breaking a complicated geometry into tens, hundreds or millions of prisms that do have nice closed-form solutions. Since two adjacent prisms must experience similar stresses and strains, the results for one prism inform the loading conditions for the next. For instance a bar with a few holes and notches, shown in Figure 2.

Lab_05_-_FEA_1_.pdf(813.8 KB) - download

Rated Testing Survey

Marissa Harkness - Apr 26, 2020, 6:20 PM CDT

Title: Rated Testing Survey

Date: 4/26/20

Content by: Team

Present: Team

Goals: To change the open ended testing survey to be statements that the subject answers that they agree, disagree or are unsure about

Content:

1. The user will perform the desired exercises using the climber's forearm trainer
    1. Exercises include flexion, extension, pronation, and supination
2. The below list of statements would be stated and the user would reply by agree, disagree, or unsure:

1. Stretching can be felt in the forearm
2. The motion of the bicep is limited
3. There was no lateral movement
4. The handle is easy to grip
5. Grip position is comfortable
6. The elbow angle is comfortable
7. The device padding is comfortable
8. No discomfort is experienced
9. The device is intuitive to use
10. The tightening aspect is easy to understand
11. Range of motion is not limited
12. The straps are comfortable
13. The straps were easy to secure.
14. The design looks like a finished piece.
15. What improvements do you think could be made to our design?

Conclusions/action items: To incorporate this in our final report

FEA Results

JONATHON MURPHY - Apr 27, 2020, 8:34 PM CDT

Title: FEA Results

Date: 4/19/20

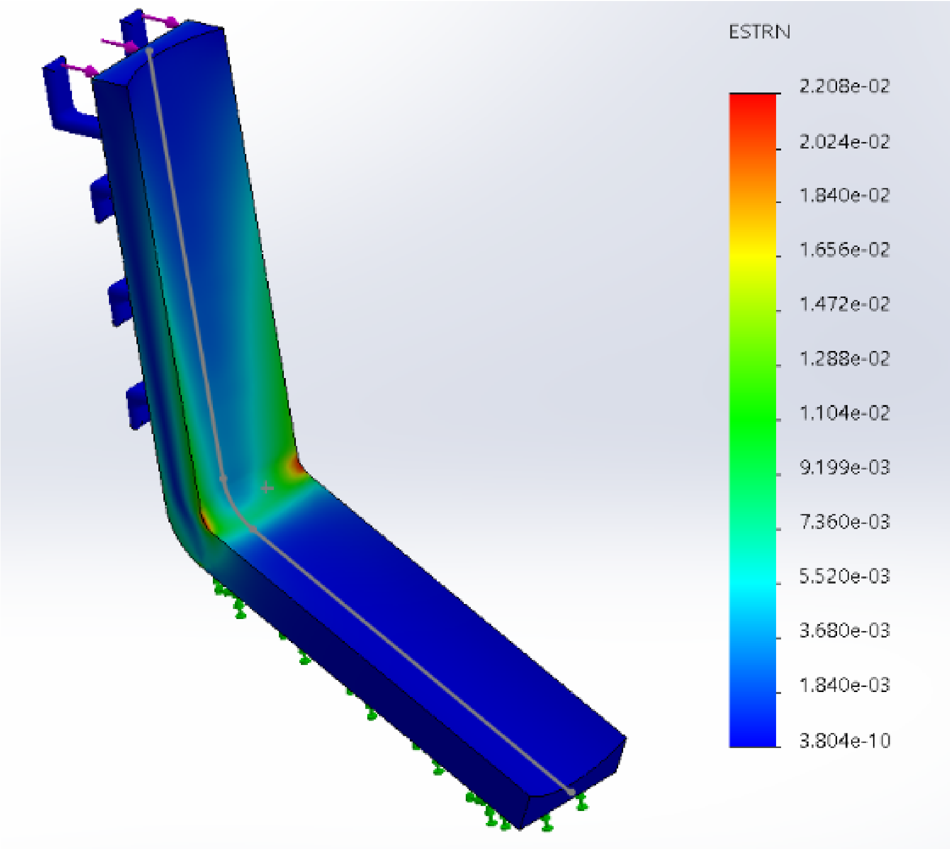
Content by: Jonathon

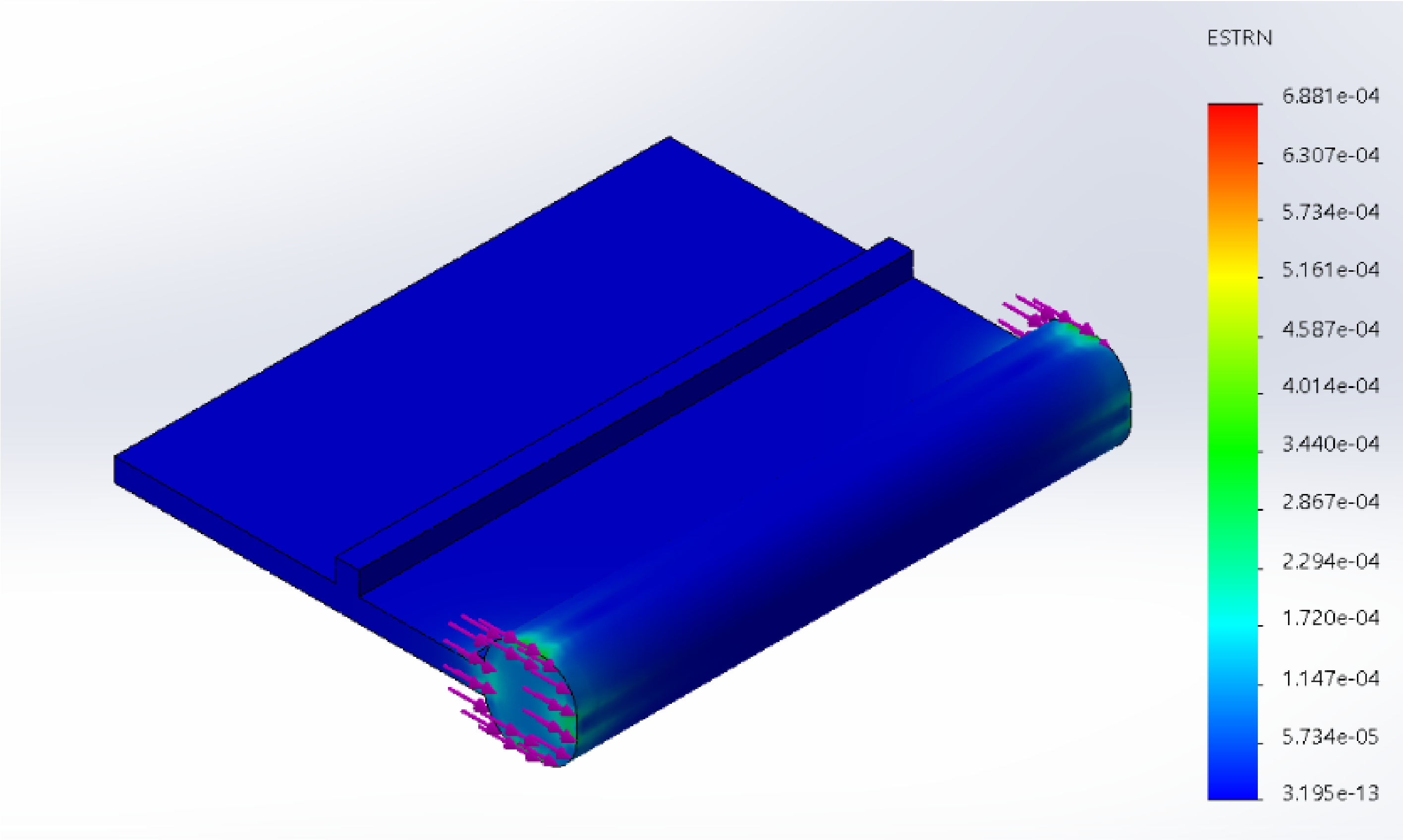
Present: N/A

Goals: results of the FEA

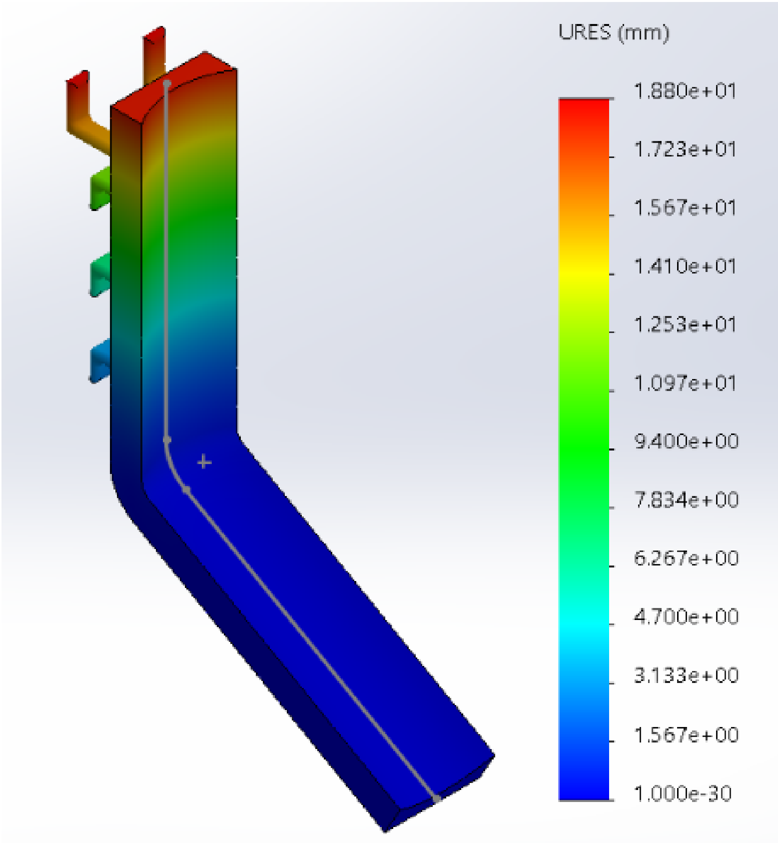
Content:

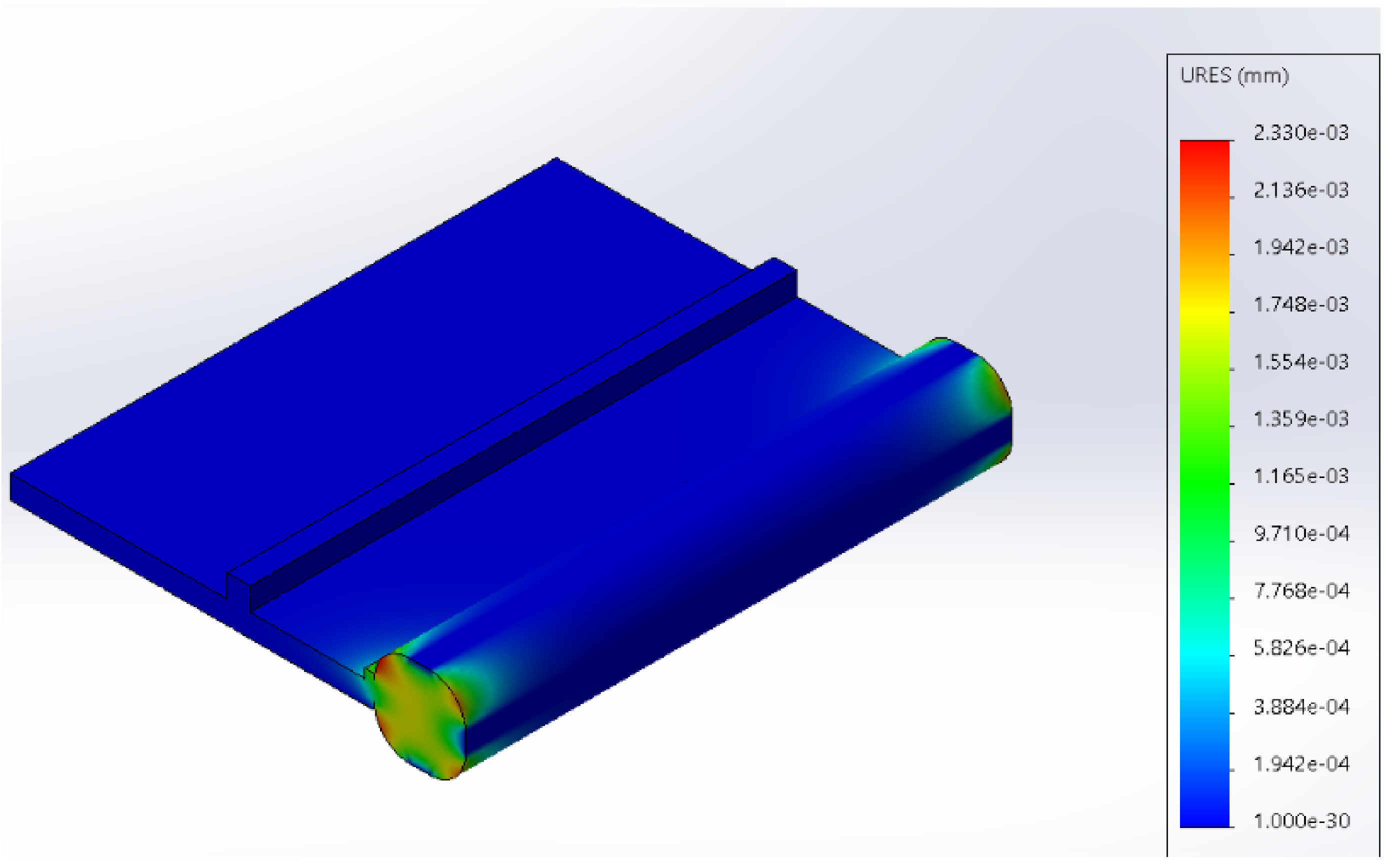
Strain plots for handle and base models:





Deflection plots for handle and base models:





Maximum deflections:

Base design - 18.8 mm

Handle design - $2.33e^{-3}$ mm

Conclusions/action items:

This data will be analyzed and discussed before being added to our paper and presentation.

References:

Grip Aperture

Brittany Glaeser - Feb 25, 2020, 2:51 PM CST

Title: Grip Aperture

Date: 2/25

Content by: Brittany

Present: Brittany

Goals: To understand the ideal aperture size for grip strength

Content:

This article studied a bunch of children and their grip vs. pinch grip strength (specifically the aperture size). It focused on the breakaway strength (the strength required to pull an object from the grasp of the child). This is important too for climber's as the amount of force they exert allows them to hold on to a variety of climbing holds at the gym. It was found that with a larger grip aperture that they are capable of exerting more force. The study determined that increasing the size of holds on play grounds will prevent kids from falling. With climber's, many of the holds are small and require more of a pinch grip, therefore, it would be more beneficial to strengthen the grip with a smaller aperture.

Conclusions/action items:

The "Pinch Grip" Design was made based off of this idea that a smaller aperture is weaker and therefore would need to be strengthened more. It would be more beneficial to find an article that focused primarily on the pinch grip rather than grip aperture since it would be more applicable to the design.

References:

Ehrlich, P., Young, J., Ulin, S., Woolley, C., Armstrong, T., Galecki, A., Chen, S. and Ashton-Miller, J. (2012). Maximum Hand-Rung Coupling Forces in Children. Human Factors: The Journal of the Human Factors and Ergonomics Society, 55(3), pp.545-556.

Muscle Groups for Rock Climbing

Brittany Glaeser - Feb 26, 2020, 12:16 AM CST

Title: Muscle Groups using in Rock Climbing

Date: 2/25

Content by: Brittany

Present: Britt

Goals: To understand more of the specific muscles used in rock climbing

Content:

- Used electromyographing
  - Good to know the accuracy of it since this is something we will do as a team
- Difficulties in rock climbing are mainly due to muscle fatigue
  - Would help to strengthen these muscles so the onset of fatigue is delayed
- Grip strength and endurance is positively correlated with climbing ability and performance
  - This is a good way to help promote our device
- This study looked directly at fatigue where as some studies only focus on using grip dynmometer
- The study found that the digital flexors and elbow flexor are the most easily fatigued muscles and the fatigue in these muscle could cause a rock climbers ability to decline
  - Even more so than the pull up motion from pull ups

Conclusions/action items:

The article was very useful instating what muscles groups are caused by poor performance. Before it was harder to find which muscles are directly associated with grip since many of the forearm muscles are involved, but with the EMG testing from this article stating that the main fatigue is in the digital flexors it may be easier to go about research of these muscles. It would be beneficial to look even further into what movements activate the digital flexors.

References:

Deyhle, M., Hsu, H., Fairfield, T., Cadez-Schmidt, T., Gurney, B. and Mermier, C. (2015). Relative Importance of Four Muscle Groups for Indoor Rock Climbing Performance. *Journal of Strength and Conditioning Research*, 29(7), pp.2006-2014.

Affect of Elbow Movement on Grip

Brittany Glaeser - Mar 09, 2020, 12:09 PM CDT

Title: Affect of Elbow Movement on Grip

Date: 3/9

Content by: Brittany

Present: Brittany

Goals: To understand why a static movement of the elbow is beneficial in training

Content:

There was not full access to the article only the abstract.

- Wanted to determine the effect of repeated elbow movement on power grip force
    - Relates to muscle cocontraction (Multiple muscles contract around a joint for stability)
    - Could cause cumulative trauma disorder (CTD)
        - Wear on tear on muscles, tendons, and nerves from repetitive force or movements
- Movements preformed in the saggital plane (bicep curl)
    - Test was completed with voluntary static position and voluntary dynamic movements
- It was found that with an increase in motion of the arm, the grip fluctuation, finger muscle activities, and siffness significantly increased
    - Higher muscle activities that are unnecessary and therefore have a higher risk of potentially higher reptitive musculoskeletal injuries

Conclusions/action items:

This article helped to explain our reasoning behind a static elbow position; to prevent overuse and higher activities of the muscles. This article also related to an article Kaitlin had found about how we maybe don't want our device to mimic climber motions as the repetition can cause muscle tears. This article explains that even a voluntary static position can work to prevent higher muscle activity. This can be looked into more to determine whether or not the device needs to lock the arm in place or the user can do it on their own.

References:

Gao, F., 2012. Power grip force is modulated in repeated elbow movement. *Ergonomics*, 55(4), pp.489-499.

Forearm Circum. and Grip Strength

Brittany Glaeser - Apr 01, 2020, 11:03 PM CDT

Title: Forearm Circumference and Grip Strength

Date: 4/1/20

Content by: Brittany

Present: Britt

Goals: To find forearm circumference to determine the radius for our device

Content:

- One article I found had the following forearm circumferences for ~80 female and ~170 male ranging in age of 18-80 [1]
  - This study had done measurements 12 cm distal to the tip of the olecranon in the supinated position at 90 degrees
    - Female Average
      - Dominant: 20.4 cm
      - Non-Dominant: 20.2 cm
    - Male Average
      - Dominant: 24.3 cm
      - Non-Dominant: 23.9 cm
- The numbers above were lower than normal weighted females in another study were there were ~200 females between the ages of 20-80 [2]
  - This study had measured forearms at the largest part and did not specify which hand
    - Female: 23.1
- Forearm circumference generally decreased with age [1]
- Mean grip strength [1]
  - Men: 48.6 kg
  - Women: 28.5 kg
- This article also mentions the 10% rule, that the dominant is generally 10% stronger than the non-dominant hand [1]
- Forearm circumference is a good indicator of grip strength [1]
- The forearm values will be used to calculated the radius of curvature for the base of the L-piece. An average radius will ensure that the device is comfortable for the user and won't slide horizontally on the user
- The above circumferences can be used in the equation below to calculate the radius

$$2 * \pi * r = c$$

$$r = c / (2 * \pi)$$

- The max and min values were used so that an average of that can be used as a trial for the curvature
  - min = 20.2: 3.21 cm
  - max = 24.3: 3.87 cm

Conclusions/action items:

The first thing that should be done will be to modify the current L-piece with a new radius and print it. But with current conditions, we will not be able to print or test the device for comfort so it will just be modified in the CAD. More research will be done to figure out how to make the device more comfortable. This information can also be used if testing were to be completed over long periods of time. For example, if the device were to be used, one could measure the forearm circumference and use it as an indicator for increase in grip strength.

References:

[1] ANAKWE, R., HUNTLEY, J. and MCEACHAN, J., 2007. Grip Strength and Forearm Circumference in a Healthy Population. *Journal of Hand Surgery (European Volume)*, 32(2), pp.203-209.

[2] Polymeris, A., Papapetrou, P. and Katsoulis, G., 2014. An Average Body Circumference Can Be a Substitute for Body Mass Index in Women. *Advances in Medicine*, 2014, pp.1-6.

Moment Arms of Forearm

Brittany Glaeser - Apr 20, 2020, 10:52 PM CDT

Title: Moment arms for FBD

Date: 4/16

Content by: Brittany

Present: Britt

Goals: Find moment arms for forearm extensors, flexors, and pronator teres

Content:

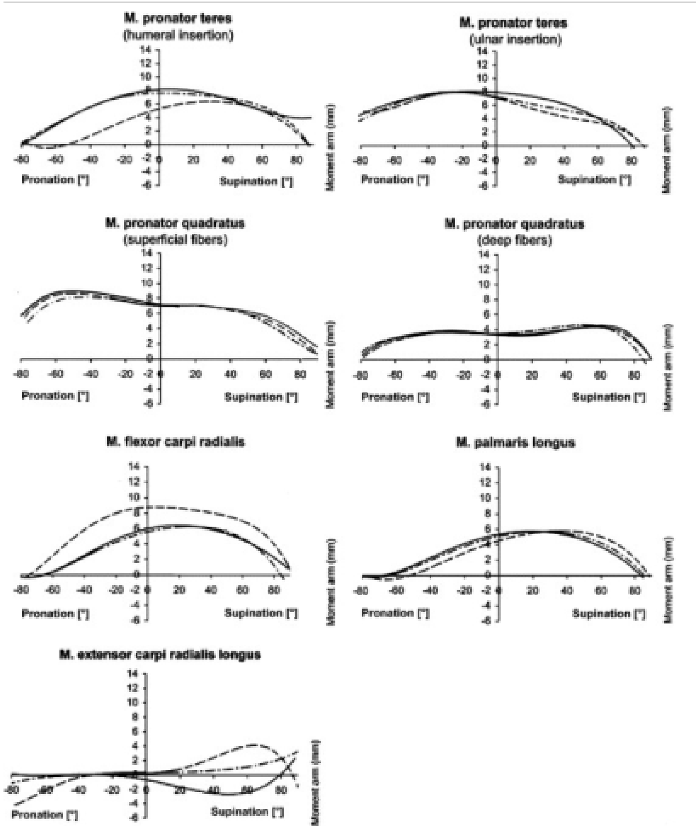


Figure 1: Forearm angle vs. Moment arm

The above figure was found in an article that testing for moment arms with different forearm angles. There were also moment arms for the upper arm and a few other muscles, but since we plan on doing FBD on the forearm, these were less important to include.

Positive degrees is full supination and negative degrees is full pronation.

Moment arm in diagram is (mm)

Moment Arm = F * d

I found a second article that also list moment arms for the pronator teres. The values seem similar so either can be used for calculations. [2]

Conclusions/action items:

The next step will be to use the above moment arms for FBD.

References:

[1] Bremer, A., Sennwald, G., Favre, P. and Jacob, H., 2006. Moment arms of forearm rotators. *Clinical Biomechanics*, 21(7), pp.683-691.

[2] Murray, W., Delp, S. and Buchanan, T., 1995. Variation of muscle moment arms with elbow and forearm position. *Journal of Biomechanics*, 28(5), pp.513-525.

Length Tension Relationship

Brittany Glaeser - Apr 17, 2020, 3:19 PM CDT

Title: Length Tension Relationship of Muscles

Date: 4/16

Content by: Brittany

Present: Britt

Goals: Determine how the length tension relationship can help with our project

Content:

The length tension relationship basically just further states how there is an optimal length of the muscles that will produce the most force. This is important because it further proves the moment arm vs. angle idea (in another entry). From the figure below, the optimal length is when the sacromeres are between 2.1 and 2.2 um. From the angle vs. moment arm, it can then be assumed that when the maximum force is produced, that the sacromeres are overlapping at that length.

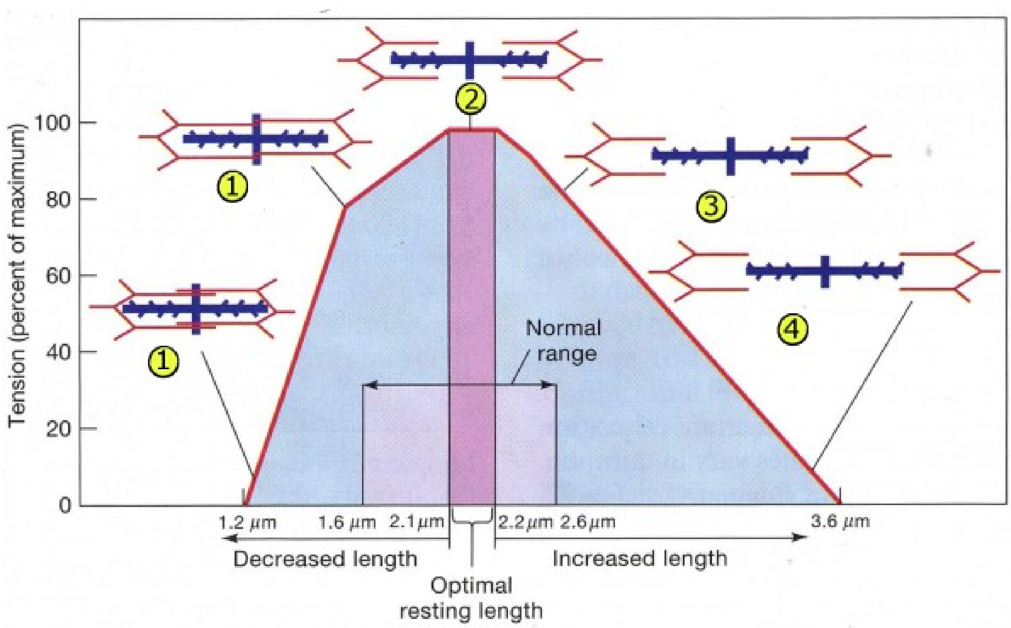


Figure 1. Length tension relationship

There would be little force when the muscles are fully contracted or fully extended.

Conclusions/action items:

This information will be used in the report for reasoning behind the angle vs. moment arm data.

References:

Old lecture content

Muscle Activation Direction

Brittany Glaeser - Apr 22, 2020, 10:27 PM CDT

Title: Muscle Activation Plane Direction

Date: 4/20

Content by: Brittany

Present: Britt

Goals: To understand which plane the muscles act in

Content:

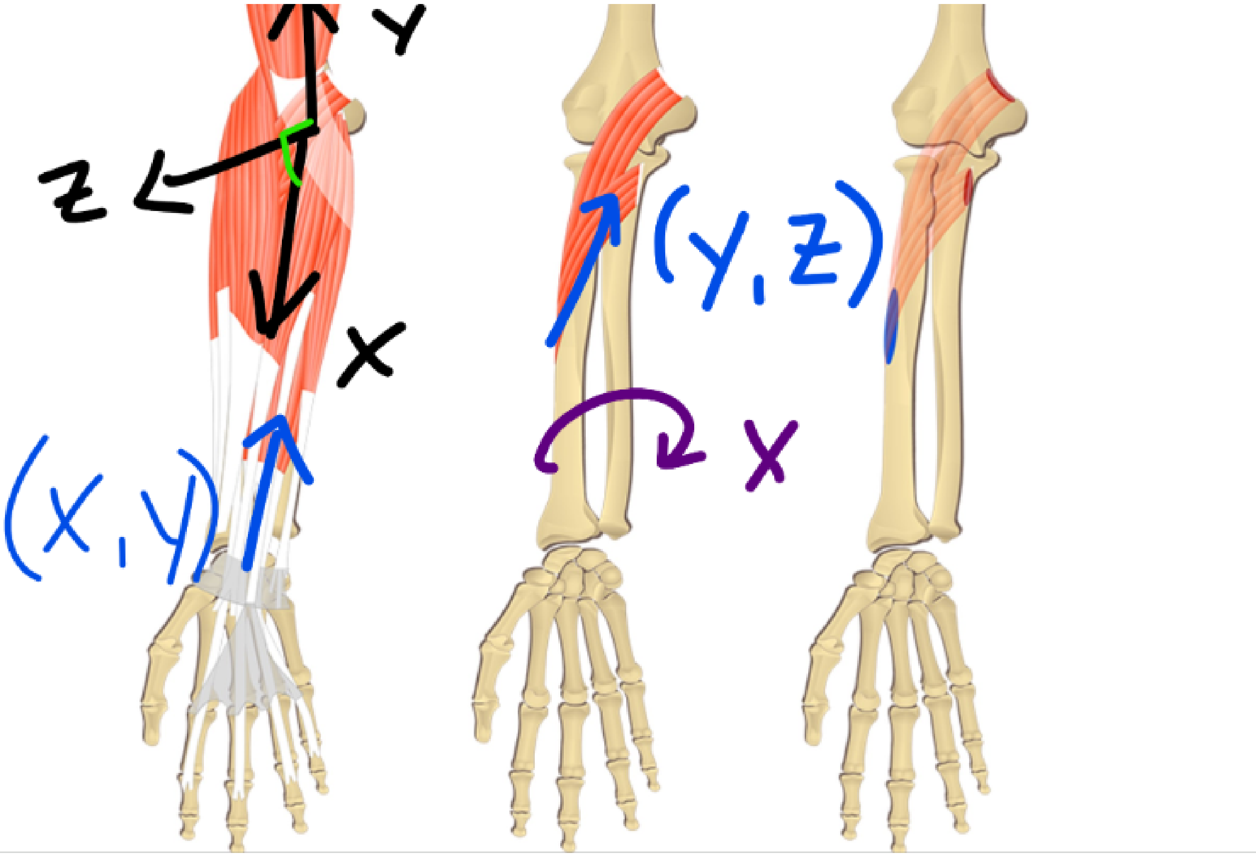


Figure 1. Shows the muscles of the forearm and with drawn arrows of their direction. The arm in the middle specifically shows the pronator teres. This is the top view of the arm [1].

A side view would be easier to show the coordinate axis, but it didn't show the muscles as well. The y axis is shown up the bicep and the x axis extends down the forearm, while the z axis is shown pointing laterally to the forearm.

The flexors of the forearm flex the wrist downward (-y) pulling along the x axis as well as slightly downward in the -y direction.

The extensors of the forearm flex the wrist upward pulling up (+y) along the y axis.

The extensors and flexors create a moment about the z axis (wrist rotates about z)

The pronator teres works differents as it creates a moment about the x axis. This muscle pulls laterally along the z axis and also pulls upward along the y axis. The movement upward along the y axis is also how the muscle is involved in the flexion of the elbow.

Conclusions/action items:

The photo was a quick indicator of how the muscles are working in action. Knowing that the muscles only work by contracting rather than extending can indicate which direction they act. The direction they act in is helping to know for creating FDB and finding the corresponding equations.

References:

[1] GetBodySmart. 2020. *Pronator Teres - Attachments, Action & Innervation*. [online] Available at: <https://www.getbodysmart.com/arm-muscles/pronator-teres-muscle> [Accessed 18 April 2020].

FBD

Brittany Glaeser - Apr 22, 2020, 7:06 PM CDT

Title: FDB to find equations for muscle force

Date: 4/21

Content by: Brittany

Present: Britt

Goals: Find equation for the force exerted by the muscle

Content:

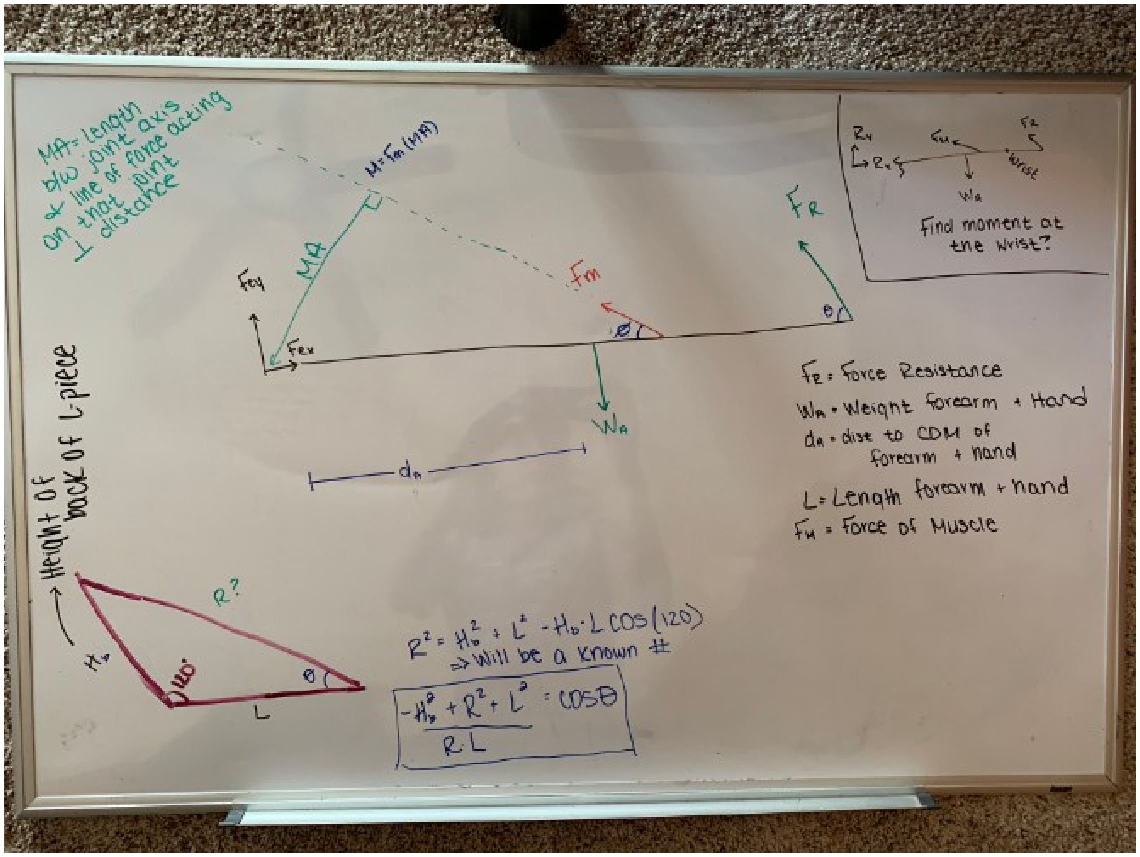


Figure 1. Rough sketches of the free body diagram of the lower arm as well and trig equation for angle of resistance band

The muscle force should be able to be calculated by taking the moments about the elbow (Fex, Fey) to calculate for the unknown. Them moments arms used for the calculations will be based off the numbers given in another page called "Moments Arms of Forearm"

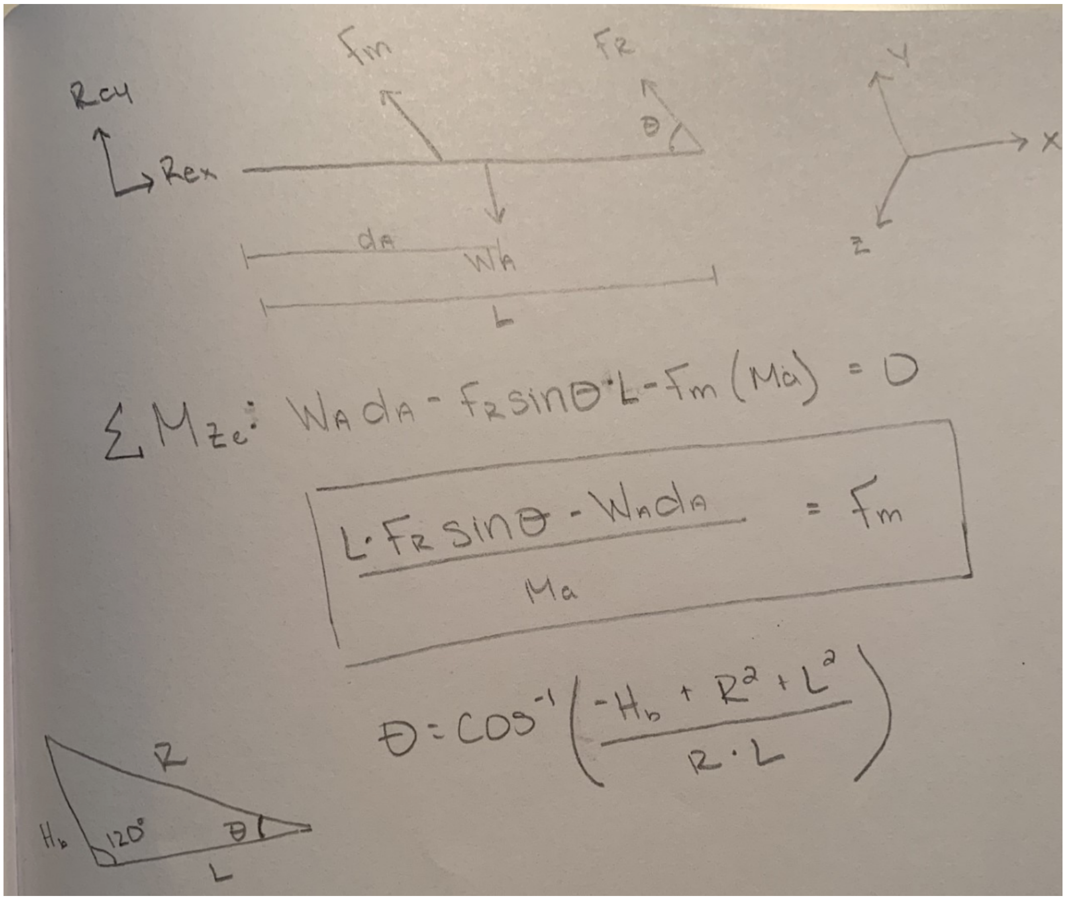


Figure 2. The equation above will work for the FBD above. It also shows the value for theta.

One of the concerns we were originally having was whether or not the moment arm data was about the wrist or the bicep. In the end, this would not change the equation since the distance the moment acts does not matter since the moment produce from the moment arm (MA * Fm) will simply be added into the moment equation.

Conclusions/action items:

The above equations will be reviewed and implemented into the poster presentation. Rather than stick drawings of FBD, the FBD will be atop of the arm wearing the device to have a better idea of force direction. The equations will also be used in the final report but likely kept as all variables for easy calculations later on for variation in resistance angle, resistance force, and forearm lengths.

References:

MVC Forearm Flexors

Brittany Glaeser - Apr 25, 2020, 4:34 PM CDT

Title: MVC of forearm flexors

Date: 4/25

Content by: Brittany

Present: Britt

Goals: Determine the MVC exerted by the forearm flexors

Content:

- One big point was the fact that the article states the most major forearm flexor used in rock climbing (found in a couple articles) was the Flexor Digitorum Profundus
- The MVC was determine by attaching a load cell to a fingerboard apparatus
- The MVC found for climber's was 29.4 kg with a lead or 36.9 kg for boulderers
    - This is interesting because it was something we had discussed with Masters as she would climb outdoors
- The climber's in this study were ones that had years of experience
    - Muscle size was also measured in this study
    - Circumferences were measured but they are not given in the study
- Normal forearm training was at about 40% MVC

Conclusions/action items:

The main takeaway from this article is the MVC. This will give us more information on the force that a user can exert and the strength of bands that will be needed. Currently, our bands would not meet the MVC for climber's, but would be able to be used for training purposes. Also, it is possible are bands can reach higher forces with elongations greater than 200%, assuming well before fracture point, but this cannot be determined without further testing of the bands.

References:

Fryer, S., Stone, K., Sveen, J., Dickson, T., España-Romero, V., Giles, D., Baláš, J., Stoner, L. and Draper, N., 2017. Differences in forearm strength, endurance, and hemodynamic kinetics between male boulderers and lead rock climbers. *European Journal of Sport Science*, 17(9), pp.1177-1183.

Weights

Brittany Glaeser - Apr 23, 2020, 9:36 PM CDT

Title: Weights as an alternative to forearm training

Date: 4/22

Content by: Brittany

Present: Britt

Goals: To explain how our device would be better than using weights

Content:

PROS to weights:

- Found at most gyms
- Can be used for exercises other than forearm training
- More force can be provided if needed
- Easy to use
- One size fits all

CONS to weights:

- Heavy - less portable
- Force is not as incremental - less adaptable
- Unstable surface focus more on balancing many muscles rather than focusing on specific muscles
- Expensive and would need multiple
- Won't include a grip element

Conclusions/action items:

CONS > PROS therefore CFT > weights

References:

Stable vs. Unstable Surfaces

Brittany Glaeser - Apr 06, 2020, 10:34 PM CDT

Title: Stable vs. Unstable surfaces

Date: 4/5/20

Content by: Brittany Glaeser

Present: Britt

Goals: To understand the importance of stable surfaces during exercising

Content:

- With regard to muscle power, there was only a small effect from stable and unstable against the control
- Unstable devices are generally used to promote postural disequilibrium as it changes in response to the center of pressure
    - Not what are device is intended to be used for
    - May have an impact with the memory foam that is used within the L-piece
- Unstable devices suggest that the greater instability may stress the neuromuscular system to a greater extent
    - This is why we want to add walls!
- Unstable training can be good for sports that require balance and posture and certain activities can replicate the stability
    - For our device we aren't trying to model rock climbing (which is unstable), we are focused on the strengthening of the muscles
    - If one were to want an unstable surface, free weights would likely be best to work the forearm and replicate the stability of rock climbing
    - BOTH is good!
    - Unstable training is also good for those who need less load/weight (elders or rehabilitation) because it will still activate the neuromuscular system in the same way
        - This slightly counteracts previous rehabilitation findings were a stable surface/movements are better. My guess would that an unstable with lower load for balance would be best, but to regain strength than a stable surface would be better (This is my own thought based off the reading). This is obviously important for our device as the goal is to be used for both prevention (training) and rehabilitation of Climber's Elbow
- This meta analysis found that it is not recommended for healthy adolescents or young adults to train on unstable surfaces unless what their are training for is unstable
- There is smaller effects when the stable and unstable were compared
    - Therefore, the main purpose of this article was to state that for specific activities unstable or stable training would be better

Conclusions/action items:

This article provided a lot of interesting information. More importantly, it consisted of information that is relevant to the design. This article further supports our idea of adding curved edges to our device to prevent horizontal movement. This would allow for strength training with larger load to focus ONLY on strengthening the muscle and not on balance/support of the muscles. If one were to want to train their muscles with an unstable surface, free weights would suffice.

References:

Polymeris, A., Papapetrou, P. and Katsoulis, G., 2014. An Average Body Circumference Can Be a Substitute for Body Mass Index in Women. *Advances in Medicine*, 2014, pp.1-6.

Static vs. Dynamic Training

Brittany Glaeser - Apr 08, 2020, 10:41 PM CDT

Title: Static vs. Dynamic Training

Date: 4/5/20

Content by: Brittany

Present: Britt

Goals: To understand benefits of dynamic vs. static training

Content:

- Static = isometric
- Isometric training has shown to induce less fatigue
- Resulted in superior joint angle specific strength
- Benefits certain dynamic sports
  - Used running, jumping, and cycling as an example - Why?
- Keeps athletes from becoming overly fatigued while still having positive neuromuscular adaptations to improve strength
- Isometric is also good during injury when athletes may have limited movement
  - Potential issue with Climber's Elbow
- Isometric training should be performed at 70-75% max voluntary contraction with sustained contraction of 3-30s
- To increase max strength, Isometric training should be performed at 80-100% MVC with sustained contraction of 1-5s
  - With different joint angles or at a specific angle
- Isometric training can maximize the improvement of rate of force development
- Dynamic training is preferred for dynamic sports/movements because it will translate better
  - Climber may have more of the static positions since climber's don't generally climb for speed

Conclusions/action items:

Above is the main points of the article. The most important thing to take away from this article is that isometric training has many of the same benefits as dynamic training, the main difference is that dynamic training will translate better to dynamic sports (not necessarily climbing). Isometric training is good when there is limited mobility or reducing fatigue is muscles which is beneficial for rehabilitation, such as for climber's elbow. Another thing to mention in this article is that isometric training greatly enhances strength at a specified angle. This could allow for a grip design to be static rather than dynamic making fabrication easier. It may be beneficial to include different hand holds for different angles of the fingers to strengthen the muscles at more than one angle.

References:

Lum, D. and Barbosa, T., 2019. Brief Review: Effects of Isometric Strength Training on Strength and Dynamic Performance. *International Journal of Sports Medicine*, 40(06), pp.363-375.

Bicep Activation

Brittany Glaeser - Apr 15, 2020, 7:35 PM CDT

Title: Bicep Activation based on elbow angle and forearm posture

Date: 4/15

Content by: Brittany

Present: Britt

Goals: Determine how to limit bicep activation to focus our device on the forearm muscles

Content:

- The affects of this study was done using EMG with electrodes placed on the biceps
  - We did this!
- Each muscle's contribution to elbow joint torque is affected by changing joint angle
- At least one muscle of the biceps is affects by angle changes in the supination position
- In a neutral position, the sensitivity of the bicep was subject dependent
  - Neutral and supination were tested
- Joint angle, type of contraction, and generated force level are factors that affect activation
  - Type of contraction - concentric and eccentric
- For MVC, different strategies are used and different activation levels are required for concentric and eccentric contractions
  - Generally lower for eccentric motions
- During muscle contraction, the muscle is not homogeneously activated along the muscle length
  - For this, electrodes were placed closest to the largest portion of the muscle
  - This is important to note for EMG testing of our own
- This study was done using isometric conditions
- Triceps were not affected by joint angle or forearm position
- From 60 to 90 degrees, the short head of the bicep brachii was affected but not the long head
  - Activation was increased
- Forearm position can change the geometry of the muscles within the upper arm
  - During supination, it is show that the biceps have higher activation than neutral position

Conclusions/action items:

The key points from this article for the design was noting that biceps were overall more activation with increased elbow angles. This experiment did not test at angles above 90 degrees which is not ideal since we plan to have our device between 100-110 degrees. It was also noted that biceps are more activated in the supination position of the forearm and may be hard to completely limit activation when preforming this motion. Another important fact, was for EMG testing that electrodes should be placed at the largest part of the muscle since the muscle is not uniformly activated.

References:

Hajian, G. and Morin, E., 2017. Effect of Joing Angle and Forearm Posutre on the Elbow Flexor and Extensor Muscles during Isometric Contraction. *Conference of the Canadian Medical and Biological Engineering.*

Elbow Flexor Activation

Brittany Glaeser - Apr 15, 2020, 7:58 PM CDT

Title: Flexor Activation with a Pulley

Date: 4/15

Content by: Brittany

Present: Britt

Goals: Determine muscle activation at different angles

Content:

- Elbow going was measured at 55, 70, 90 degrees
  - Not really ideal since we want our design to be above 100 degrees for comfort and ease of use
- The flexor muscles showed changes between 55-70 degrees (the biceps brachii did not change)
  - Biceps was most activated at 55 degrees
- Joint angle changes lever arm length and muscle length which accompanies variation in muscle contraction
  - There should be a joint angle that is optimal
- Muscular strength would be determined by length-tension relationship
  - The length tension relationship was taught in biomechanics - should be something to revisit
- Muscle length increases - activation will decrease
  - I knew this, but seemed important to remember
  - Muscle length is not related to activation
- There is a muscle length that generates optimal strength
  - This should be researched for the grip part of the design since it will only have one position
- When muscle was stretched to 20-30% of its length, the bigger the passive force
  - The angle of the handle should allow for the muscles to be stretched to 20% of their length to create an optimal force

Conclusions/action items:

The studied itself was not very useful, but it brought up some good points to consider. Such as, revisit the length-tension curve and how that can be included in our report. Also, that for optimal strength of the muscle, an angle should be created that stretches the muscle to 20% of their resting state.

References:

T. Kang, Y. Seo, J. Park, E. Dong, B. Seo, and D. Han, “The Effects of Elbow Joint Angle Change on the Elbow Flexor Muscle Activation in Pulley with Weight Exercise,” *Journal of Physical Therapy Science*, vol. 25, no. 9, pp. 1133–1136, Oct. 2013.

Pinch Grip Design

Brittany Glaeser - Feb 22, 2020, 3:58 PM CST

Title: Pinch Grip Design

Date: 2/16/20

Content by: Brittany

Present: Brittany

Goals: To create a grip strengthening design to incorporate into the existing design

Content:

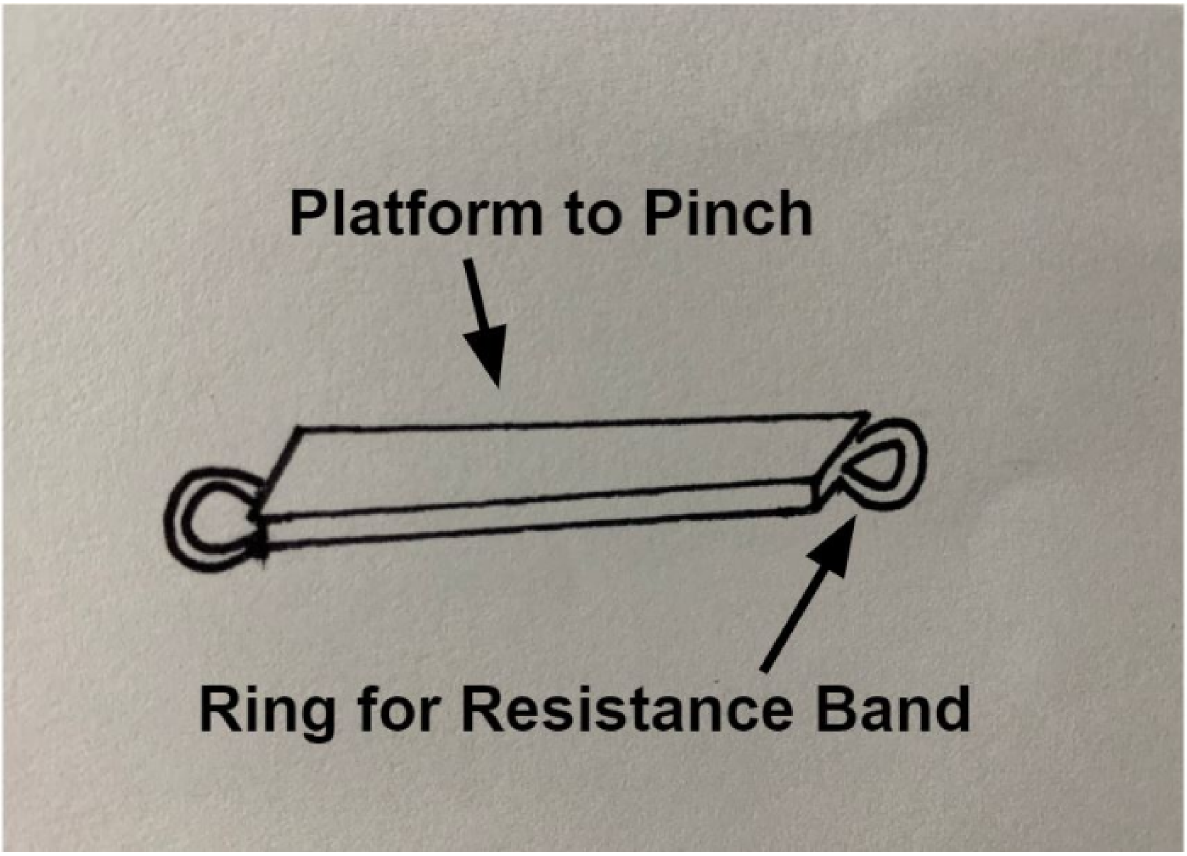


Figure 1. Pinch Grip Design

The idea of this design was to take the idea of the hang board competing design. The hand board competing design consists of small platforms that allow the user to pinch and pull themselves upward. This is common for rock climber's to use as it models boulders or holds on a rock wall. The material would have to made of something not too slick so the user's fingers won't slide off. The material would also have to be strong enough so that the force exerted by the resistance bands do not bend the thin platform.

The rings on the side of the handle are for attachment of the new resistance bands the team is planning on adding to the device. The new resistance bands may consist of a carabiner clip or hollow tubing that has a plastic insert (This type of design mechanism was shown to us at the SAPC during the fall semester).

Figure 2. Tubed Resistance band with plastic inserts [1]. The plastic insert is placed into the cone shape of the handle to keep from sliding out. Allows for easy removal of the resistance band.

A pro to this design is that it is easy to use and only one handle will be needed. It also allows for adjustable resistance based on the increase of the resistance bands for the device. Another pro is that it will activate many of the different muscle involved in grip that are located in the more distal region of the forearm.

A con is that the only way to increase resistance would be to change the bands of the entire device and it doesn't work individual fingers (something client was hoping to see).

Conclusions/action items:

This design will be placed into the design matrix for evaluation. If this were to be the design we move forward with, modifications would need to be made depending on the style of resistance bands the team decides on. Fabrication plans would also need to be considered - especially since the team lab would not be an option. This deign would be easy to implement into the design and would not require any modifications of the base design if that were to change.

References:

[1] Gronk Fitness Products. (2020). *BB Fitness Beachbody Line Resistance Bands Set*. [online] Available at: https://www.gronkfitnessproducts.com/products/beachbody-b-lines-super-kit-8pcs-kit [Accessed 22 Feb. 2020].

Brace Base Design

Brittany Glaeser - Feb 26, 2020, 12:36 AM CST

Title: Base Design

Date: 2/16

Content by: Brittany

Present: Britt

Goals: Create a Base design

Content:

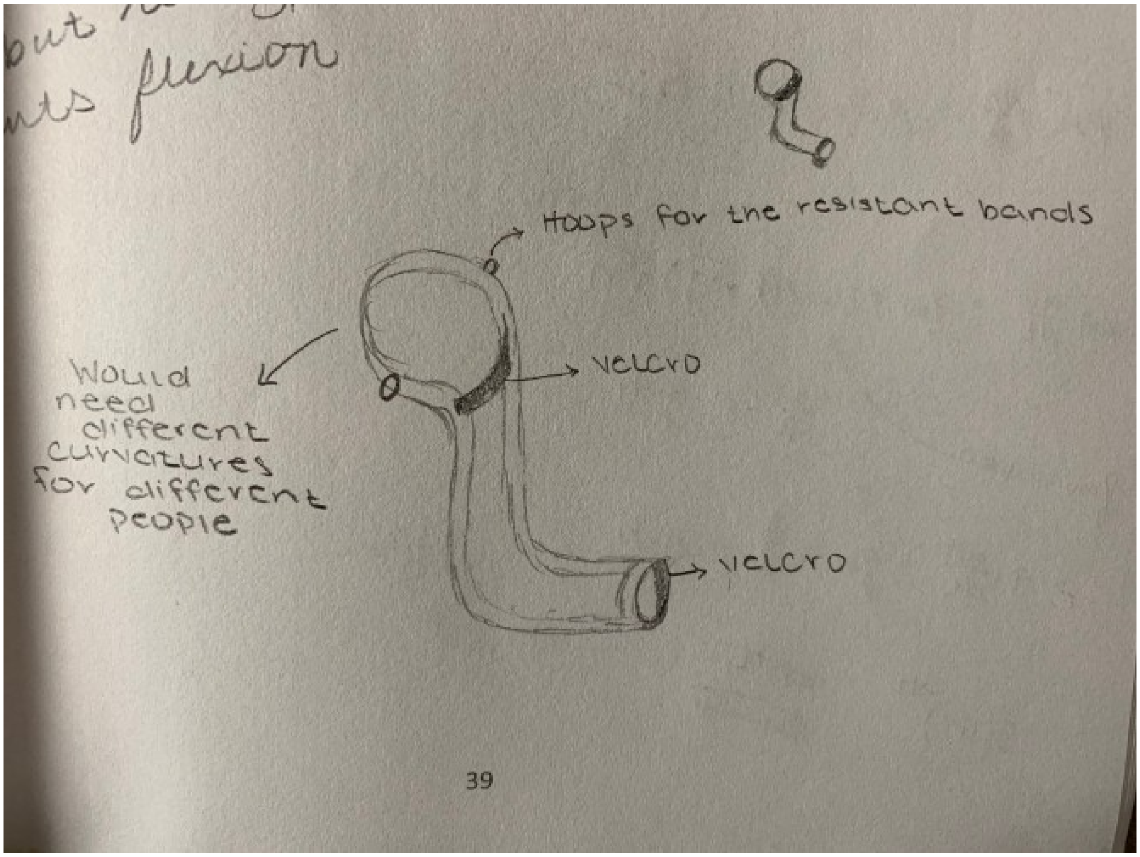


Figure 1. The brace base design.

The idea for this design was based off of the knee braces that many football players use. This would help lock the arm in place and prevent any lateral movement. Ideally, this design would be either have an angle of about 110 degrees or have an locking hinge mechanism placed at the elbow. The velcro straps for this design would already be laced through the spots and the user would slide their arm in and tighten the straps. The resistance bands would slide through the loops at the top of the brace design and loop around the back.

This design may be too bulky and harder to fabricate ourselves. Also, there were need to be a way to increase the tension in the resistance bands to include more force. This could either be by adding a rigid curved piece along the back of the upper arm where hooks could be placed or by a new mechanism.

Another issue with this device is that it is not unique and it taken from something that is already preexisting.

Conclusions/action items:

Next would be to present this design to the team and determine whether or not to use this design in the design matrix. More thought would need to go into how to make change to the design to fit the design specifications.

References:

Fabrication Ideas

Brittany Glaeser - Feb 26, 2020, 9:38 AM CST

Title: Learn more about thermoforming

Date: 2/26

Content by: Brittany

Present: Brittany

Goals: To understand if thermoforming is something we could use for the project

Content:

I had recently heard of thermoforming and didn't know if it was something the team could use for fabrication. This morning I was able to stop in the makerspace and learn more about it.

- Uses different types of plastics
    - 1/16 or 1/8 inch thick
- A mold is created using 3D printed and placed into a thermoforming
    - Must have a higher melting point than what the thermoformer opperates at (60-80 degrees)
- The plastic will melt around the mold
- Issue is that it isnt a very thick plastic and depending on how much the plastic melts it could stretch and certain areas could become thinner
- It is more ideal for making molds
- Excess plastic can be cut off
- There are different colored plastics

Conclusions/action items:

After learning more about thermoforming, I do not think this would be a good idea for this project. The plastic would be too think and may break under the force of the user or resistance bands. This is more useful for making molds which is also something that we don't need for the project. It was interesting to learn more about it as it could be used for future projects.

References:

Resistance Band Attachment

Title: Resistance Band Attachment

Date: 3/1/20

Content by: Brittany

Present: Britt

Goals: To come up with ideas to attach resistance bands to the new pinch grip

Content:

Figure 1. Tube resistance bands with carabiner clip for attachment

These resistance band handles are made of nylon straps that are sown together to hold the carabiner clip in place. This is easily something we could create ourselves. It also has a metal eyel
to keep the resistance band from falling out.

Some of the inserts have been cone shaped to lock the band more inplace, but those have been hard to find and this design may be easier to incorporate and the band would not slide out.

Conclusions/action items:

Talk with the team and potentially move forward with the eyelet design. The plastic balls can be found almost anywhere or potentially fabricated ourselves. The eyelets are also easy to find in r
carabiner clip idea would also likely be easy for many users to use since they are a common type of clip.

References:

Amazon.com. (2020). [online] Available at: https://www.amazon.com/dp/B01LY9ES97/ref=sspa_dk_detail_1?psc=1&pd_rd_i=B01LY9ES97&pd_rd_w=SvkJe&pf_rd_p=c83c55b0-5d97-454a-a
eca0fe5519a2&spLa=ZW5jcnlwdGVkUXVhbGlmaWVyPUEzMFo4TjZXRVY0NEY5JmVuY3J5cHRlZElkPUEwNzIxNzA1MjBDSTJYUU9ZN1Y0JmVuY3J5cHRlZEFkSWQ9QTA5NTI2OTExOEc
[Accessed 2 Mar. 2020].

Rigid Element for Base Design

Brittany Glaeser - Mar 01, 2020, 7:26 PM CST

Title: Rigid Element Design

Date: 3/1

Content by: Brittany

Present: Britt

Goals: Replace the straps with a rigid element

Content:

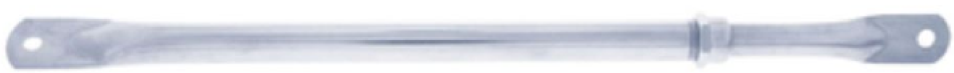


Figure 1. Stainless Steel adjustable extensor

One of the issues with the straps design was that the straps would prevent extension, but the thin plastic could flex and the straps would not allow for this. A rigid element is needed to prevent the extension. This design would certainly be strong and would only require screws on the side of the design and the adjustment mechanism would only be within the screw on the extensor.

One issue with this design is that it may not be easy to use, but the idea is that it would only need to be adjusted once for the user once the individual user finds a comfortable angle. Another issue could potentially be if the user is not strong enough to tighten it could move on the user based on the amount of force applied.

Conclusions/action items:

This idea will be presented to the team for the next meeting. More research will be continued to determine if there is a better alternative that is more intuitive and easy to use. It may also be beneficial to look for more of these extensors to see if there are ones with a different tightening mechanism, or one that has a different adjustment length as the one pictured above has a range of 5" which may be too much.

References:

Deyhle, M., Hsu, H., Fairfield, T., Cadez-Schmidt, T., Gurney, B. and Mermier, C. (2015). Relative Importance of Four Muscle Groups for Indoor Rock Climbing Performance. *Journal of Strength and Conditioning Research*, 29(7), pp.2006-2014.

Resistance Band Tightening

Brittany Glaeser - Mar 09, 2020, 11:17 AM CDT

Title: Resistance Band Tightening

Date: 3/9

Content by: Brittany

Present: Britt

Goals: Find a better way to add tension to the resistance bands

Content:

Tightening the resistances bands currently, uses the hook's on the back on the L-piece. This isn't ideal as it only provides 3 increments for tightening for each band. They are also not the easiest to use and not intuitive. This was not something that was planning on being accomplished this semester, but I cam across an idea that could be potentially added by the end of the semester.

This semester, with the new tubed resistance bands, the idea was to attach the resistance bands to nylon straps attached them via carabiner clips to the handle. My thought was to cut the resistance bands shorter and increase the length of the nylon straps so a cam buckle can be added.

Figure 1. Cam Buckle

The cam buckle works by attaching a nylon strap rigidly to one end, and the other end contains a clip. The nylon strap is threaded through and pulled. The lock the strap in place, the clip would be pressed down and ideally the strap would not slide or loosen from result of the user. By pulling the nylon strap through the buckle, it will pull on the resistance band increasing the tension. This idea would be more intuitive for a user as it is similar to a backpack strap.

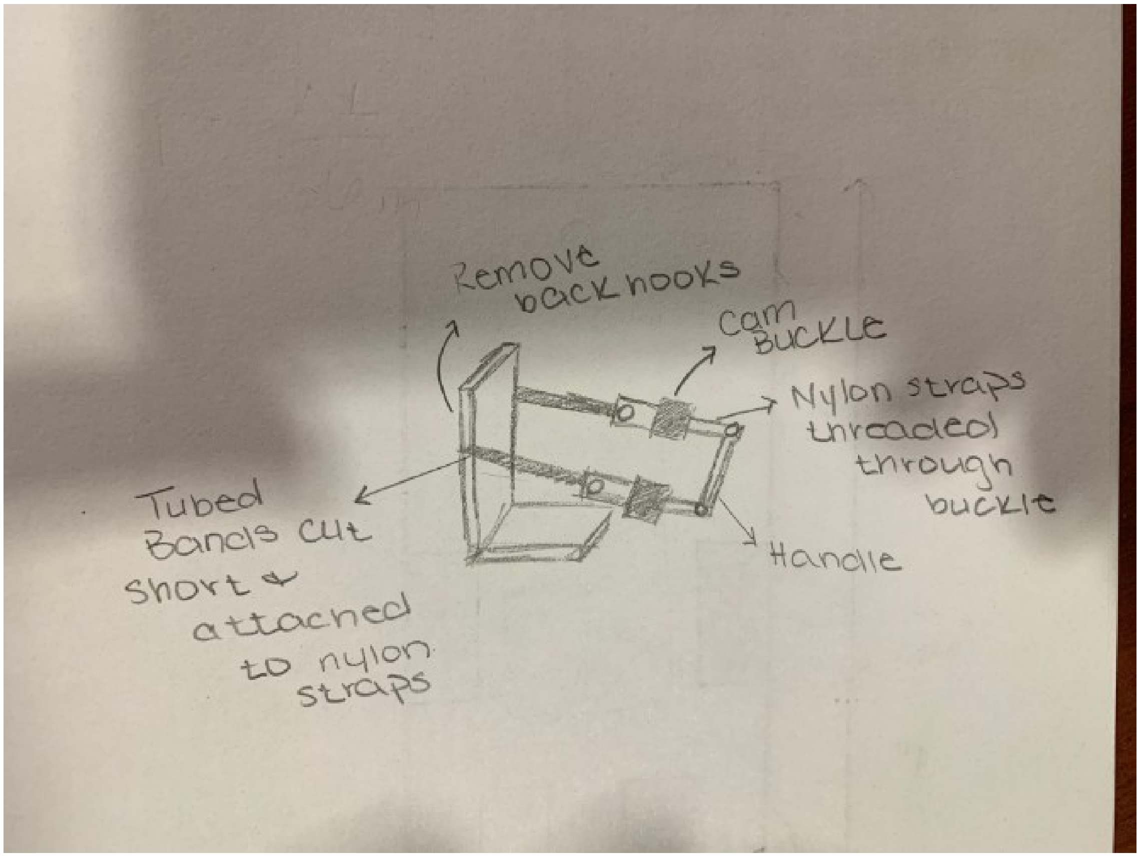


Figure 2. Drawing of the resistance band and cam buckle idea.

Conclusions/action items:

The plan is to move forward with changing the resistance bands and attaching them to the nylon straps. If that idea works as planned, more research would be done to find a type of cam buckle that is compatible and strong enough to prevent slip. The cam buckle would allow us to remove the hook's on the back of the L-piece for a slimmer and more intuitive design.

References:

Discount Ramps. 2020. *2" X 6' Cam Buckle Strap Tie-Downs With S-Hooks*. [online] Available at: <https://www.discountramps.com/cargo/tie-down-straps/2-inch/p/CAMSTRAP2/> [Accessed 9 March 2020].

Brittany Glaeser - Apr 22, 2020, 8:07 PM CDT

In addition to what is above. An idea similar to the cam buckle would be a tension buckle on a backpack. These are generally easier to use and more intuitive since they are found on many everyday items. The only issue with this is whether or not they would not slip while being pulled by the resistance bands. This could likely be tested using an MTS machine to see if they will withstand the max force exerted by the bands.

Green Pass

Brittany Glaeser - Feb 26, 2020, 12:03 PM CST

Title: Green Pass

Date: 2/26

Content By: Brittany

Present: Brittany

Content:

Obtained Fall of 2018

Conclusion:

Upgrades can be done if needed.

Grip Strengthening

KAITLIN LACY - Feb 26, 2020, 10:06 AM CST

Title: General Grip Strengthening

Date: 2/25/2020

Content by: Kaitlin Lacy

Goals: Learn about recommended ways for climbers to improve their grip strength.

Content:

As climbing has become more sophisticated over the years, devices and training have become very specific to target the exact muscles commonly used. This article claims that all of these specific activities and exercises can be detrimental to the climber for several reasons.

-Continuously doing the same exercises that pinpoint very specific muscles can over work these muscles and can lead to injury more quickly.

-Doing exercises for one group of muscles and not their antagonizing muscles, or the muscles that perform the opposite movements, can lead to an imbalance between these muscle groups which can also lead to injuries such as Climber's Elbow.

-Many climbers plateau when improving their grip strength. This is actually a way that their body is trying to prevent injury as it is not letting them work their fingers past the strength of the opposing muscle in that particular joint.

This article also offered several suggested exercises for climbers to do in order to train their muscles in a way to build up grip strength. This is in a healthy way that will be less likely to lead to injury.

-Wrist Curls: supinate the forearm and move hand from full extension to full flexion while gripping a dumbbell.

-Reverse Wrist Curls: pronate the forearm and move hand from full extension to full flexion while gripping a dumbbell.

-Wrist rotation: grip something such as a hammer, and rotate it until it is parallel to the floor. Reverse directions.

This article mentions the ineffectiveness of devices such as the donuts that offer resistance in flexion as they do not offer variable resistances. It suggests using a spring-loaded device that can change resistances

It also says that most finger extensors on the market are a waste of money and you can do the same thing with layered rubber bands.

Conclusions/action items: Exercising the flexors, extensors, pronators, and supinators in the forearm can cut down on the imbalance between the muscles and allow climbers to start building up strength again if they have plateaued. The exercises mentioned are ones we've already incorporated into the design. This suggests that these exercises themselves can help to increase grip strength, so the part that we add will just be supplementing the training that is currently happening on the device.

References:

"Developing General Grip Strength | Climb Strong", Climb Strong, 2020. [Online]. Available: https://www.climbstrong.com/education-center/developing-general-grip-strength/. [Accessed: 25- Feb- 2020].

Detailed Overview of Climber's Elbow

KAITLIN LACY - Feb 26, 2020, 12:36 PM CST

Title: Detailed Overview of Climber's Elbow

Date: 2/19/2020

Content by: Kaitlin Lacy

Goals: Refresh my understanding of Climber's Elbow and learn any more details necessary for the preliminary presentation.

Content:

-Same as Golfer's Elbow

-Arises from climbing too much, increasing intensity too quickly, and not allowing enough time for rest and recovery

-From tendon connecting pronator teres and other muscles involved in finger flexion

-Pronator teres activated when hand is pronated and is opposed by activation of the bicep which is responsible for supinating the hand. As the bicep is often stronger, this puts considerable strain on the pronator teres and the tendon connecting it to the medial epicondyle. Overuse or a particularly large gap in strength between these muscles can lead to micro tears in this tendon.

-Tendinosis is a gradual onset of pain whereas tendinitis is an acute onset of pain and swelling. Based on this, Climber's elbow is most likely a specific case of Tendinosis

-Two phases of recovery: phase 1 is immediately stopping all climbing and training as well as icing the elbow. Phase 2 involved exercises to stretch the area as well as build up strength.

-Warm up muscles before training and start gradually. There should be no sharp pain and discomfort, only mild and dull pain.

-Start with stretching until full range of motion is restored. Then light strength training can be implemented.

Conclusions/action items: This supports our design specification that it needs to target the pronator teres. Having variable resistances for both forearm and grip training is also important because it is important for those that are injured not to push themselves too much in the beginning. However, they need to be able to build up strength to prevent reinjury.

References: E. Hörst, "Treating “Climber’s Elbow”", Training For Climbing - by Eric Hörst, 2020. [Online]. Available: https://trainingforclimbing.com/treating-climbers-elbow-medial-epicondylitis/. [Accessed: 19- Feb- 2020].

Climbing Holds

KAITLIN LACY - Apr 28, 2020, 7:28 PM CDT

Title: Climbing Holds

Date: 3/12/2020

Content by: Kaitlin Lacy

Goals: Research the different types of climbing holds in climbing gyms. This is important because climbers who train primarily in the gym hurt themselves more frequently than those who climb outside.

Content:

Positivity is a general term for the easiness to grip a surface of a particular hold (rougher has more positivity).

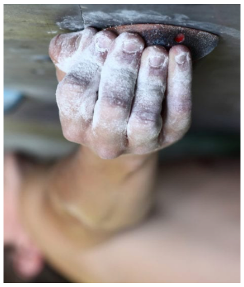
Jugs: Smooth and kind of a shirt-pocket type design that is easy to grip. Mini jugs are just a smaller version.

Slopers: Rounded holds without any edge to grip.

Pockets: have openings with only enough space for a few fingers to grip.

Pinches: have two faces that can be pinched to grip.

Crimp: have shallow edges for space for about one finger pad or knuckle. Require putting the second knuckle higher than the finger pad to have a downward force on the grip.



Conclusions/action items: Knowing the types of holds are used in climbing gyms may help to determine the method in which this device strengthens the grip. There seems to be a wide variety of grips used, so it could be difficult to incorporate multiple types into the device. The team needs to brainstorm ways to incorporate training that would help with all of these grips. There could possibly be one training exercise that could incorporate all of these holds.

References: “Climbing Holds Terminology,” *Kendall Cliffs*, 01-Aug-2019. [Online]. Available: https://www.kendallcliffs.com/top-7-terms-rock-climbing-holds. [Accessed: 12-Mar-2020].

Inter-Limb Coordination for Expert and Beginner Climbers

KAITLIN LACY - Apr 28, 2020, 7:11 PM CDT

Title: Inter-Limb Coordination for Expert and Beginner Climbers

Date: 4/2/2020

Content by: Kaitlin Lacy

Goals: Learn more about how different people climb and whether or not this affect our project. Specifically, the way expert climbers train may have some application to the training with this device.

Content:

This particular study defined an expert as an individual with 10 years experience or at least 10000 hours of dedicated practice. They compared the ratio of exploratory movements to performed actions and the perceived environmental variables that were "significant" for the climb.

Overall, experts had more movements that were coordinated between the upper and lower limbs. They also had less exploratory movements than beginners. Beginners, on the other hand, had to adjust their tools more frequently (like kicking their crampons in more) to develop better holds.

Experts were also better at evaluating their environment to find useful information about constraints and the degrees of freedom they had to move.

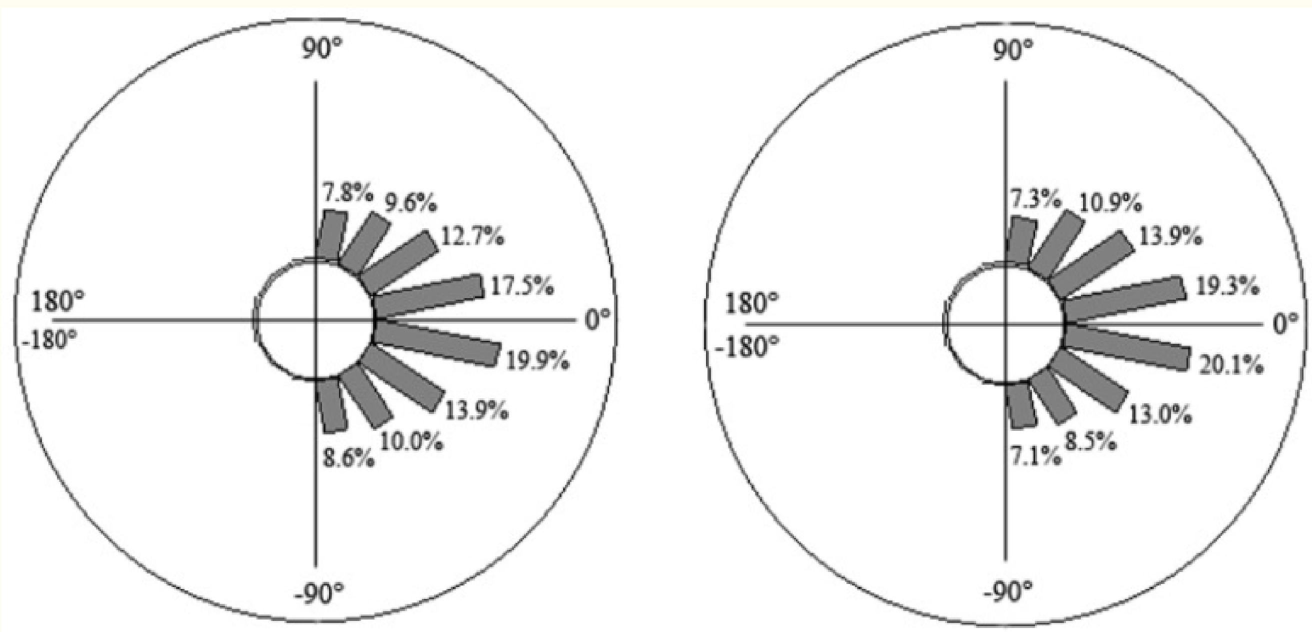


Figure 1: Upper-lower limb coordination - time spend (in % of duration) with upper and lower limbs in different coordination modes; left is experts while right is beginners.

Conclusions/action items: The fact that experts had to move around less because they had better holds with their equipment provides more motivation for us to design a device that can improve grip strength. If more beginners are using the product, they are going to be using a wider variety of holds than an expert, so dynamic training may better mimic actual climbing. However, if more established climbers are using the device, they will not be changing holds as much and could be better candidates for isometric holds.

References: L. Seifert, L. Wattebled, R. Herault, G. Poizat, D. Adé, N. Gal-Petitfaux, and K. Davids, “Neurobiological Degeneracy and Affordance Perception Support Functional Intra-Individual Variability of Inter-Limb Coordination during Ice Climbing,” *PLoS ONE*, vol. 9, no. 2, 2014.

Isometric Training for Physical Therapy

KAITLIN LACY - Apr 28, 2020, 4:16 PM CDT

Title: Isometric Training for Physical Therapy

Date: 4/17/2020

Content by: Kaitlin Lacy

Goals: Learn more about why isometric training may be good after injury since it was mentioned in the meeting with Dr. Wille

Content:

Isometric exercises can be an important. part of a training regimen. While many people believe dynamic training seems more effective, isometric training has several areas where it should be used over dynamic training.

-After surgery: protects against injury concerning scar tissue or any incisions

-When muscle is too weak to move the associated joint

-Improvement in neuromuscular recruitment - aids in muscle contraction

-If the person in question has arthritis

Drawbacks:

-Only increases strength in a small range of motion - only in the position that the exercise is performed in

-could still be good for climbers as it would increase the strength of their holds - need to look into the variability of climbing holds to tell whether or not this is a drawback or a benefit

Conclusions/action items: Overall would be good for people who are recovering from medial epicondylitis as they will likely have pain and will need to guard against re-injury. May be just as effective as dynamic if climbing holds are similar.

References: B. Sears, “Isometric Exercise in Physical Therapy,” *Verywell Health*, 07-Jul-2019. [Online]. Available: https://www.verywellhealth.com/isometric-exercise-in-physical-therapy-2696510#citation-2. [Accessed: 17-Apr-2020].

Differences in Building Muscles Mass in Isometric, Eccentric/Concentric Training

KAITLIN LACY - Apr 28, 2020, 6:21 PM CDT

Title: Differences in Building Muscles Mass in Isometric, Eccentric/Concentric Training

Date: 4/16/2020

Content by: Kaitlin Lacy

Goals: Further investigate the effects of isometric exercises on neuromuscular recruitment

Content:

Background on muscle firing: when a muscle is overloaded, a process of protein synthesis occurs due to the myofibers and extracellular matrix being disturbed

Eccentric work: increases of fiber length, more muscle mass recovery and muscle mass gains than concentric and isometric work

-Implied that stretch combined with overload was the best way to promote muscle growth as mechanical intensity can increase stress and induce protein synthesis pathways

-triggers sub cellular damage to contractile and structural components of skeletal muscle - activates pathways for gene expression and muscle hypertrophy

-mechanotransduction (exercise-induced mechanical stimuli) increases the number of sarcomeres without fiber death

-eccentric has the most mechanical tension which would add sarcomeres faster

Isometric: reduction in torque, IEMG (Integrated Electromyography), and MPFS could mean lower neural drive

-the study acknowledged that there could be some kind of pre-programmed CNS activity that could cause this

-reduction in force - could be due to ischemia due to increased pressure or increased metabolites that are markers of fatigue (H^+, K^+, Pi, NH_3)

Fatigue profiles of the three exercises are different

Conclusions/action items: Both studies seemed to lean towards eccentric training increasing muscle mass the most, but neither one was looking at the best approach after injury which is something to be considered for this project. It seems to be accepted that dynamic training is better, but that can pose some risks to injured users.

References:

N. Hedayatpour and D. Falla, “Physiological and Neural Adaptations to Eccentric Exercise: Mechanisms and Considerations for Training,” *BioMed Research International*, vol. 2015, pp. 1–7, Oct. 2015.

D. Kay, A. S. C. Gibson, M. Mitchell, M. Lambert, and T. Noakes, “Different neuromuscular recruitment patterns during eccentric, concentric and isometric contractions,” *Journal of Electromyography and Kinesiology*, vol. 10, no. 6, pp. 425–431, 2000.

Handsaver Plus

KAITLIN LACY - Feb 26, 2020, 11:29 AM CST

Title: Handsaver Plus

Date: 2/8/2020

Content by: Kaitlin Lacy

Goals: Learn more about designs that work on improving grip strength.

Content:

This device is useful for both strengthening the flexors and extensors of the fingers. Resistance bands loop around each finger and offer resistance in extension while clenching the ball offers resistance in flexion.

Figure 1: Handmaster Plus

Conclusions/action items: This device does not offer variable resistances, and would be difficult to incorporate into our current handle design. Look into other grip strengthening devices to see if there's a way to incorporate variable resistance with these.

References: Handmaster Plus, *Handmaster Plus*. 2020.

Vive Health Finger Exerciser

KAITLIN LACY - Feb 26, 2020, 11:53 AM CST

Title: Vive Health Finger Exerciser

Date: 2/7/2020

Content by: Kaitlin Lacy

Goals: Learn more about the type of grip strengtheners discussed at the client meeting.

Content:

This device allows for strengthening of individual fingers. It offers resistance through spring-loaded keys.

Figure 1: Vive Health Finger Exerciser

Conclusions/action items: This lacks the range of motion desired by our client and does not offer variable resistances like he requested. However, he did like the ability to train individual fingers.

References: Handmaster Plus, *Handmaster Plus*. 2020.

Xtensor Grip Strengthener

KAITLIN LACY - Feb 26, 2020, 11:49 AM CST

Title: Xtensor Grip Strengthener

Date: 2/11/2020

Content by: Kaitlin Lacy

Goals: Learn more about current grip strengtheners.

Content:

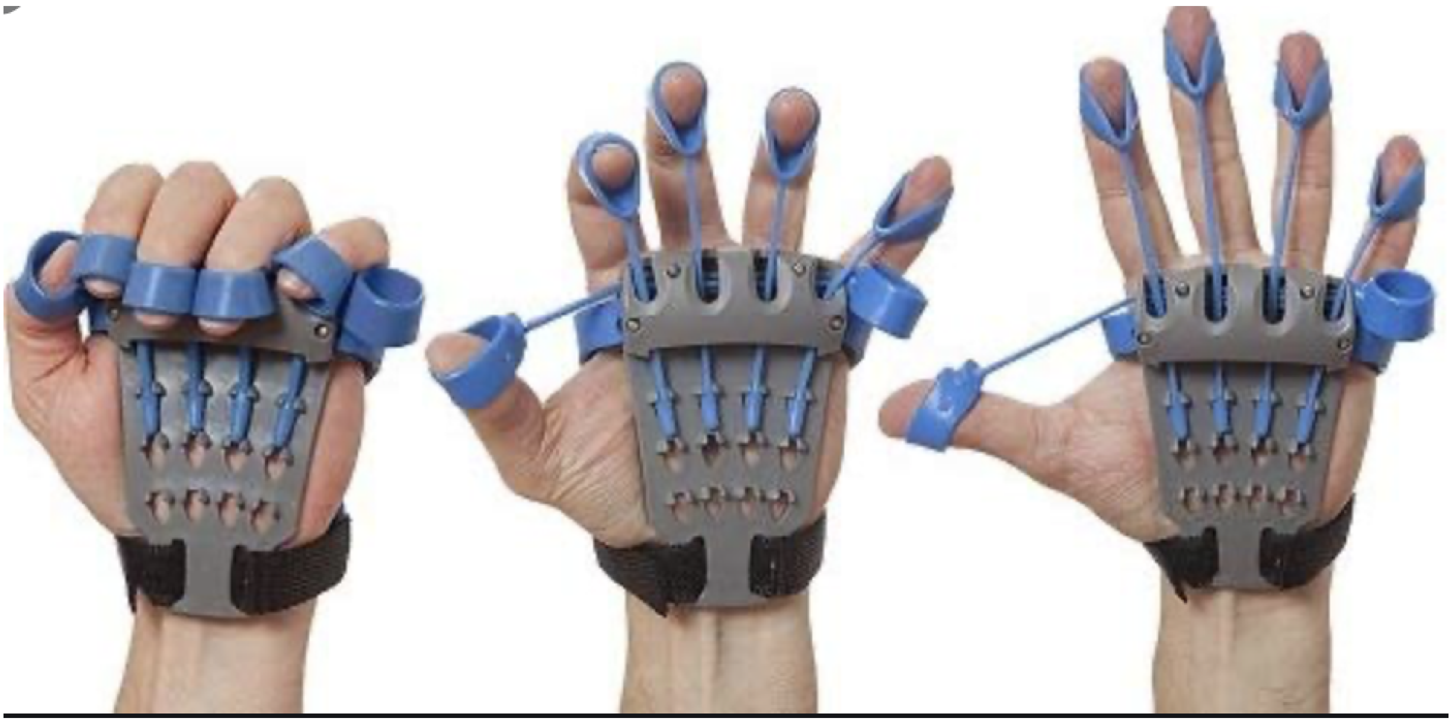


Figure 1: Xtensor Grip Strengthener

This device utilizes individual resistance bands attached to each finger. This allows for resistance in extension in order to improve grip strength. All of the bands attach to a piece inside of the palm. Same basic idea as the Handsaver Plus.

Conclusions/action items: There could be a way to modify this idea to allow for bands coming across the back of the hand. This would offer resistance in flexion, which is what the team is really looking for. It would also be possible to attach the bands to some sort of screw or other mechanism that could tighten the bands and offer variable resistances. The resistance bands could have velcro pieces to go across each finger to prevent slippage as well. Discuss this idea with the team to see if there is interest in an idea similar to this.

References: Clinically Fit Inc., *Clinically Fit Xtensor Reverse Hand Grip Strengthener Forearm Training Device Improves Finger Flexibility Helping Hand Stiffness*. 2020.

Grip Design

KAITLIN LACY - Feb 26, 2020, 9:44 AM CST

Title: Grip Design

Date: 2/15/2020

Content by: Kaitlin Lacy

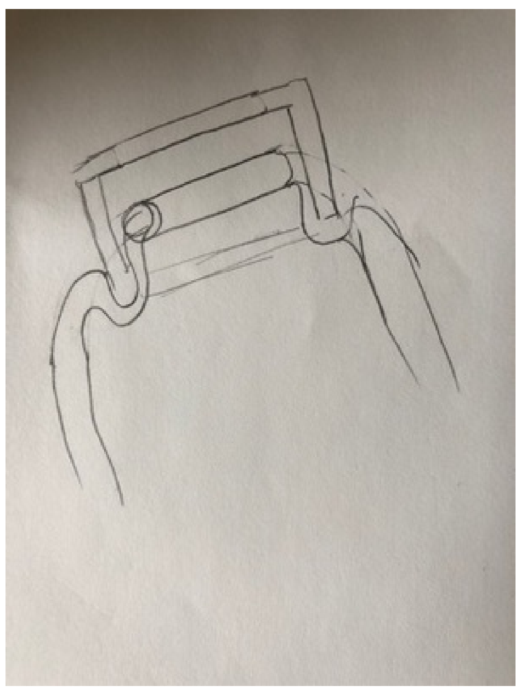
Goals: Come up with a grip strengthening design that can be incorporated into the handle and possibly has the resistive components on the sides or elsewhere in the device.

Content:

See image below for depiction of the device. The device would utilize the existing handle, but it involve another component that would allow resistance in flexion. This bar would hook into the resistive straps, and would be resisted when the user would press down on the bar. This device would allow for a wide range of motion in flexion, but would likely not offer the levels of resistance that we would be looking for.

Conclusions/action items: Discuss potential design ideas with the team at the next team meeting. Evaluate designs, and decide on ones to include in the design matrices. If necessary think of ways this device could be fabricated and improvements could be made, especially in offering more resistance to the user.

KAITLIN LACY - Feb 26, 2020, 9:38 AM CST



Grip_Design_Kaitlin.jpg(28.3 KB) - download

Pinch Grip Ideas

KAITLIN LACY - Apr 28, 2020, 6:47 PM CDT

Title: Pinch Grip Ideas

Date: 2/26/2020

Content by: Kaitlin Lacy

Goals: Brainstorm possible ideas for introducing dynamic training into the pinch grip as well as different fabrication methods.

Content:

Materials to use: I found a HPDE sheet for $16 that was 1/8th inch thick and two by four feet which would leave room for error. Materials for attachment would depend on bands selected

There is a possibility of including little clips on the top of the pinch grip to offer dynamic grip training. We could possibly 3D print them if CAD drawings were generated. It may be hard to get them to work really well, but there would be a possibility of changing the resistance depending on the springs used. Making the clips removable would be another way to change the resistance without needing an entire new grip.

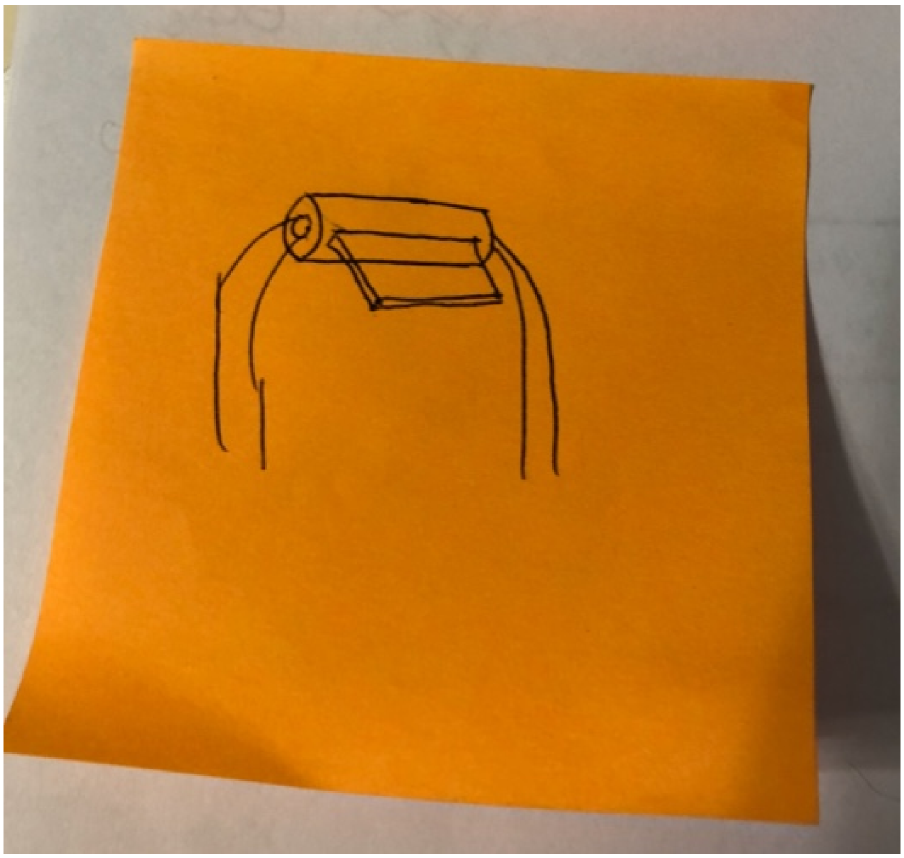


Figure 1: This is a possible design idea. It would incorporate the existing handle and band attachment, but would add a thin rectangular piece onto that to function as the pinch grip. We would need to play around with the thicknesses and the strength of attachment. to make sure it doesn't snap off.

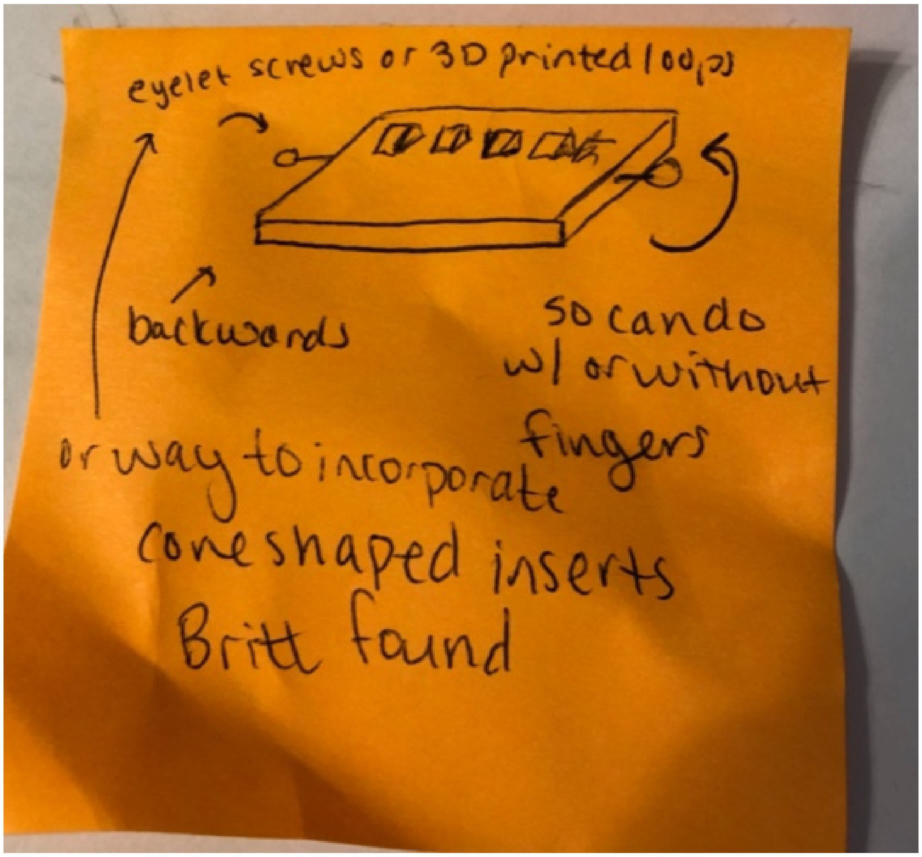


Figure 2: This would be a way to incorporate the clips. If the grip could be flipped over, the user could choose whether or not to use the clips or just grip the pinch grip and do the normal exercises. Another clip possibility could be thin metal pieces that are flexible but have resistance to them (like the clips to attach a table cloth to a picnic table that I've used when camping). This could be difficult to fabricate because I personally don't have experience working with metal and there could be sharp edges.

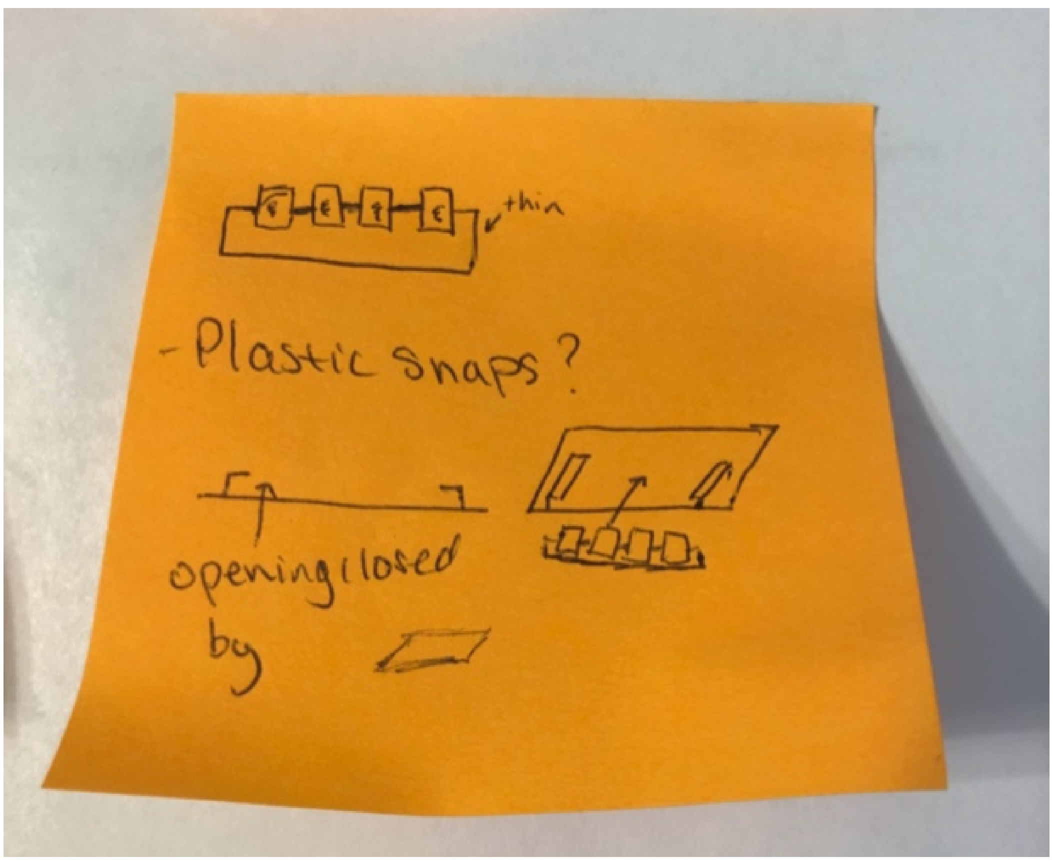


Figure 3: All of the clips could be attached onto one piece that could slide onto the pinch grip to allow for an easy way to switch them out.

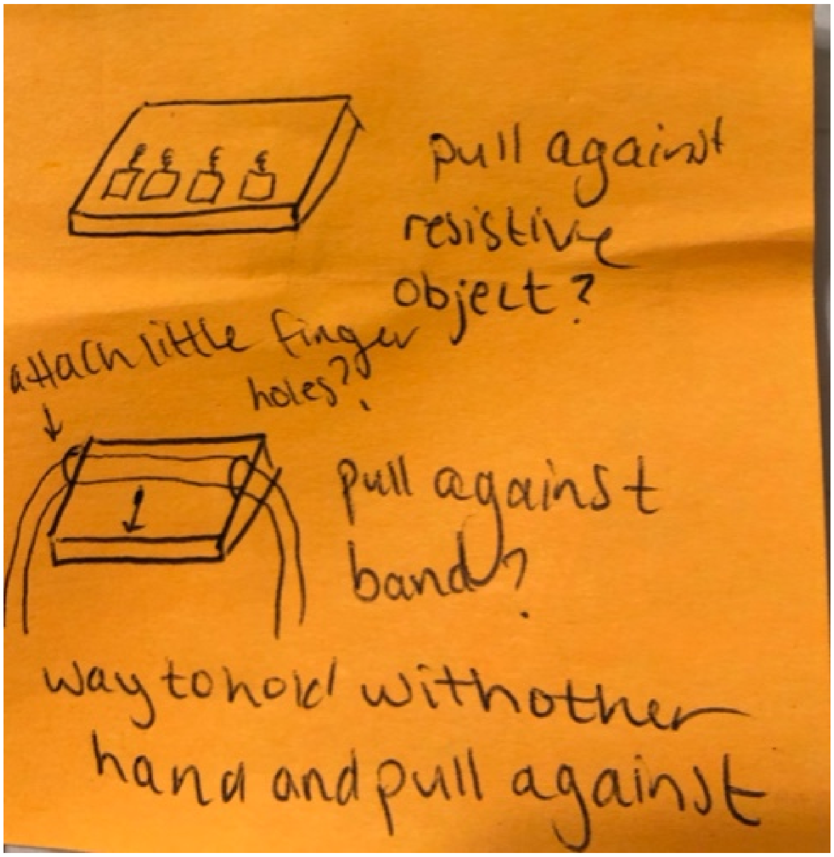


Figure 4: Another possible way to incorporate dynamic training. The band would lay on top of the pinch grip with finger holes on it, and the user could pull their fingers down the grip. This wouldn't be able to be used at the same time as the other exercises, but the static part of the pinch grip would be working the grip during those exercises anyway.

Conclusions/action items: Meet with team to discuss these ideas and decide on what to pursue.

Cover for Back Piece

KAITLIN LACY - Apr 28, 2020, 4:16 PM CDT

Title: Cover for Back Piece

Date: 4/26/2020

Content by: Kaitlin Lacy

Goals: Research possible fabrics and decide on method of attachment.

Content:

The issue of cleaning the device if it were to change users arose during a team discussion as well as the deterioration of the memory foam padding with continued use. A removable cover could be created that would protect the padding and could be easily washed to prevent the buildup of dirt.

Neoprene is a possible fabric as it is used in existing physical therapy/medical equipment (braces, handles, etc.) as well as sports equipment such as scuba suits. Research into the material showed that it will likely absorb some sweat, but not enough to soak into the foam underneath.

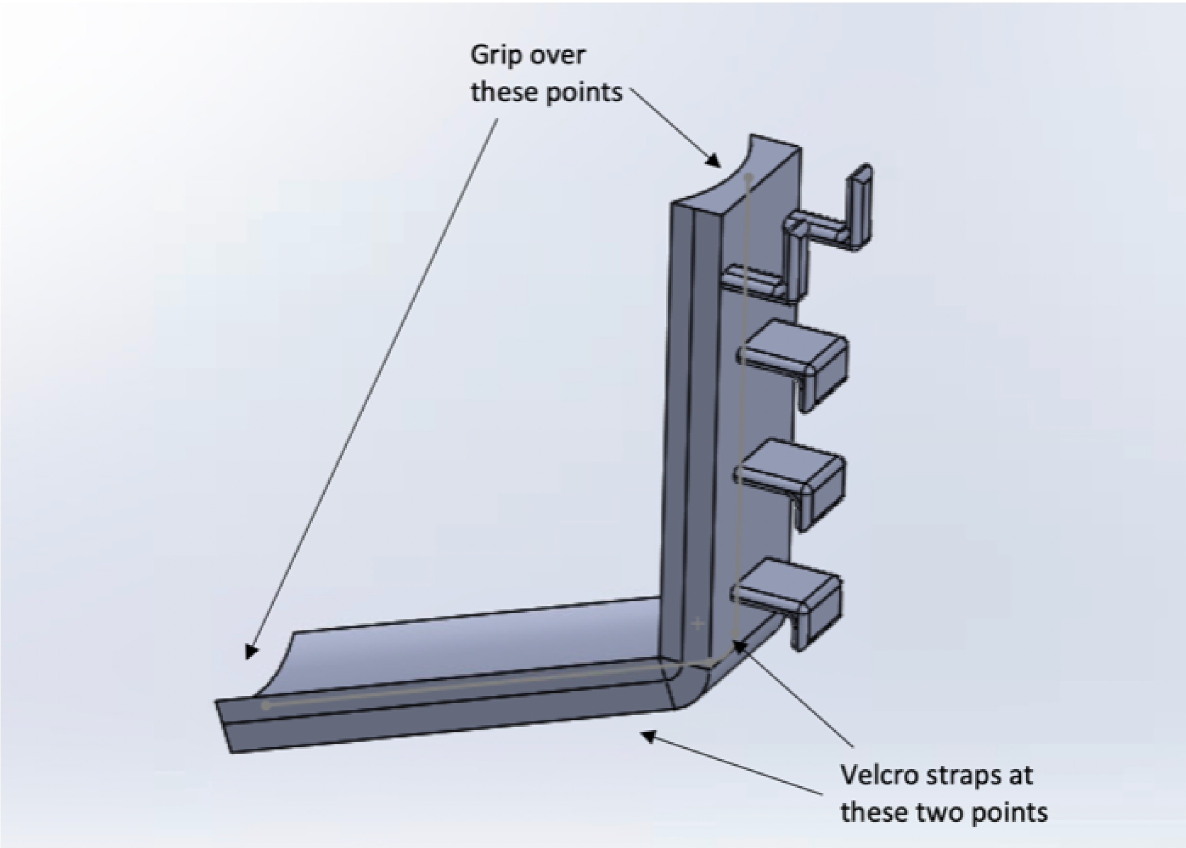
- as far as fabrics go it is pretty tough: very temperature and chemical resistant

-it will not degrade from sun, ozone, light, oxidation, sand, or snow (weather resistant)

-provides and additional layer of cushion

-latex free to protect those with latex allergies

Design: could grip over the top and bottom of the device and be attached with two velcro straps above and below the curve for additional stability. Another possible design would be to find a way to zip it on and off, but a zipper might not go over the angle in the device well. Velcro would be easy to work around the hooks on the back.



Conclusions/action items: Ask my mom and her sisters about specifics of sewing something like this as they do a lot of tailoring work.

References: Technavio, “Top 5 Benefits of Using Neoprene: Global Neoprene Market,” *Technavio*, 19-Sep-2018. [Online]. Available: https://blog.technavio.com/blog/top-5-benefits-neoprene. [Accessed: 26-Apr-2020].

Green Permit

KAITLIN LACY - Feb 26, 2020, 9:51 AM CST

Green_Permit_Kaitlin.jpg(36.1 KB) - download

KAITLIN LACY - Feb 26, 2020, 9:51 AM CST

Green_Permit_Kaitlin.jpg(40.3 KB) - download

2020/01/25 - Anatomy of Climber's Elbow

ZOE SCHMANSKI - Jan 25, 2020, 2:40 PM CST

Title: Anatomy involved in Climber's Elbow

Date: 01/25/2020

Content by: Zoe

Present: n/a

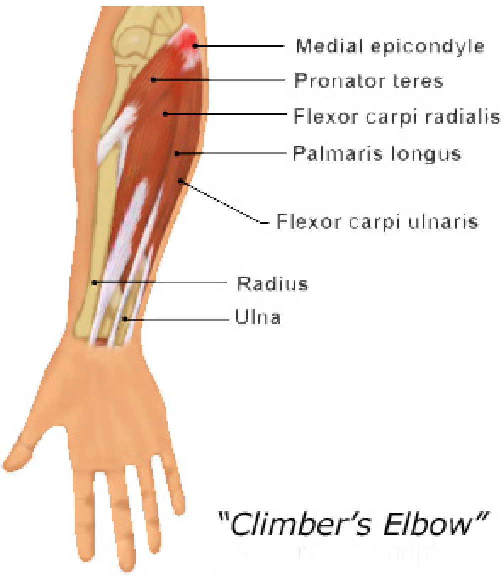
Goals: To become familiar with what parts of the arm are included in the issue of Climber's Elbow

Content:

Also called "Golfer's Elbow" with pain starting from the medial epicondyle

Pain develops in the tendons connecting the pronator teres muscle and/or the many forearm flexor muscles

Main strain is experienced from the connection between the pronator teres and the medial epicondyle, as a result of the two motions supination of the bicep muscle and the need to maintain a pronated hand position in order to grip the rock working against eachother



https://trainingforclimbing.com/treating-climbers-elbow-medial-epicondylitis/

Conclusions/action items:

Familiarize myself with the anatomy in order to be able to use the correct terminology when speaking and writing in the future.

2020/01/25 - Background of Climber's Elbow

ZOE SCHMANSKI - Jan 25, 2020, 2:40 PM CST

Title: Background Information of Climber's Elbow

Date: 01/25/2020

Content by: Zoe

Present: n/a

Goals: Establish an understanding of the problem at hand, what it is caused by, and what the consequences of the problem are

Content:

Also known as "medial epicondylitis"

Main problem experienced between the connection of the pronator teres muscle and the medial epicondyle portion of the humerus bone

All tendons and muscles that result in finger and wrist flexion are anchored at the medial epicondyle, resulting in where the pain originates when these muscles are used excessively and become damaged

The tendons experience microtraumas from the sustained stress over a long period of time, weakening them as the muscles continue to produce high stress

Tendinosis is often experienced, first pain and soreness followed by inflammation and swelling

Treatment

Phase 1

Withdraw from climbing or other activities that apply stress to these damaged areas in order to relieve pain and inflammation

Phase 2

Rehabilitation of the damaged tendons and tissue through stretching and strength exercises

Stretches include finger and wrist extensor muscle stretching along with grip strength

Solution

A device to train and strengthen these specific tendons and muscles in order to prevent injury before it happens

Also include the stretching mechanisms used for rehabilitation in the device including the grip strength and resistance for extensor muscles

Conclusions/action items:

Use the background knowledge gained to apply to the changes needed in the device to make it more efficient and effective.

https://nicros.com/training/treating-climbers-elbow-medial-epicondylitis/

2020/03/10 - Upper and Lower Arm Sizing

ZOE SCHMANSKI - Mar 10, 2020, 12:50 PM CDT

Title: Upper and Lower Arm Measurements

Date: 3/10/2020

Content by: Zoe

Present: n/a

Goals: Research common, universal sizing of the upper and lower arm

Content:

Anthropometric table

Height	170 cm
Upper arm length	35 cm
Lower arm length	45 cm
Relative mass of upper arm	2.6% of body weight 1.86 kg
Relative mass of lower arm	2.3% of body weight 1.64 kg
Centre of gravity of the upper arm	51.3% of the length 17.95 cm
Centre of gravity of	62.6% of the length

Conclusions/action items:

Bring measurements to add to SolidWorks designs

References:

2020/04/09 - FBD Sketch of Forearm

ZOE SCHMANSKI - Apr 09, 2020, 3:46 PM CDT

Title: Free Body Diagram Sketch

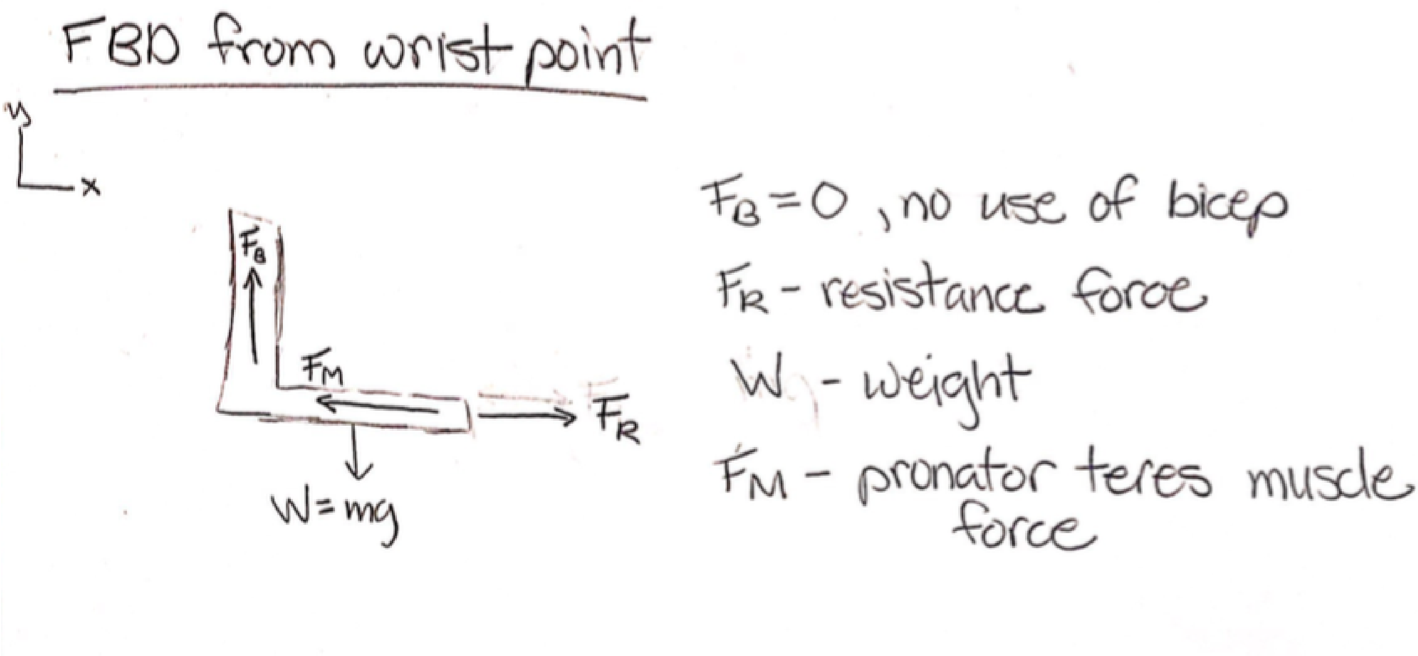
Date: 4/9/2020

Content by: Zoe

Present: n/a

Goals: Possible sketch for the FBD of the forearm

Content:



Conclusions/action items:

Bring to team to discuss

Once an elbow angle is decided on, implement change in angle

References:

2020/04/16 - Pinch Grip Finger Indent Spacing

ZOE SCHMANSKI - Apr 19, 2020, 2:55 PM CDT

Title: Spacing for Finger Indents on Pinch Grip Handle

Date: 4/16/2020

Content by: Zoe

Present: n/a

Goals: Research average separation of fingers while gripping to approximate where the finger indents on the handle should be placed

Content:

Research

- spacing between fingers increases with increased weight of object being gripped
- spacing between fingers increases with increased width of the object being gripped
- brain alters digit placement based on the criteria of weight and size that is perceived
- did not depend on use of the wrist versus the elbow

Measurements

- take into account the width of the handle

Climbing

- size of the rock changing the placement of the fingers
- we will mimic basic gripping with a small handle for less strain while being gripped to solely strengthen the muscles involved

Conclusions/action items:

References:

A. Butler, M. Heroux, S. Gandevia, *How Weight Affects the Perceived Spacing between the Thumb and Fingers During Grasping.* PLOS Journal, 2015.

2020/01/25 - RitBit Extensor Exerciser

ZOE SCHMANSKI - Jan 29, 2020, 4:05 PM

Title: Existing devices for Climber's Elbow - RitBit Extensor Exerciser

Date: 01/25/2020

Content by: Zoe

Present: n/a

Goals: Research devices in the market that can be used to decrease the problem of Climber's Elbow

Content:

No one device that combines arm flexor and extensor muscle exercises and grip strength practice into a single device.

Fingers are essential in climbing to latch onto the rocks, can also become weak and tired easily.

Need aspect of device to focus on finger flexor and extensor strengthening, similar to this current device.

Finger Flexor/Extensor

RitBit Extensor Exerciser for rehabilitation and pain relief

https://www.amazon.com/RitFit-Exerciser-Exerciser%EF%BC%8CFinger-Rehabilitation-Relaxation/dp/B076J94L9M/ref=asc_df_B076J94L9M/?tag=hyprod-20&linkCode=df0&hvadid=241955637300&hvpos=1o3&hvnetw=g&hvrand=8768447157703070943&hvpone=&hvptwo=&hvqmt=&hvdev=c&hvdvcmdl=&hvlocint=&hvlocphy=9018944&hvtargi 522831602761&psc=1

Conclusions/action items:

Use the ideas of this finger strengthening exercise in our device along with exercises for the wrist muscles along with grip strength practice.

2020/01/25 - TheraBand FlexBar

ZOE SCHMANSKI - Jan 29, 2020, 4:03 PM

Title: Existing devices for Climber's Elbow - TheraBand FlexBar

Date: 01/25/2020

Content by: Zoe

Present: n/a

Goals: Research devices in the market that can be used to decrease the problem of Climber's Elbow

Content:

We would like to include full finger and wrist flexor and extensor resistance practice in our device.

This current device focuses on wrist flexor and extensor muscles using resistance in the bar for strengthening.

Could be used in our design.

Wrist Flexor/Extensor

TheraBand FlexBar for elbow therapy

https://www.amazon.com/TheraBand-Tendonitis-Strength-Resistance-Tendinitis/dp/B00067E4YU/ref=asc_df_B00067E4YU/?tag=hyprod-20&linkCode=df0&hvadid=198080784939&hvpos=1o1&hvnetw=g&hvrand=8768447157703070943&hvpone=&hvptwo=&hvqmt=&hvdev=c&hvdvcmdl=&hvlocint=&hvlocphy=9018944&hvtargi 829758849484:pla-350280801728&psc=1

Conclusions/action items:

Use the fundamental properties to exercise the wrist flexor and extensor muscles in our design.

2020/01/25 - Captain of Crush Grippers

ZOE SCHMANSKI - Jan 29, 2020, 4:01 PM CST

Title: Existing devices for Climber's Elbow - Captain of Crush Grippers

Date: 01/25/2020

Content by: Zoe

Present: n/a

Goals: Research devices in the market that can be used to decrease the problem of Climber's Elbow

Content:

Our client would like grip strengthening to be a part of the device to help prevent Climber's Elbow.

There are many simple current devices that provide this mechanism for resistance/strengthening grip.

Grip Strength

Captain of Crush Grippers for practicing and enhancing grip strength

https://www.roguefitness.com/captains-of-crush-grippers?prod_id=2352&gclid=CjwKCAiA66_xBRBhEiwAhrMuLS--3Osb3VXrliW-2iAcQXjQGJlwtIetaXnsEcX03hWFZdnNXYThhhoCXgcQAvD_BwE

Conclusions/action items:

Use the fundamental properties of this grip strengthening device to incorporate into our design

2020/02/09 - Finger Flexor Addition

ZOE SCHMANSKI - Feb 12, 2020, 4:18 PM CST

Title: Finger flexor exercise addition

Date: 2/9/2020

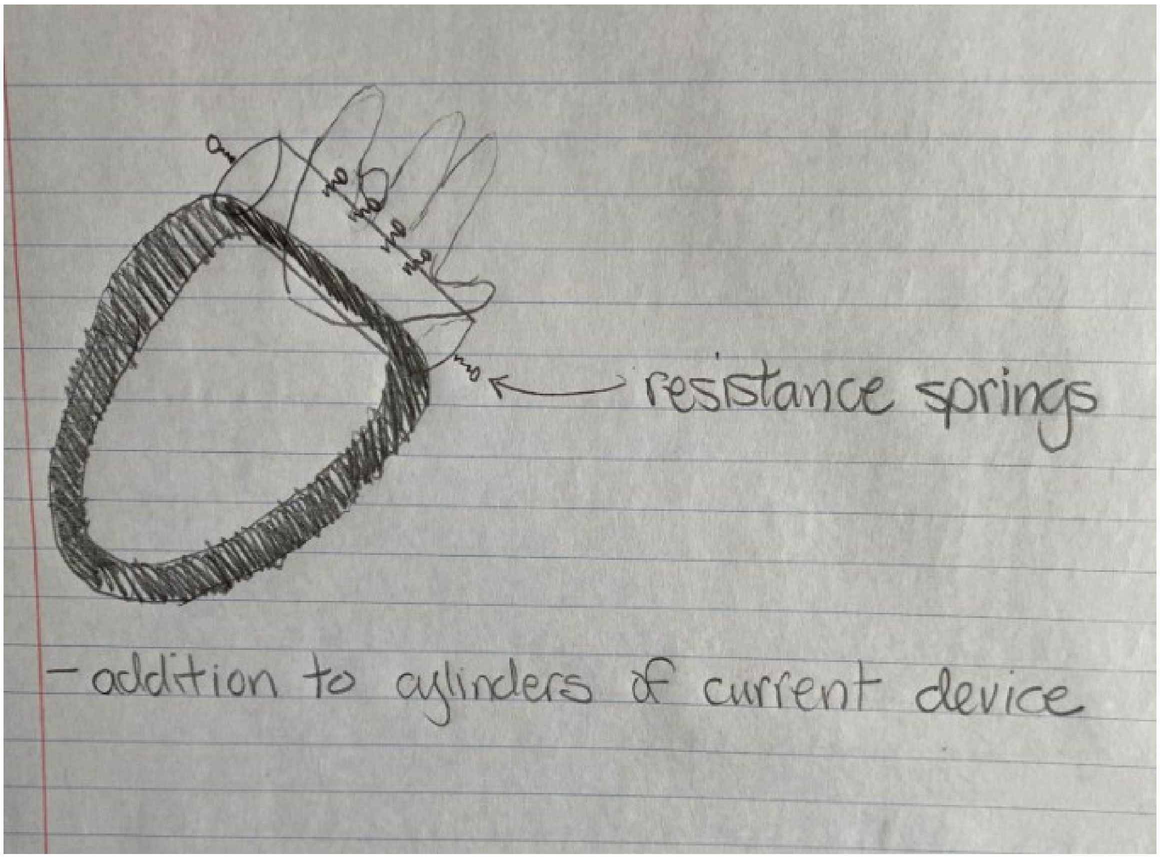
Content by: Zoe

Present: n/a

Goals: Brainstorm ideas for an added piece to the prototype in order to allow the user to stimulate and stretch their finger flexor muscles

Content:

My 1st Design



- Use of springs to provide resistance to individual fingers
- Simple addition to the cylinders holding the resistance bands
- Does not provide flexion to the full finger, mostly upper finger
- Small parts sticking out of the design not very appealing to the eye

1st Inspiration: Individual resistance

- individual slots for each finger to be inserted into (as the client wanted)
- resistance bands connecting the finger slots to the inside of the plastic barrel already used in the device
- ability to stretch one finger at a time

https://www.dynatomyproducts.com/exercises/varigrip-uno/

2nd Inspiration: Netting resistance

- Could be less focused on individual fingers
- Gives the ability for the user to use their other fingers to apply more or less resistance to the finger being stretched
- Implement as attachment to the plastic barrel in our device

https://rehabmart.com.sg/physiotherapy-rehab-therapy/exercise-training/fingers-hand-wrist-training/cando-extension-flexion-web-fb10-085x

Conclusions/action items:

Come to the team meeting to talk about initial ideas and come up with the best one to continue to execute.

2020/02/12 - Hinge Application

ZOE SCHMANSKI - Feb 12, 2020, 4:14 PM CST

Title: Hinge Application

Date: 2/12/2020

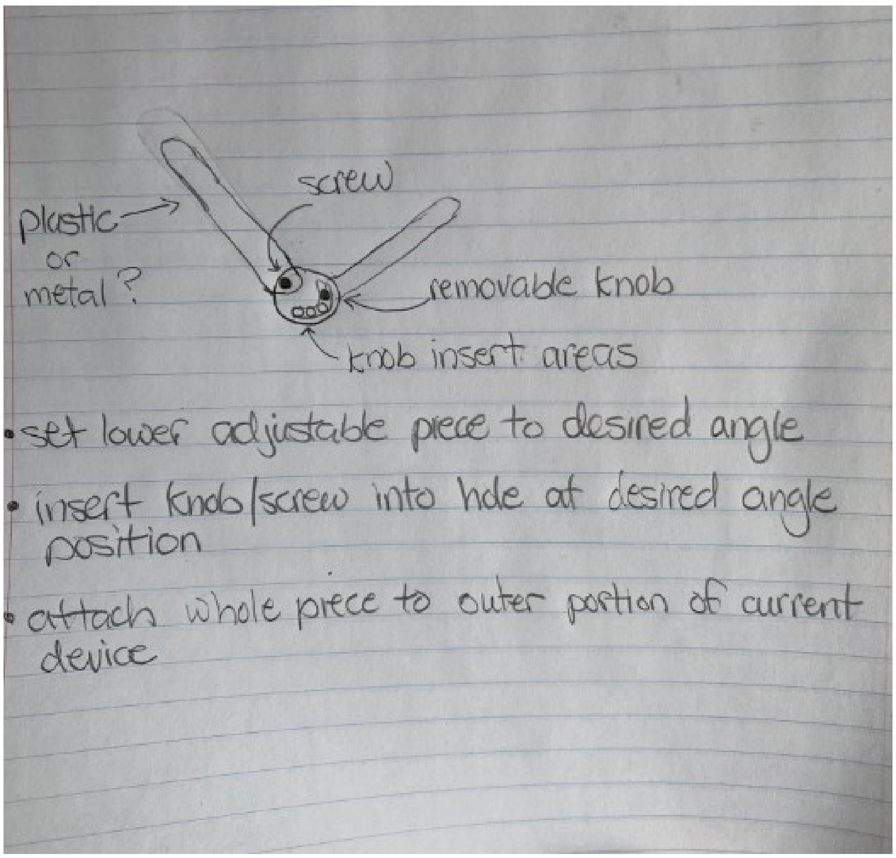
Content by: Zoe

Present: n/a

Goals: Brainstorm ideas for the hinge addition to the design to keep arm at different angles

Content:

My Design

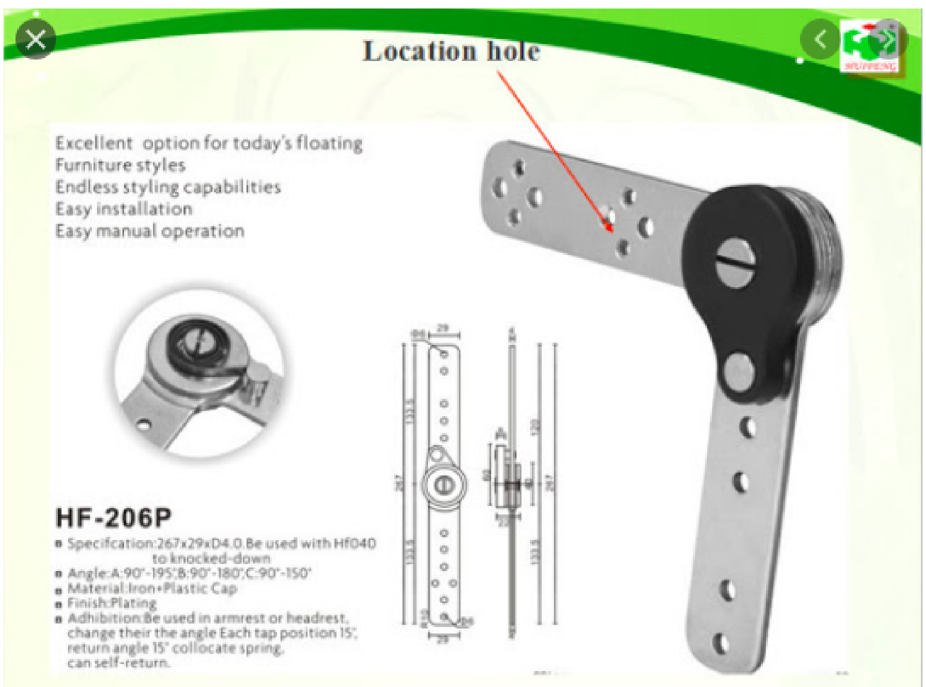


- 2 plastic or metal rectangular pieces
- the upper arm piece attached to a center hinge with a screw
- The lower piece also attached with a screw that can be removed
- Additional holes allow for the lower piece to be moved to different positions and secured with the screw

Possible products from outside Sources

- hinge with multiple notches to allow different angles
- insert knob into desired position to secure
- could manufacture this out of plastic or 3D print (might not be as sturdy)

https://www.ebay.com/itm/Brace-Elbow-Orthosis-Adjustable-Joint-Support-Arm-Fracture-Corrective-Protector-/303134557057



- Used to mimic floating furniture
- Metal, more sturdy
- similar notch mechanism for securing angle position

https://www.alibaba.com/product-detail/Function-adjustable-angle-Sofa-Bed-Hinge_60239608320.html

Conclusions/action items:

Draw sketches with these ideas in mind and bring to the group design meeting

References:

2020/03/1 - Alternative Fabrication Methods for Base

ZOE SCHMANSKI - Mar 02, 2020, 5:17 PM CST

Title: Alternative fabrication methods for the base

Date: 3/1/2020

Content by: Zoe

Present: n/a

Goals: Research other methods of fabrication for the base design besides 3D printing

Content:

3D Printing

- cost efficient
- can print multiple trials with different designs
- undesirable edges and material, not a clean finished look
- could use a covering or other material to allow for smooth edges

Laser cutting

- cut individual pieces
- not ideal to have to then attach the pieces together, not stable

UW Madison Physical Science Lab

- get a quote
- meet with manager to get ideas for materials
    - they will design it with you and fabricate it
    - kind of a cop out

Thermoset Plastics

- thermoset molding with outsourced company
- highly durable
- more cost heavy
- outsourcing could take a while, only get one chance

Flex Seal

- option for coating the 3D printed plastic to give a more cohesive complete prototype
- smooth edges with rubber finish

https://www.homedepot.com/p/FLEX-SEAL-LIQUID-Black-32-oz-Liquid-Rubber-Sealant-Coating-LFSBLKR32/301711448

Conclusions/action items:

Come to team meeting with ideas for alternatives to 3D printing

References:

2020/04/09 - Revised Handle with Pinch Grip

ZOE SCHMANSKI - Apr 09, 2020, 4:16 PM CDT

Title: Revised Handle with Pinch Grip Sketch

Date: 4/9/2020

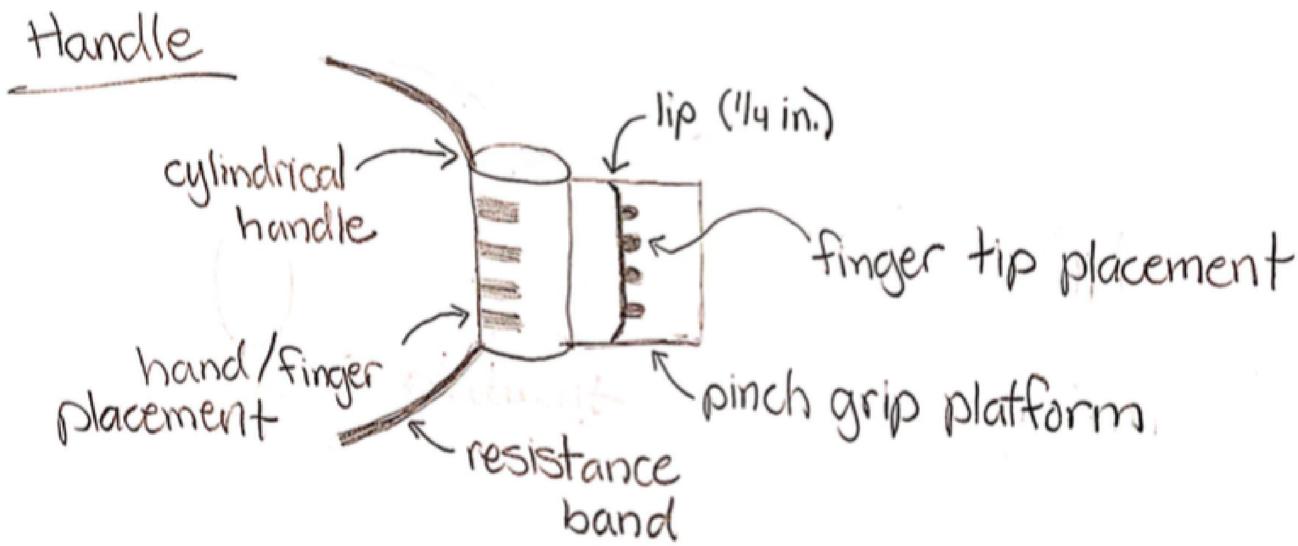
Content by: Zoe

Present: n/a

Goals:

Sketch the new handle design to include the pinch grip feature to later be created in SolidWorks

Content:



Conclusions/action items:

Bring to team to devise design to be made in SolidWorks

References:

Understanding Climber's Elbow 1/30/20

Marissa Harkness - Jan 30, 2020, 11:41 AM CST

Title: Understanding climber's elbow

Date: 1/30/20

Content by: Marissa Harkness

Present: Marissa Harkness

Goals: To get a better understanding of the anatomy and causes of climber's elbow

Content:

Climber's Elbow is also commonly called Medial Epicondylitis. The medial epicondyle is located medially on the inner arm near the the elbow. Pain begins in the tendons that connect the pronator teres muscle and the various forearm flexor muscles. The flexor muscles are those exercised during forearm and finger flexion. The muscles required from finder flexion, protonation and supination all strain the pronator teres muscles and its origination from the medical epicondyle.

The onset of climber's elbow is typically overuse. The climber climbs too frequently with too little rest. Finger flexion is the motion required to grip the rock. Hand protonation is the motion of turning the palm to face the rock. Supination is produced by bicep contraction in the turning of the palm upwards motion.

Proactively strengthening of the tendons increases the amount of stress they can withstand and ultimately slows the progression of micro-traumas to the muscle.

Conclusions/action items:

I need to conduct more research on training interventions and delaying the onset of climber's elbow. Additionally, it would be beneficial to look into any competing designs currently on the market and differentiating between the applications that are important verse those that can be improved upon in the design.

References:

"Treating Climber's Elbow (Medial Epicondylitis)," *Nicros*, 03-May-2019. [Online]. Available: https://nicros.com/training/treating-climbers-elbow-medial-epicondylitis/. [Accessed: 30-Jan-2020].

Marissa Harkness - Jan 30, 2020, 11:45 AM CST

climbers-elbow_image.jpg(63.3 KB) - download Attached is an image of the anatomy of the muscles effected in "Climber's Elbow".

Climber's Elbow Rehabilitation 1/30/20

Marissa Harkness - Jan 30, 2020, 11:55 AM CST

Title: Climber's elbow rehabilitation

Date: 1/30/20

Content by: Marissa Harkness

Present: Marissa Harkness

Goals: To learn about the training and protocol put in place to strengthen the medial epicondyle

Content:

If you take measures to address the tendinosis, the acute onset of pain, in the early stages of injury rather than the later stages, it can make a difference in recovery time as much as 6 weeks to 6 months. Treatment has two phases. Phase 1 focuses on relieving pain and reducing inflammation. In order to achieve this, the climber must withdraw from climbing temporarily. It is recommended to ice the elbow 3-6 times daily and take anti-inflammatory medication. Severe cases may require a cortisone injection. Phase 2 is to rehabilitate the tendon muscle through stretching and strengthening exercises.

Prior to strengthening the muscles, there should be a stretching warm up activity. Warming the elbow with a heating pad is something that should be considered. Additionally, strength exercises should only be introduced once the stretching exercises have restored the normal range of motion of the elbow and eliminated pain. Adjust back to your normal climbing routine only once pain has subsided.

Conclusions/action items:

May want to consider developing a product that has stretching instructions that are to be completed before strengthening the forearm muscles with our design.

Consider adding a heating element to our design.

Consider looking into the resistances that are used when strengthening the forearm.

References:

"Treating Climber's Elbow (Medial Epicondylitis)," *Nicros*, 03-May-2019. [Online]. Available: https://nicros.com/training/treating-climbers-elbow-medial-epicondylitis/. [Accessed: 30-Jan-2020].

Marissa Harkness - Jan 30, 2020, 11:58 AM CST

injury-pronator_teres.jpg(118.9 KB) - download The various images include stretching and strengthening exercises. The first image demonstrates exercises to strengthen the pronator teres. Image 2 shows finger and wrist flexor stretch exercises. Image 3 displays extensor stretches.

Marissa Harkness - Jan 30, 2020, 11:58 AM CST

injury-forearm-flexor-stretch-1.jpg(128.8 KB) - download The various images include stretching and strengthening exercises. The first image demonstrates exercises to strengthen the pronator teres. Image 2 shows finger and wrist flexor stretch exercises. Image 3 displays extensor stretches.

Marissa Harkness - Jan 30, 2020, 11:58 AM CST

Cam_extensor_stretch.jpg(108.6 KB) - download The various images include stretching and strengthening exercises. The first image demonstrates exercises to strengthen the pronator teres. Image 2 shows finger and wrist flexor stretch exercises. Image 3 displays extensor stretches.

Anatomy of Fingers - Pinch Grip 4/6/20

Marissa Harkness - Apr 26, 2020, 12:09 PM CDT

Title: Precision - Pinch Grip - Functional Anatomy of the Hand

Date: 4/6/20

Content by: Marissa Harkness

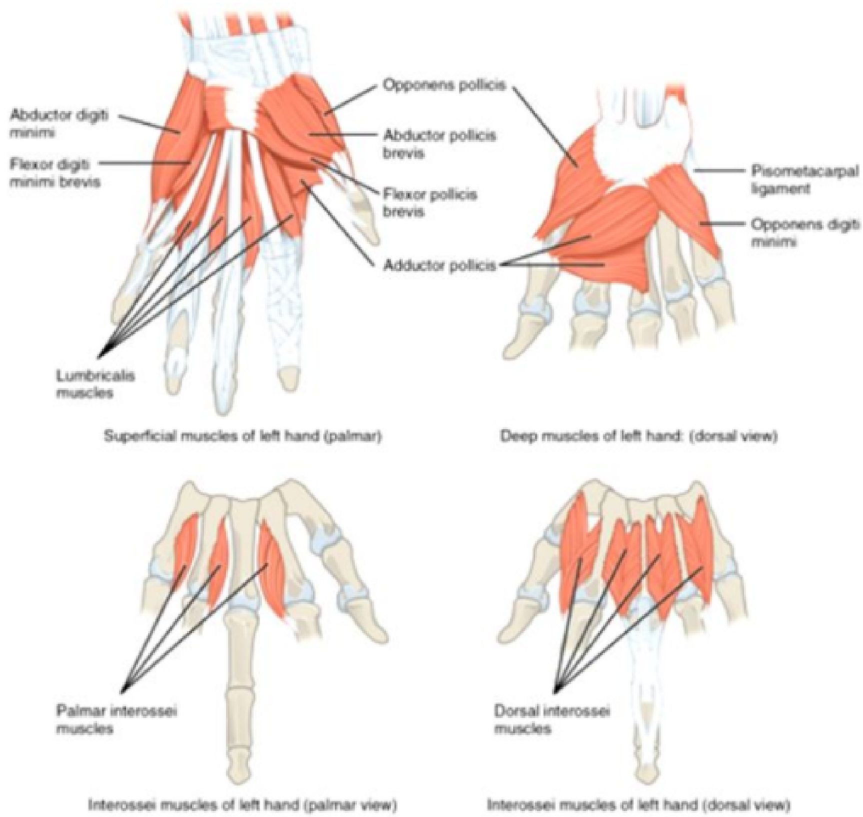
Present: Marissa Harkness

Goals: To understand the functioning muscles during the act of pinching

Content:

The control of the hand is classified into two categories: power grip and precision grip. Precision increases control, while power increase strength. The pinch grip requires precision as the palmar surface of the fingers and the opposing thumb. The median nerve is a prominent for precise and pinch movements. The ulnar nerve would also be involved when doing power grip or strengthening exercises. If a person is unable to pinch their index finger to their thumb, they likely have damage to their anterior interosseours nerve which is between the pronator teres muscle. This issue is called AINS. If you are able to make an OK sign with your index finger and thumb, you have a normal functioning anterior interosseours nerve and have passed the pinch test.

Below are muscles used within the hand during the pinching mechanism:



Conclusions/action items:

Determine the ideality or benefits of using a static verse dynamic pinching mechanism

References:

"Precision – Pinch Grip," *Functional Anatomy of the Hand*, 07-May-2016. [Online]. Available: https://functionalanatomyofthehand.wordpress.com/2016/04/14/precision-pinch-grip-2/. [Accessed: 26-Apr-2020].

Pinch Grip Training for Climber's 4/26/20

Marissa Harkness - Apr 26, 2020, 1:27 PM CDT

Title: Pinch Grip Training for Climber's

Date: 4/26/20

Content by: Marissa

Present: Marissa

Goals: To understand optimal pinch grip training exercises for climbers

Content:

Functional pinch grip training is important for climbing. Hangboarding is a current method for increasing grip strength but does not focus on the pinch grip. There are 18 forearm muscles and 17 hand muscles, many of which are activated during the pinch grip. Often times failure is experienced in the IP region of the thumb. This muscle can be strengthened through exercises that includes flexion of the thumb muscles. Tension Climbing is a company that sells "The Block" which is a tool for improving your pinch grip. However you can make your own block by obtaining 3 2x4 pieces of wood and bolting then together. Then you determine the maximum weight that you can hold for 12 seconds using the block, with only the strength of your fingers. You want to grasp the block with the widest pinch possible because it works the stabilizer muscles. Hold the block at that weight on one hand for 7 seconds. Then switch to the other hand. Repeat this 6 times with each hand. Rest for 3 to 5 minutes between sets. Do 3 sets in total. Perform the exercise 2-3 for optimal results.

Conclusions/action items:

Consider forearm and grip strengthening exercises for the instructions

References:

2019 159622 views / Posted July 10, 2016 126232 views / Posted November 1, 2016 80348 views / Posted July 20, and 2016 51999 views / Posted February 1, “Video: Pinch-Grip Repeater Training for Climbers,” *Training For Climbing - by Eric Hörst*, 28-Jan-2020. [Online]. Available: https://trainingforclimbing.com/pinch-grip-repeater-training-for-climbers/. [Accessed: 26-Apr-2020].

Exercises for Strengthening Forearms 1/30/20

Marissa Harkness - Jan 30, 2020, 12:14 PM CST

Title: Exercises for strengthening forearms

Date: 1/30/20

Content by: Marissa Harkness

Present: Marissa Harkness

Goals: Learn the various exercises used with resistances bands for forearm training

Content:

The stretch described below focuses on stretching the front of the elbow. Frequent exercising of these muscles can prevent overuse and tendon inflammation.

Detailed below are the steps for a forearm stretch using resistance bands:

1. Stand or sit in a comfortable position

2. Bend your right arm at the elbow, keeping the elbow close to the body

3. Open your palm and flex your fingers forward

4. Place the resistance band on your hand

5. With your left hand, hold both ends of the resistance band

6. Pull the band in a downward motion, being sure to feel the stretch

7. Slightly push against the resistance band with your right hand, keeping the pressure for 5-10 seconds

8. Relax for 15 seconds

9. Repeat this exercise a few times a day, 5 times each time, also making sure to alternate hands between reps

Common mistakes:

1. Bending the fingers

2. Bending the elbow

3. Too short of a relaxation time

Conclusions/action items:

I need to look into the specific resistance bands and resistances used for forearm training.

References:

S. V. den bergh, “Resistance band - exercises for stretching the forearms,” *Welcome to Fyziopedia.org*. [Online]. Available: http://fyziopedia.org/articles/552-resistance-band-exercises-for-stretching-the-forearms. [Accessed: 30-Jan-2020].

Hand Grip Strengthener 2/17/20

Marissa Harkness - Feb 25, 2020, 7:53 PM CST

Title: Hand Grip Strengthener

Date: 2/17/20

Content by: Marissa Harkness

Present: Marissa Harkness

Goals: To investigate competing designs that can be implemented to strengthen finger grip

Content:

The handle is typically made with a nonslip material, like aluminum, to increase grip strength. A steel spring provides resistance and ultimately is what controls the exercise. It improves grip strength which is needed in rock climbing. It can also be used for rehabilitation after injury.

Conclusions/action items:

I plan to research individual finger strengthening exercises and any designs that may exist.

References:

Kuklovskai͡a Elizaveta, *Amazon*. [Online]. Available: https://www.amazon.com/dp/B07YVTJGMR?tag=thegymguides-20&linkCode=osi&th=1&psc=1&keywords=Best Hand Grip Exerciser 2019. [Accessed: 26-Feb-2020].

Pinch Clip 2/25/20

Marissa Harkness - Feb 25, 2020, 8:03 PM CST

Title: Pinch Clip

Date: 2/25/20

Content by: Marissa Harkness

Present: Marissa Harkness

Goals: To better understand ways of strengthening grip on individual fingers

Content:

The pinch exerciser is designed to increase pinch/grip strength. Additionally, it improves coordination. There are varying resistances that are available. Over 25 different pinch grips available through the company Roylan.

This design implements our Pinch Grip idea that we chose to move forward with from Preliminary Presentations. However, it includes a way of implementing the same concept but specific to individual fingers. This way, each individual finger can be strengthened. The fault in our current design is that all fingers are being used at the same time, so some fingers may overcompensate and work harder than others.

Conclusions/Action Items:

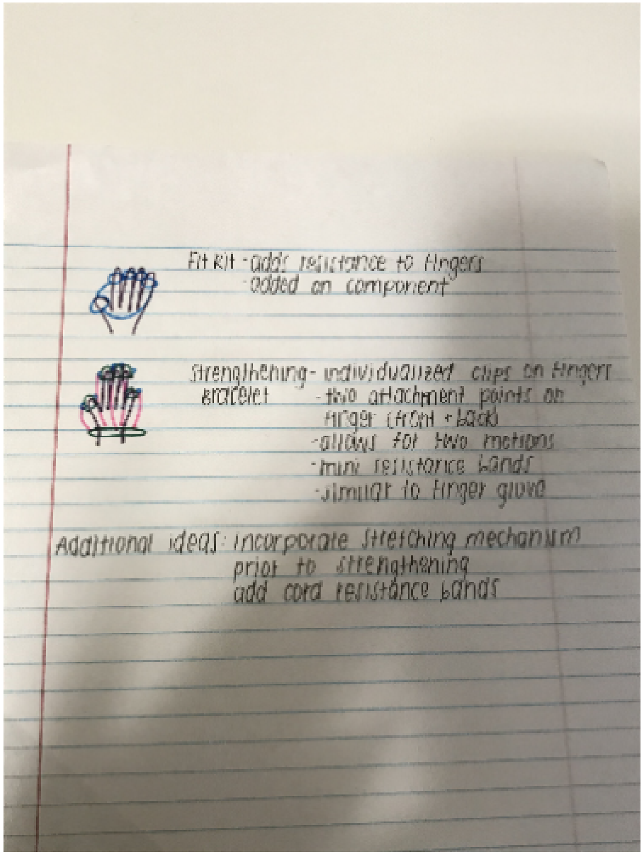
I need to discuss this design that is currently on the market and determine whether or not it can be incorporated with our overall forearm strengthener design.

References:

Black, T. (2020). *The Original Rolyan Graded Pinch Exerciser #8 - Black*. [online] Performancehealth.com. Available at: https://www.performancehealth.com/rolyan-grade-pinchpins-8-black [Accessed 26 Feb. 2020].

Design Ideas 2/11/20

Marissa Harkness - Feb 11, 2020, 10:10 AM CST



Marissa Harkness - Feb 11, 2020, 10:11 AM CST

Marissa Harkness - Feb 25, 2020, 8:18 PM CST

Title: Summary of Competing Designs

Date: 2/11/20

Content by: Marissa Harkness

Present: Marissa Harkness

Goals: To incorporate methods or potential designs that already exist on the market

Content:

One design incorporates a glove with mini resistance bands. This design would be hard to incorporate with our current design and would likely be a stand alone design that is used in addition to the forearm exerciser.

Another design includes mini resistance bands that wrap around each individual finger. Moving your finger in various directions, works different muscle groups. This design is also a stand alone design.

A third design is a bracelet that behaves similarly to the glove. Bands stretch from the bracelet to caps that are placed on the finger. This design would be hard to incorporate with the forearm strengthener design.

A fourth design has a spring feature that wraps around the knuckle. It exercises the upper portion of the finger. This doesn't exercise the whole finger like our client is looking for.

Conclusions/action items:

I need to discuss these ideas with my team and see where the brainstorming process takes us. We will be mindful of the current products on the market.

Finger Flexion Design 2/16/20

Marissa Harkness - Feb 16, 2020, 2:48 PM CST

Title: Finger Flexion Design

Date: 2/16/20

Content by: Marissa Harkness

Present: Marissa Harkness

Goals: To brainstorm ideas that will strengthen the muscles exerted during finger flexion

Content:

I believe we shouldn't over-complicate the original forearm strengthening design. The finger flexion and forearm strengthening are not going to be performed simultaneously, therefore I think they can both be two different designs. The finger flexion design can encompass a glove or bracelet of some sort with rubber bands attached to the back of the fingers. By closing the fingers inward toward the palm, you can experience the exercise. Below are two similar ideas that we can potentially replicate, however the mini resistance bands would be on the back of the finders instead of the front.

An additional idea would be using the standard, mechanical hand grip exerciser. We can replace it with the current handle that holds the resistances bands for the forearm exerciser. By doing so, both the finger flexion and forearm strengthener will be incorporated into one design. The handle could have low resistance and potentially exchangeable handles in order to allow a singular finger to fully press the grip. A picture is attached below.

Conclusions/action items:

The team will need to clarify with the client to confirm whether or not he prefers one or two designs. I also need to research the varying resistances that the grip exercises have.

Red Permit - Obtained Spring 2018

Green Permit - Obtained Spring 2019

02/24/2020 Project Significance

JONATHON MURPHY - Feb 24, 2020, 11:21 PM CST

Title: Ethics

Date: 02/24/2020

Content by: Jonathon Murphy

Present: N/A

Goals: highlight the significance of the project

Content:

Climber's Elbow, medically termed medial epicondylitis, is one of the most common injuries climber's develop [1]. Rock climbing is a foreman intensive sport and when the muscles connecting to the medial epicondyle and the tendon itself is overworked. This creates microtears and disorganizes the collagen-based tendon [2]. This creates pain in the elbow that affects the climber's ability to hang on to the rocks.

There are no devices on the market that work on equally strengthening the flexors and extensors of the forearm. The reason we need to target both is that another contributing factor to developing climber's elbow is a large difference in the strength of the flexors and extensors [1]. Designing a product that will strengthen both flexors, extensors, and help resist pronation and supination of the hand will help decrease the probability of developing climber's elbow. The product may also be able to be used as a rehabilitation technique to loosen the forearm muscles and tendons when experiencing climber's elbow.

Conclusions/action items:

Our client is an avid climber and has come to us with the problem of designing a product that will flex and extend the forearm muscles while resisting pronation and supination of the hand. This task will hopefully be able to decrease the amount of people affected by climber's elbow, or help people that currently have climber's elbow get rid of it.

References:

[1] Edwards, A. and Evans, K. (2019). Stretches to Avoid Elbow Pain from Climbing - Gripped Magazine. [online] Gripped Magazine. Available at: https://gripped.com/indoor-climbing/stretches-to-avoid-elbow-pain-from-climbing/

[2] Saunders, D. (2020). *Dodgy Elbows – Dr Julian Saunders*. [online] Drjuliansaunders.com. Available at: http://drjuliansaunders.com/dodgy-elbows/ [Accessed 8 Feb. 2020]

Climber Elbow - What is it? 2/4/2020

JONATHON MURPHY - Feb 08, 2020, 6:42 PM CST

Title: Understanding Climber's Elbow

Date: 02/08/2020

Content by: Jonathon

Present: N/A

Goals: to get a better understanding of what climber's elbow is

Content:

BACKGROUND:

Climber's elbow is pain in tendons connected to forearm muscles used in finger flexion

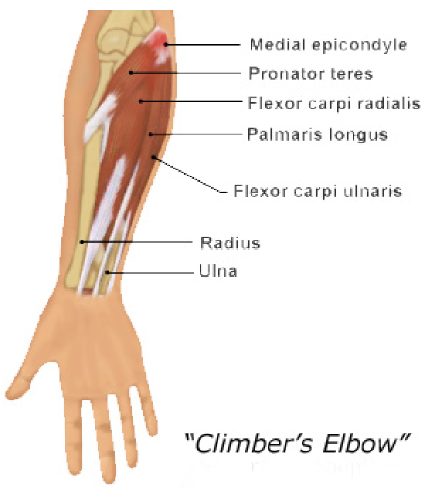
All muscles around medial epicondyle producing finger flexion as well as pronating muscles fight against the biceps which produce supination

this creates excess stress on the muscles attached medial epicondyle, creating pain, tendinitis can set in

REHAB/TREATMENT:

resting and icing is first step to bring down inflammation

then stretch and strengthen the inflamed tendons and muscles



Conclusions/action items:

After researching the area of inflammation in climber's elbow, I will need to delve deeper into ways of isolating the muscles/tendons in exercises as well as other rehab methods.

References:

Hörst, E. (2020). *Treating "Climber's Elbow"*. [online] Training For Climbing - by Eric Hörst. Available at: https://trainingforclimbing.com/treating-climbers-elbow-medial-epicondylitis/ [Accessed 8 Feb. 2020].

How to prevent climber's elbow 02/08/2020

JONATHON MURPHY - Feb 08, 2020, 7:05 PM CST

Title: Preventing Climber's Elbow

Date: 02/08/2020

Content by: Jonathon

Present: N/A

Goals: to understand climber's elbow more by looking into how to prevent it

Content:

Other names for climbers elbow:

- Golfer's Elbow
- Tendinitis in medial elbow tendons
- Medial epicondylitis

inflammation and pain is due to small microtears in tenons that have not had the time to heal

deep tissue massages will help loosen the tightened, inflamed tendon

elbow braces and strapping tape do not help -- they just relocated most of the stress to another group of muscles

strengthen, stretch specific tendon and muscle groups:

- medial epicondyle
- pronator teres
- wrist extentions/flexions

Conclusions/action items:

most treatment looks to be rest and specific stretches

our product should incorporate these stretches

look for some competing designs and designs on the market already

References:

Saunders, D. (2020). *Dodgy Elbows – Dr Julian Saunders*. [online] Drjuliansaunders.com. Available at: http://drjuliansaunders.com/dodgy-elbows/ [Accessed 8 Feb. 2020].

Ways of Increasing Grip Strength 02/12/2020

JONATHON MURPHY - Feb 24, 2020, 11:51 PM CST

Title: Ways of Increasing Grip Strength

Date: 02/12/2020

Content by: Jonathon

Present: N/A

Goals: learn more about ways to increase grip strength

Content:

Strong fingers are necessary to be able to move on to harder climbs, so finger strength is important to have. During climbing, climbers need to be able to grab and hold for 5 to 10 seconds in order to perform transitions holds over small area contact. During climbing, the fingers remain still in a position over the course of some time; therefore, unlike usual strengthening techniques, where one works the muscles over the entire range of motion, climbers can use a hangboard to increase grip. Hangboards create a similar environment to that of climbing. The climber uses a technique called the "dead hang" where he/she hangs from the hangboard using a certain finger position. This is a more efficient way of increasing grip strength due to the similar environment of climbing.

Conclusions/action items:

try to implement the static strengthening into our design. Although the client would like to work individual fingers, this creates a more similar environment to actual climbing. Start to brainstorm ideas on how to create a grip design with this.

References:

Blanchard, B. (2020). Learn to Train: How to Get Stronger Fingers. [online] Climbing Magazine. Available at: https://www.climbing.com/skills/learn-to-train-how-to-get-stronger-fingers/ [Accessed 12 Feb. 2020].

FBD information and muscle assumptions 04/05/20

JONATHON MURPHY - Apr 08, 2020, 5:58 PM CDT

Title: FBD of the forearm and our product

Date: 04/05/20

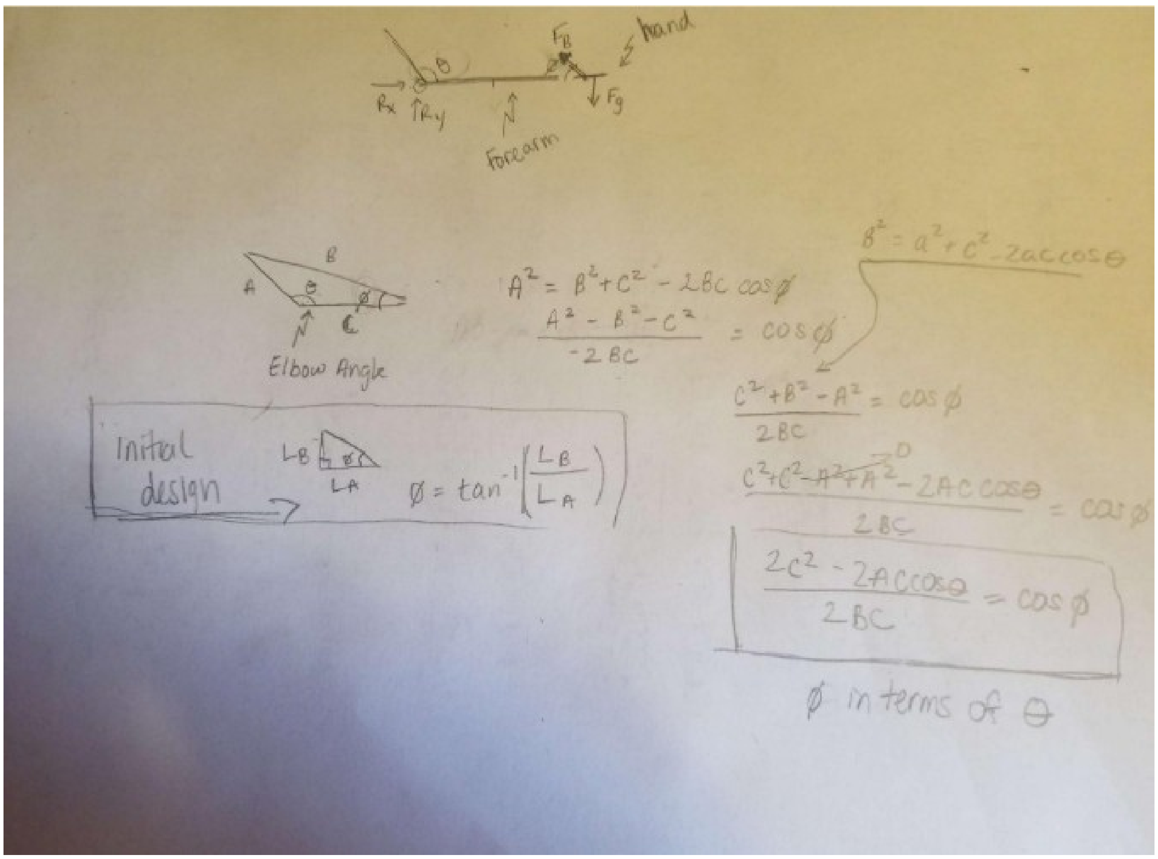
Content by: Jonathon

Present: N/A

Goals: create an FBD and show how the angle at the elbow affects the muscles

Content:

We are looking at the muscles in the forearm in the superficial compartment and how to depict them in an FBD. These muscles all originate from the medial epicondyle. This gives the wrist the ability to pronate, flex and abduct. The bands of the product will be forcing the hand in extension. The angle of the bands is dependent on the angle of the elbow joint of the prototype.



The top drawing shows the beginning of an FBD of the design with θ being the elbow angle and Φ being the angle of the bands relative to the forearm. The boxed equation in the bottom right is an equation that represents Φ in terms of θ. "A", "B", and "C" represent the lengths shown on the triangle in the middle of the figure.

Conclusions/action items:

This relationship is a good starting point in terms of finding the optimal elbow angle. There is a team meeting tomorrow where we will discuss what it means to be the optimal angle. I will also discuss my ideas with this equation. I also need to find the equation of the tension of the resistance bands in terms of displacement, similar to a spring.

References:

[1] " Muscles of the Anterior Forearm - Flexion - Pronation - TeachMeAnatomy." https://teachmeanatomy.info/upper-limb/muscles/anterior-forearm/ (accessed Apr. 05, 2020).

FBD continuation 04/17/2020

JONATHON MURPHY - Apr 17, 2020, 8:24 PM CDT

Title: Continuation of FBD

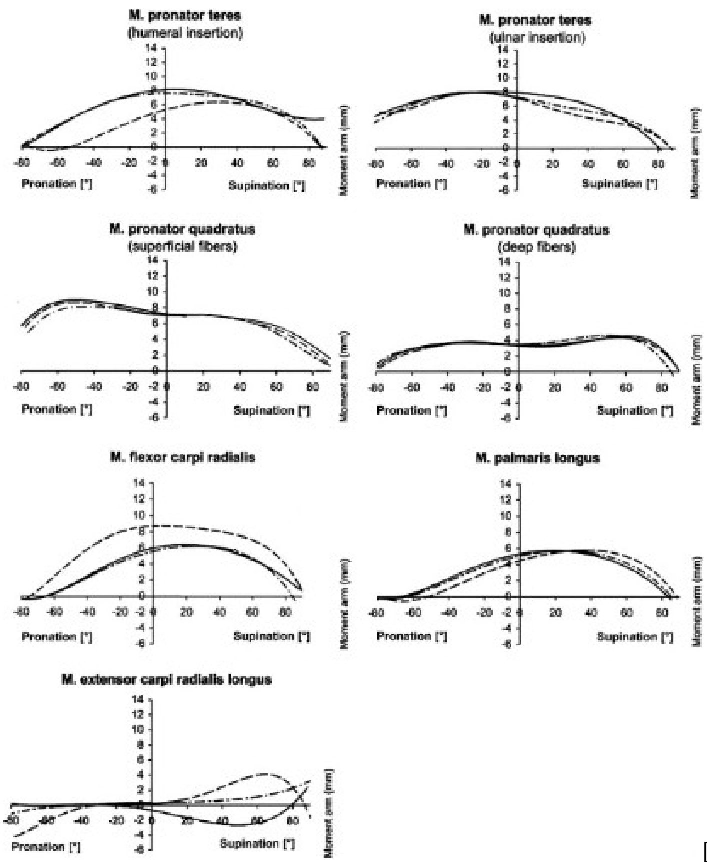
Date: 04/17/2020

Content by: Jonathon

Present: N/A

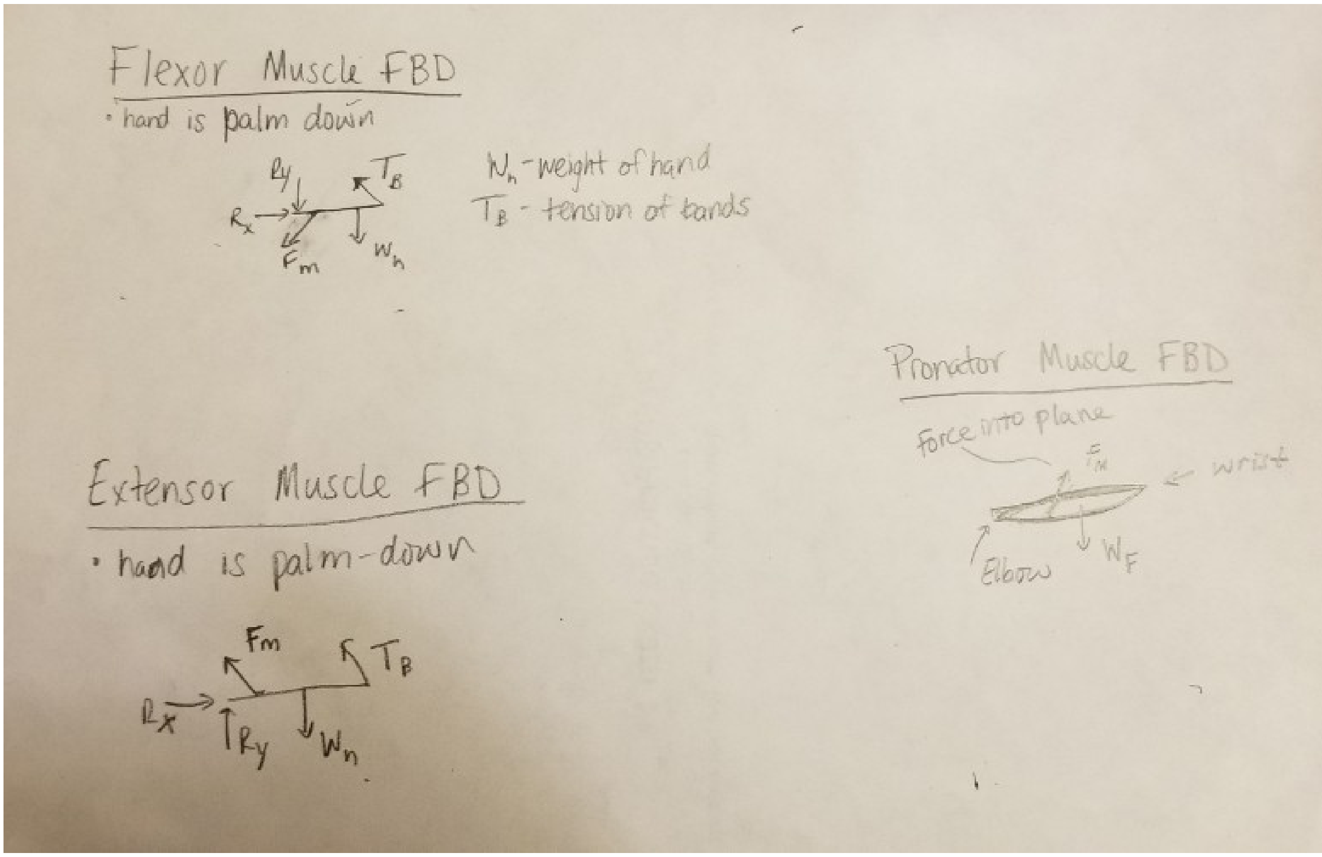
Goals: find moment arms and finish FBD

Content:



[1]

These graphs show the moment arms of each of the muscles at specific degrees of pronation and supination of the forearm. These moment arm numbers will be used to calculate the moment generated by the muscles when used in our design. The flexor and extensor muscle FBDs will be of the wrist joint and hand. The pronator teres muscle will be an FBD of the forearm.



The reaction forces on the FBDs will cancel. The only forces we are really concerned about are the tension in the bands (T_B) and the force generated by the muscle (F_m). The moment arms give me the ability to calculate the moment generated about the wrist from the muscle that will counter the moment generated from the tension of the bands. The tension in the bands will be calculated based off of the tension tests we plan to do as a team.

Conclusions/action items:

run tension tests on bands to be able to quantify the tensions

then calculate F_m using a sum of moments equation about the wrist.

References:

[1] A. K. Bremer, G. R. Sennwald, P. Favre, and H. A. C. Jacob, “Moment arms of forearm rotators,” *Clinical Biomechanics*, vol. 21, no. 7, pp. 683–691, Aug. 2006, doi: 10.1016/j.clinbiomech.2006.03.002.

2/09/2020 Marcy Wrist and Forearm Developer/Strengthener

JONATHON MURPHY - Feb 16, 2020, 9:18 PM CST

Title: Forearm Developer Marcy WEDGE

Date: 2/09/2020

Content by: Jonathon

Present: N/A

Goals: get some ideas from other designs on the market

Content:

the arm fits through the device and you flex your forearm to strengthen it

the device has a variable resistance

quick and easy to use

Conclusions/action items:

This is similar to the design we have at the moment, but much easier to slip on. However, our design can strengthen the forearm in multiple ways than just flexion. I will keep looking up other existing designs in order to brainstorm more ideas for a finger flexion strengthening add on to our design.

References:

WEDGE, F. (2020). *Forearm Developer | Marcy WEDGE*. [online] MarcyPro. Available at: https://www.marcypro.com/forearm-developer-marcy-wedge [Accessed 09 Feb. 2020].

02/11/2020 Forearm strengthening exercises

JONATHON MURPHY - Feb 12, 2020, 10:20 PM CST

Title: Forearm exercises

Date: 02/11/20

Content by: Jonathon

Present: N/A

Goals: understand the movements that will work the area of intent

Content:

Exercises that activated forearm muscles:

- Pinch plate holds/dumbbell holds - this builds grip strength as you work against gravity to hold the plate/dumbbell
- Finger Curls - holding a barbell and curling your fingers towards your chest
- Rice Bucket Squeeze - simplistic, repeatedly squeeze rice in a bucket
- Towel Pull Ups - throw a towel over a bar and use it to do pull-ups

Conclusions/action items:

all of these exercises either include grip strength or flexion of the forearm...it would be good to try to implement these movements into our design

References:

Becker, S. (2020). *Increase Your Grip Strength With These 6 Forearm Workouts*. [online] Showbiz Cheat Sheet. Available at: https://www.cheatsheet.com/health-fitness/forearm-workouts-to-increase-grip-strength.html/ [Accessed 11 Feb. 2020].

Grip Trainers 02/13/2020

JONATHON MURPHY - Feb 25, 2020, 9:30 PM CST

Title: Grip Trainers

Date: 02/13/2020

Content by: Jonathon

Present: N/A

Goals: look at competing designs of ways to increase grip strength

Content:

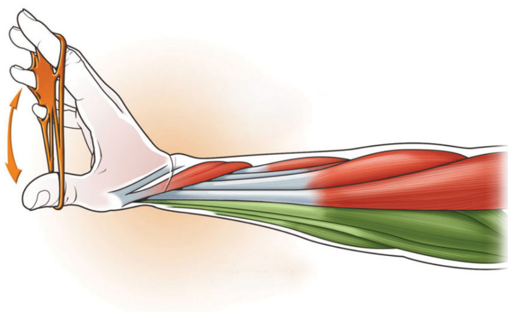
The Gripmaster

- works individual fingers
- each finger has a different resistance
- is used in rehab more than strengthening

Captains of Crush Grippers

- torsion spring gripper
- used for strengthening
- must buy multiple for different resistances, but can be very strong

PowerFingers



- work the extensors to better balance the strength of the flexors and extensors

- work individual fingers
- can stack multiple to increase resistance

Conclusions/action items:

None of these match what our client wants (individual fingers and multiple resistances), but this gives me some good ideas as to ways we can implement multiple resistances. For example, stacking the PowerFingers is used to increase resistance. This idea could be used to create multiple resistances using a different design. We could also use different spring set ups like the Crush Gripper or the Gripmaster. I will need to start brainstorming design ideas.

References:

Gresham, N. (2020). Grip Trainers - Gimmicks, or Worth the Money? - Rock and Ice. [online] Rock and Ice. Available at: https://rockandice.com/rock-climbing-training/grip-trainers-gimmicks-or-worth-the-money/ [Accessed 13 Feb. 2020].

02/15/2020 Grip Design Idea

JONATHON MURPHY - Feb 24, 2020, 10:36 PM CST

Title: Grip Design Idea

Date: 02/15/202

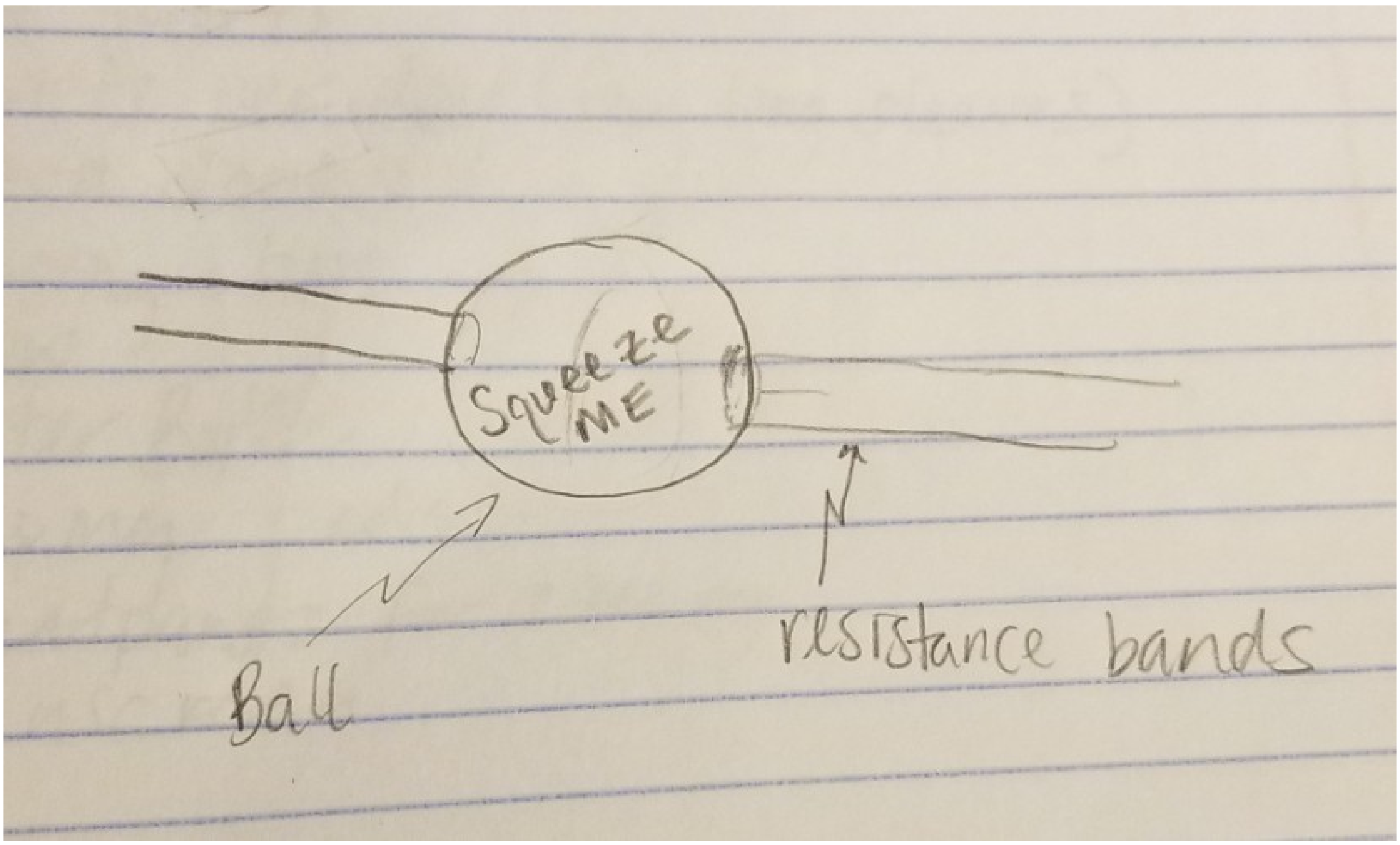
Content by: Jonathon

Present: N/A

Goals: create a design for a new grip handle the implements adjustable resistance and individual fingers

Content:

This design will you a ball to make sure the user has a full range of motion of their fingers. The ball also makes it possible for the user to work individual fingers as well. The ball will need a hole cut into it on either side for the resistance bands to feed through. The resistance bands used will be thin and cylindrical in order to keep the hole in the ball as small as possible.



Conclusions/action items:

Bring this to the design team meeting on 2/16. Research materials or ball designs that will create a good amount of resistance for the user. Think up a way to possible change resistance without making multiple handles/

References:

N/A

Fabrication Ideas for the Pinch Grip

JONATHON MURPHY - Mar 02, 2020, 1:08 PM CST

Title: Fabrication Ideas for Pinch Grip Design

Date: 03/01/20

Content by: Jonathon

Present: N/A

Goals: come up with other plausible ways to fabricate the pinch grip design other than 3D print

Content:

The pinch grip design is based off of the hangboard competing design. Hangboards are most commonly built out of polyeurethane, polyester resin, and wood [1]. I think our client would prefer a plastic over wood do to durability and comfort. We don't necessarily need to make the pinch grip design out of polyeurethane or polyester resin. We could use HDPE, something that the entire team is familiar with. This can be fabricated using a bandsaw or dropsaw. This isn't a very complex design so fabrication will be relatively easy.

Conclusions/action items:

References:

[1] https://americanurethane.com/polyurethane-casting-molding/

Green Permit

Red Permit

2014/11/03-Entry guidelines

John Puccinelli - Sep 05, 2016, 1:18 PM CDT

Use this as a guide for every entry

- Every text entry of your notebook should have the **bold titles** below.
- Every page/entry should be **named starting with the date** of the entry's first creation/activity, subsequent material from future dates can be added later.

You can create a copy of the blank template by first opening the desired folder, clicking on "New", selecting "Copy Existing Page...", and then select "2014/11/03-Template")

Title: Descriptive title (i.e. Client Meeting)

Date: 9/5/2016

Content by: The one person who wrote the content

Present: Names of those present if more than just you (not necessary for individual work)

Goals: Establish clear goals for all text entries (meetings, individual work, etc.).

Content:

Contains clear and organized notes (also includes any references used)

Conclusions/action items:

Recap only the most significant findings and/or action items resulting from the entry.

2014/11/03-Template

Marissa Harkness - Apr 06, 2020, 11:21 AM CDT

Title:

Date:

Content by:

Present:

Goals:

Content:

Conclusions/action items:

References: