

Climber's Forearm Trainer

Product Design Specifications

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Function:

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 microtears 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.

Client Requirements:

- The device must not cause the client any discomfort as it could affect the amount of force they are willing to exert; therefore, negating the purpose of the device.
- The device should include a component that allows the user to vary the resistance.
- The device should act on the four major groups of forearm muscles (flexor capri radialis, pronator teres, palmaris longus, flexor capri ulnaris).
- The end position should end in an eccentric stretch of the wrist, this will allow the device to not only strengthen but stretch the muscles, preventing muscle strain.
- The setup of the device should be simple enough so that the user will not require any additional help.
- The cost should be kept as minimal as possible without affecting the quality of the design, with small grip strengtheners costing about five dollars and hangboards ranging in price from \$80 to \$450. This would allow for a larger profit margin if the device would be used for commercial sale.
- The device should be able to be used freestanding, without any other supporting structures such as a table.

Design Requirements:

1. Physical and Operational Characteristics

a. Performance Requirements:

- The device can be used either at home or in a gym
 1. It will most likely be used daily if used in a home setting.
 2. If in a gym setting, multiple uses per day would be expected. Each use would most likely take five to ten minutes.
- Range of force exertion by the resistance bands between 0 to 133.4N (0 - 30 lbs) [1]
- Able to withstand force exerted by the user
- Holds the biceps and upper arm relatively rigid in comparison to the forearm at an angle larger than 90 degrees but no more than 130 degrees such as 120 degrees.
- Targets the flexors and extensors of the forearm, especially the pronator teres.
- Incorporates a component to improve grip strength

b. Safety:

- Must be comfortable enough so that the user can exert force without any pain.
 1. No sharp edges or corners.
 2. No unwanted pressure; may include cushioning.
- Accommodate climber's with various size forearms ranging from 16-33cm in circumference; this could be adjustable size or creating devices with varying sizes. [2]
- Must be strong enough so that the user's force would not alter the device in any way.
- Must include a safety release system if the user is unable to quickly detach themselves from the resistive components.

c. Accuracy and Reliability:

- If resistance bands or cables are used, increasing the elongation or thickness of the resistance bands or cables needs to increase the force that the user is exerting by increasing force exerted by resistance bands
- Must consistently and accurately exert force on the forearm muscles equivalent to the weight or resistance added.

d. Life in Service:

- Five to ten years for the permanent components of the device.
- If resistance bands or other removable components (such as cushioning or straps) are incorporated, these would need to be changed out if they wear or fray

e. Shelf Life:

- Resistance components used on the device must be good quality so that they would not deteriorate over time.

f. Operating Environment:

- The device will be used at home or at a gym.
- The portability of the device could mean that there is a chance of damage when the device is being moved.
- As the device will be used indoors, there will not be any exposure to extreme temperatures or other damaging outdoor conditions. The likelihood of chemical exposure will also be minimal as it will be stored indoors and should only come in contact with products that would not be harmful to the user.
- Damage could arise while attempting to change the weight/resistance of the device.
- Damage could occur as the subject is placing their forearm into the device

g. Ergonomics:

- The device needs to be able to incorporate different sized forearms ranging from 16-33cm in circumference [2].
- The device needs to be able to incorporate different sized forearm lengths ranging from 22 to 27 cm [3]
- People with different forearm strength will be using the device, so it needs to be accommodating for a range of strengths.
- The device should be able to be attached to one's forearm without help from others

h. Size:

- Large enough to comfortably fit an average adult forearm. No larger than 28x11x35 cm

i. Weight:

- Less than 4.5 kg (10 lbs), including any detachable weights.

j. Materials:

- No material restrictions have been made at this time.
- The device needs to be fairly comfortable to use so some type of padding will need to be incorporated.

k. Aesthetics, Appearance, and Finish:

- No unfinished points or sharp edges.
- Should be comparable to a professional product that is appealing to a consumer's eye.
- No excess material should be hanging or protruding from the device.

2. Production Characteristics

- a. Quantity:** Only one Forearm Trainer needs to be produced for the time being; only needed as a prototype and testing purposes.
- b. Target Product Cost:** A starting budget of \$500 will need to be kept, but keeping the cost as minimal as possible will increase profit margin if it were to be used for consumer sales.

3. Miscellaneous

a. Standards and Specifications:

- Values stated in SI units are standard.
- Should be stable in storage, unloaded, and in the intrinsically and extrinsically loaded use conditions.
- Should support user loads and additional loads without breaking.
- All sides and corners should be free of burrs and sharp edges.
- All corners should smooth ("radiused or chamfered").
- Areas where pinching, crushing, "shearing" could occur should be "guarded" or avoided.
- All locking mechanisms shall function securely at all available adjustment positions.
- Knobs and levers shall not interfere with the user's range of motion.
- Integral hand-grips- conspicuous and reduce slippage.
- Applied hand-grips- reduce slippage and withstand an applied force of 90N (20.2 lb) with movement in the direction of applied force.

- Rotating hand-grips: reduce slippage and also be "constrained against lateral movement along their rotational axis."
- All attachment devices (ropes, belts, chains, links, shackles, end fittings, termination means, etc) should not fail under a load equal to six times the maximum static tension produced in normal conditions.
- User supporting surfaces - able to withstand single static load equal to a loading factor times the greater of 135kg (300lb) or max user weight without breakage.
- Consumer fitness equipment leading factors = 2.5 [4]
- Test load: $F_{\text{test}} = [W_p + 1.5F_a] S$ [2]
 1. F_{test} = total reactionary load to be applied during test
 2. F_a = max user applied load at point of user contact with machine or max capacity of machine
 3. W_p = proportionate amount of user's body weight being applied (or max user weight)
 4. 1.5 = dynamic coefficient
 5. S = factor of safety (2.5 for consumer fitness equipment & 4 for institutional fitness equipment) [4]
- Components that provide a resistance means and the components that transmit the load shall not fail.
 1. When cycled as intended at max user load for a minimum of 80% of range.
 2. Number of cycles at minimum= 20min of exercise * 3 times per week * 52 weeks * safety factor of 2
- Need detailed instructions if equipment requires assembly or warning for safe use.
- Details instructions for the multiple operations capable of being performed on device. [4]

b. Customer:

- Variable resistances of 0 to 133.4 N (0 to 30 lbs) load [1].
- Contains unique features from a variety of existing devices.
- Safety release.
- Fits on the forearm of a variety of different people.
- Ideally could be used for a variety of forearm muscles and injuries.

c. Patient-Related Concerns:

- Failure of removable components.
- Difficult to change the weights/resistance.
- Unnecessary pain or discomfort from the device that could affect the amount of force they are willing to exert.
- Targeting wrong muscles.
- Overloading and injury.
- Difficulty inserting forearm in the device without the help of others.

d. Competition:

- Gyroscopic balls [5]
- Hang Boards - does not target extensor muscles [6]
- Grip Saver by Metolius - does not target pronator teres [7]
- Finger Savers - only works the extensor muscles [8]

References

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