Portable Shoulder Exercise Device - Big Brains

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Overview

The UCI Medical Center is in need of a new mobility device that prioritizes shoulder rehabilitation for patients suffering from a decline in muscle performance due to strokes or spinal cord injuries.

Objective

Design a device that addresses the following requirements:

- Portable (easy to move and convenient to store)
- Self-Stable: does not need to be supported by the therapist or patient while in use
- Accessible standing, sitting, and in a supine position
- Maintain patient's arm in the sagittal plane and allow the patient to raise their arm above the head
- Provide counter-weight to support the arm during the exercise

Other Devices

The UCI Medical Center has tried other shoulder devices on the market but they have not met the needs of their patients and therapists

UE Ranger: rotating rod that assists with various movements

- Could only be used while attached to a door frame
- Ball and socket joint: patient's arm could move anywhere
- Offered no additional support for overhead movement

Research on Mobilization

New device under guidelines will mainly target the anterior deltoid, the muscle used in shoulder flexion

- Other muscles involved include the lateral deltoid, serratus anterior, upper and lower trapezius, etc.

Approximate total arm weight:

- Males- 5.70% B.W. & Females- 4.97% B.W.
- Average weight of 50-60 year old males in the U.S.: ~201 lbs
  - Arm weight is approximately 5.70% = ~11.5 lbs
- Average weight of 50-60 year old females in the U.S.: ~165lbs
  - Arm weight is approximately 4.97% = ~8.20 lbs

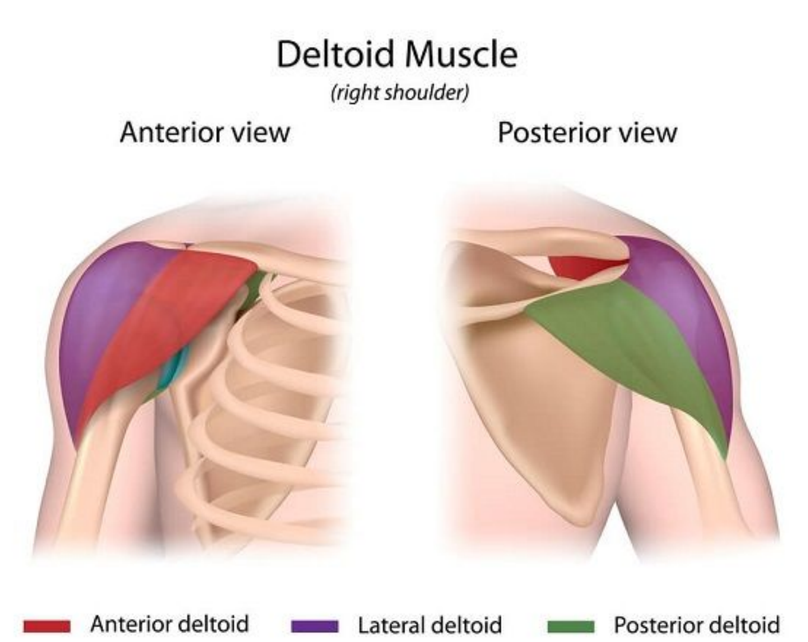

Fig. 1: Anatomy of the Deltoid Muscle

Fig. 2: The UE Ranger in use

Landmine Press

Fig. 3: Full CAD Model of the Landmine Press

- Radial Cam and Tension Spring (self-adjusting counterweight system)
- Spider base with lockable caster wheels
- Rotating aluminum rod
- Adjustable handle with velcro strap (keep patient's hand secured during movement)

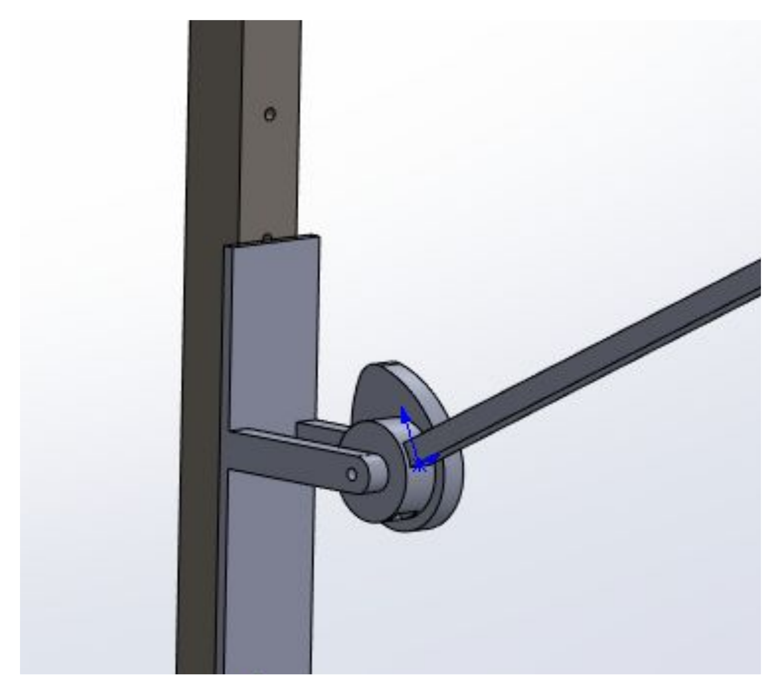

Fig. 3: The radial cam connected to the lever arm

Solution

Pivoting rod that supports and assists patients with shoulder movement in the sagittal plane

- Self adjusting counterweight: cam and tension spring system supports the patient's arm as they raise and lower
- The spring can be tightened or loosened to adjust the support based on the patient's size and physical capabilities
- Portable but able to remain stationary while in use
- Adjustable handle - for patients with different body types
  - Can be used while sitting, standing, and laying down

Testing: Torque vs Angle

Purpose

We designed and conducted a test in the lab to analyze the change in torque on the lever as the angle increased. We will use the data to design the geometry of our radial cam and select a tension spring that will provide the appropriate torque

Process

- Attached an aluminum rod to a rotary encoder (records the angle) and load cell (records the torque)
- We recorded torque of the rod as it changed angles in increments of 5 degrees
- Two team members of different sizes let the lever fully support their arm for the duration of the experiment

Results

- As the angle increased (arm was raised) the torque decreased
- We observed that different body types results in different ranges of motion

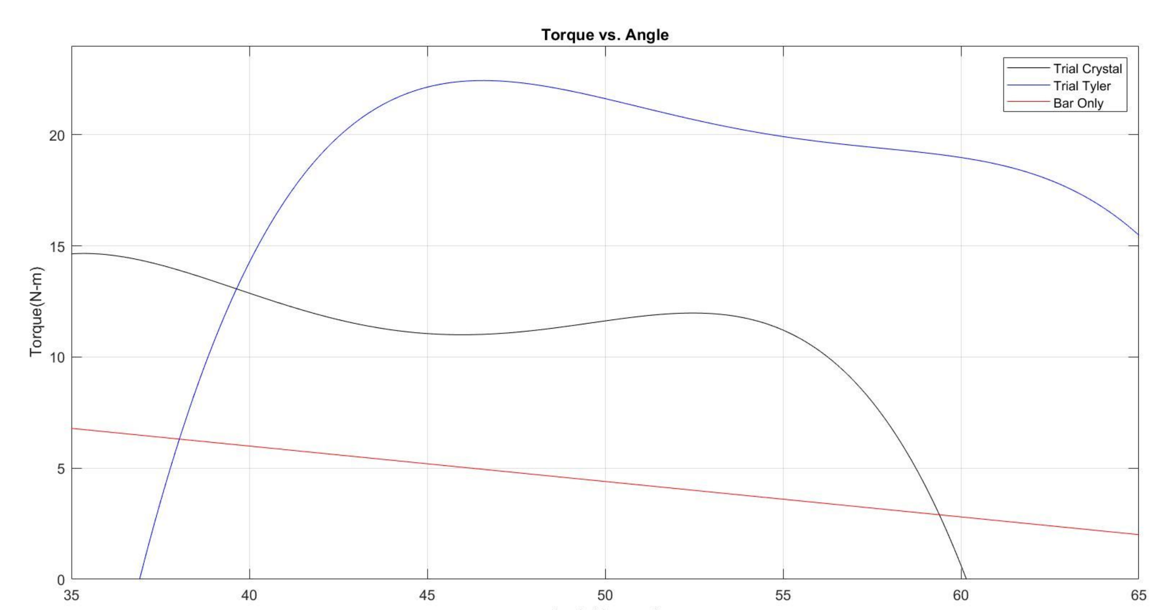

Fig. 4: Stabilized data torque vs. angle

Fig. 5: Tyler performing torque vs. angle test

Self-Adjusting Counterweight

Radial Cam

- A rotating disc that would be attached to the pivoting lever arm
- The radius (moment arm) of the cam is continuously changing as the lever is raised or lowered

Tension Spring

- Provides the counterforce that will be translated through the cam
- The cam and spring will work together to support the patient's arm for the duration of the exercise

Next Steps

- Finding appropriate CAM size relative to the spring
  - Determined by behavior of the graphs
  - Rate of how large the CAM is = how much force is being exerted by spring
- Decide how much force of spring should be set to
- Manufacture and Test Prototype
  - Note any failures/flaws and reassess design based on results
- Flexion and extension of the elbow analysis
  - Give the patients the ability to reach behind over the shoulder

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