Dynamic Arm

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Abstract

Becker's Muscular Dystrophy is a genetic disease causing atrophy of the muscle and restricting individuals from participating fully in life. This can include tasks such as eating/drinking, getting out of bed, and recreational activities. Mr. Dan Dorszynski suffers from Becker's Muscular Dystrophy, but has always loved playing tennis. The devices currently available are expensive, un-supportive, and not adaptable to Dan's specific condition. Now restricted to a wheelchair and weak upper body strength, the lack of devices to aid him in playing tennis has kept him away from his favorite sport. To cope with this he uses the momentum from his wheelchair to swing. The Dynamic Arm team has been tasked to build a device in which aids Mr. Dorszynski in his forehand and backhand tennis swing; namely, "Dynamic Arm". The team built an adjustable dynamic arm out of copper, elastic bands, and a shoulder bolt to provide him the necessary range for tennis.

Problem Statement

- **Problem Statement:**

Our client suffers from Becker's muscular dystrophy and has limited rotation of his shoulder so he has difficulty performing forehand or backhand swings. Our client would like us to design a mobile dynamic arm support that will allow him to use a full range of motion for forehand and backhand swings.

- **Motivation:**

Current products that help patients with this limited motion are expensive and range between $2,000 to $10 ,000 respectively [3]. The high cost limits the amount of people who can live independent lives which creates a sense of helplessness.. An affordable alternative can lead to an increase in participation in paraplegic sports and create a more enjoyable life.

Background

Becker's Muscular Dystrophy(BMD) is characterized by progressive muscular atrophy. Muscles affected include all Skeletal and Cardiac muscle. Each case of muscular dystrophy is unique to the patient's body, however, typically skeletal muscles in the legs and pelvic region are affected first causing patients to be wheelchair bound. The heart is the main cardiac muscle, and when affected by muscular dystrophy leads to difficulties pumping blood to the entire body, or cardiomyopathy[4]. Other symptoms include cognitive dysfunction, loss of coordination and difficulties breathing. Patients with Becker's muscular Dystrophy usually live well into their 40's and beyond[3].

Furthermore there is no cure for Becker's and it is a genetic disease occurring entirely in males; reason being, Becker's is an X-linked recessive trait. The protein dystrophin(pictured in figure[1]) provides a structural link between the muscles cytoskeleton and the extracellular matrix, providing structural integrity. Absence of this protein is what causes muscle atrophy[2]

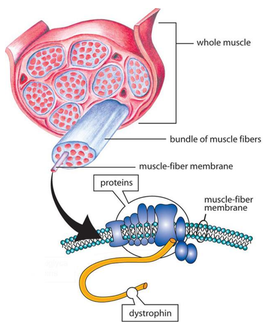


Figure [1]: Muscle anatomy showing the cytoskeleton and extracellular matrix linked with dystrophin.]

Design Criteria

- The design had to support our clients arm (maximum of 16 lbs of force) with minimal fatigue on his part
- Need for full range of motion
- Elevate the elbow ideally to a height of 34"
- Mounted for left hand use
- Aesthetically pleasing
- Avoid hyperextension
- Functional in varying environments as it will be used outdoors
- Minimal in size and weight
- Relatively easy to transport as our client travels often
- Inexpensive to repair or replace parts

Testing

Band Test:

- Three different bands with different strengths.
- 5lb, 8lb, and 10 lb weights were used.
- Measured the amount the band stretched.
- Measured if the band experienced permanent deformation after the weight was removed

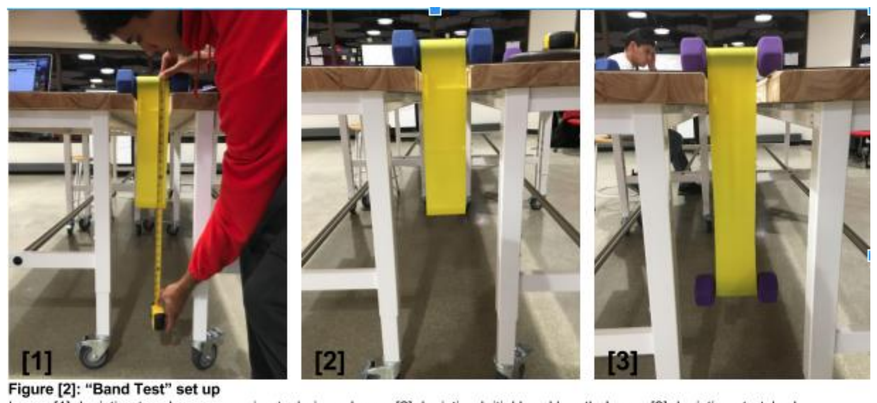
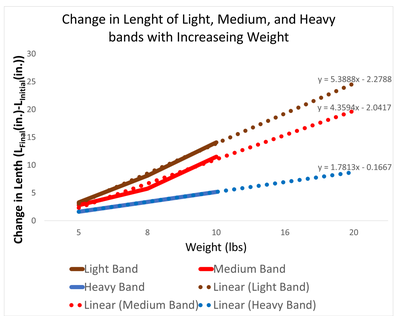


Figure [2]: "Band Test" set up
Image [1] depicting top-down measuring technique; Image [2] depicting Initial band length; Image [3] depicting stretched band

Results

- We tested the resistance of the bands with different weights to determine how its elastic properties would change.
- The lightest band experienced some permanent deformation after testing it with the 10 lb weight.
- This shows that we need to at least use the medium strength band for our design.



Figure[3]: This figure shows how the much the bands stretch to different weights.

Final Design

Materials:

- Three copper bars
- One 90 degree and one 45 degree joint
- Attachment plate
- Shoulder bolt
- Elastic bands

Description:

Our final design consisted of three copper bars connected by 45 and 90 degree joints. These joints were then blowtorched together to increase the rigidity. A piece of aluminum was press fitted into the copper bar. A shoulder bolt will then go through a baseplate and enter through the aluminum part providing an almost frictionless surface.

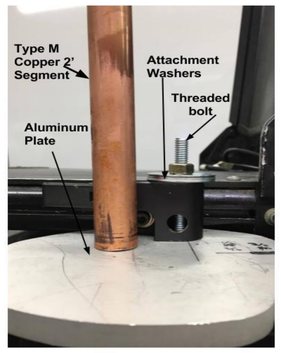


Figure [4]: This figure shows a good view of the attachment site.

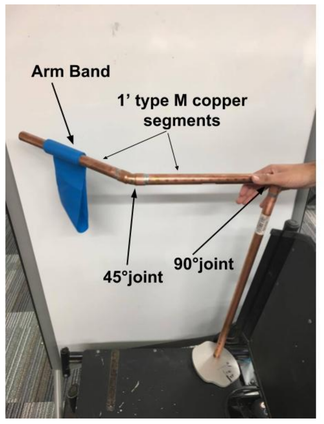
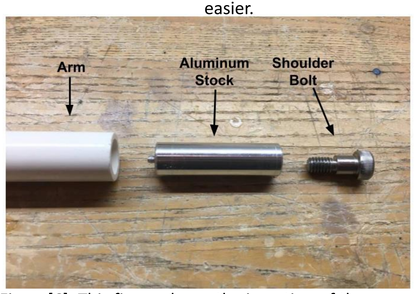


Figure [5]: This figure shows how the whole project comes together. The client's arm will go inside the blue band, and will be able to rotate his arm easier.



Figure[6]: This figure shows the insertion of the shoulder bolt to the aluminum stock. The aluminum stock will be inside the arm. Then the shoulder bolt will go through the attachment site into the aluminum stock.

Future Work

- Create more renditions of the prototype with varying materials to find the optimum material
- Develop a segmenting variation that could be altered to fit individuals of varying dimensions
- Potentially develop a more secure method of attaching the band
- Develop a method of removing and storing the arm for easier transit

References

1. [1] "Muscular dystrophy: Therapy can slow the course," Mayo Clinic, 27-Nov-2014. [Online]. Available:http://www.mayoclinic.org/diseases-conditions/muscular-dystrophy/basics/definition/con-20021240. [Accessed: 01-Oct-2017].
2. [2]"About Duchenne," About Duchenne muscular dystrophy - Parent Project Muscular Dystrophy. [Online]. Available: http://www.parentprojectmd.org/site/PageServer?pagename=understand_about. [Accessed: 01-Oct-2017].
3. [3]"WREX-Wilimington Robotic Exoskeleton," Neurorehabdirectory.com. [Online]. Available: https://www.neurorehabdirectory.com/rehab-products/wrex-wilimington-robotic-exoskeleton/. [Accessed: 11-Oct-2017].