Lower Extremity Rehabilition Device for use in Developing Countries

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Abstract

A team of five, female biomedical engineering students are focused on the design and fabrication of a device that will be used to rehabilitate the lower extremities. This project will be carried out at the University of Wisconsin-Madison and the product will be transported to La Cieba, Honduras where it will be used at the CRILA rehabilitation clinic. The device will be used by physical therapists to provide patients with a gradual physical therapy treatment plan that may be customized to each patient's specific needs. The device will serve as a platform for women in the community to develop skills in science and engineering. The team intends to teach these women how to replicate multiple versions of this device. This would in turn improve the quality and access to medical care for a larger percentage of the population.

Background

- High levels of violence and degenerative muscle disease are prevalent in Honduras, leading to a high demand for physical therapy
- Similar commercial products can cost upwards of $1500 and are not easily replicable[3]
- CRILA has access to open kinetic chain exercises (eg free weights) but no closed kinetic chain exercises

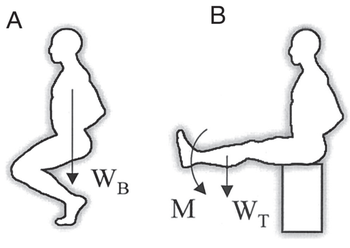

Figure 1: *Closed kinetic chain exercises (A) (CKC) incorporate fixing the feet in space and promote using multiple muscles that work in conjuction, while open kinetic chain (B) (OKC) isolates movement to one muscle. CKC better mimics a person's dailey muscle movement and the compressive forces they would normally experience[1,2].*

Design Criteria

In order to strengthen the lower extremities of the patients, we will design a device that allows the patient to lie on their back with the knees at a ninety-degree angle and feet pressed against a solid plate. The device will also include springs of increasing strength with caribeeners as hooks to aid in strengthening of the lower extremities. Our client Karen Patterson requests that the device be cost effective, locally manufactured, and easily assembled and replicated. Additionally, it must be able to withstand high frequency of use, require low maintenance, and be portable.

Final Design

Figure 2: *(A) A solidworks model of the complete device (B) The device after completed fabrication (C) The underside of the carraige displaying the plastic sliders that insert in the plastic track*

- Device stands two feet allowing the clinic therapists to assist patients in the rehabilitation and use of the device
- At the end of the frame there is a solid foot plate cut from a sheet of diamond steel plating
- Each side of the frame is constructed from a 4-by-4 with a 1.5-by-2 extrusion along which the track lays
- A mortise tenon joint was used to connect the legs of the device to the frame
- The side of the frame is further reinforced by support beams running parallel to the frame
- The carriage slides along the plastic track resisted by metal springs. Up to eight springs may be connected via carabineers on eye hooks to the front of the frame and the front of carriage

Carriage

- Composed of a cushioned back and headrest and padded shoulder supports
- Implementation of handles is still being considered
- A set of five plastic sliders located on the bottom extend outwards and insert into a plastic track

Testing

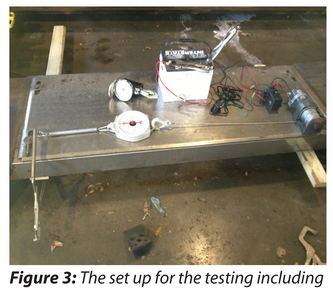

Figure 3: *The set up for the testing including a 2000 lb capacity electic winch, clamps, & weight scale*

- The weight scale was connected to the winch which was clamped securely down
- The testing began with recording the springs initial coil length and loading the spring into the setup. The spring was loaded until the weight scale read a certain increment in pounds
- When these loadings were reached the length of the coil was measured again and the displacement was calculated

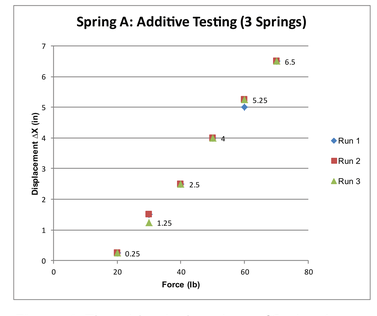

Figure 4: *Three identical versions of Spring A were used to show that the springs would have an additive effect when subject to a force in parallel.*

- ***Equation 1: [F= k Δx] where F is the force in lbs, Δx is the displacements, and k is the spring constant.***
- ***Equation 2: F1=kΔX1 F2=kΔX2***
- ***Equation 3: F= F1+F2= k2(ΔX)***

Materials List

Item	Price
4x4-10' Treated Wood	$11.97
4x4-8' Treated Wood	2@ $5.97 each → $11.94
4x4-6' Treated Wood	$5.69
1x4-8' Treated Wood	2 @ $3.57 each → $7.14
Fir Closet Pole WM233	$7.48
2x4-10' Stud/#2&BTR SPF	$3.30
Spring #193 [9.75 lbs. max load)	4 @ $4.35 each → $17.14
Spring #198 (20.94 lbs. max load)	8 @ $6.75 each → $54.00
Spring #200 (44.12 lbs. max load)	2 @ $10.65 each → $21.30
UHMW Polyethylene	

Steel	$45.00
Silicone	$642.94
Bolt/Nuts	$21.09
Shoulder/Brackets	$20.00
Glide Pads	$8.49
Carabineers	$39.03
Paint, Brushes, & Cleaner	$57.15
Spray Paint	$17.07
Wood Glue and Screws	$31.48
Eye Bolts	$9.45
Vinyl Cushions and Sewing	$130.00
4 Pillows	$75.00
Stamps	$45.00
	Total: $632.96

CRILA

CRILA is a rehabilitation clinic in La Ceiba, Honduras that serves people with a variety of disabilities. Many of the patients that use this clinic require unique treatment and rehabilitation programs however, the clinic lack the resources to properly care for the 50 patients that they see each day.

Figure 5: *A view of the CRILA clinic in Le Ceiba*

Acknowledgements

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References

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