Exercise Device for Child with Profound Weakness for use in a Wheelchair

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Abstract

Spinal muscular atrophy (SMA) is a disease that robs victims of physical strength usually showing noticeable physical deformities. Type I SMA is the most common type among SMA patients, but is the most severe type with it being fatal early on in life. Since these patients have a mutation in the survival motor neuron gene, they do not produce the protein that is critical to the function of the nerves that control their muscles. Without the protein, their muscle cells die which leads to muscle weakness. With new treatments on the market for SMA, these patients need a way to exercise their muscles to promote muscle development. There are currently no devices on the market that attach to a Ki Mobility wheelchair that allow one with SMA to exercise. This team's goal is to create a device that effectively exercises the legs of a patient with type I SMA. The design uses PVC pipe for the frame and soft leg straps to hold the legs up. The attachments to the wheelchair are capable of being removed easily while still providing solid stability. The attachments also provide the ability to attach and remove the frame from it. Our device proved to work effectively and met our goals set at the beginning of the semester. Overall, future work would include finding better straps to support the legs, a more aesthetic appeal of the frame, and a more efficient way to attach the frame to the wheelchair.

Background

- Spinal Muscular Atrophy (SMA) is a disease that robs victims of physical strength which is associated with the production of noticeable physical deformities [1]
  - 2nd most common neuromuscular disorder in children[1]
    - Leading genetic cause of infant mortality
  - 1/10000 (general population) [1]
  - Type I is most serve[1]
    - Most patients rely on a breathing tube and a feeding tube
    - Daily functions such as walking and sitting up can't be preformed
    - Patients still have full cognition and sensation

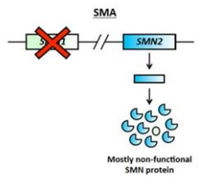


Figure 1. People with SMA have no SMN 1 and must rely on SMN 2 [1]

Motivation

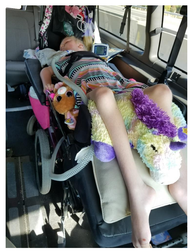


Figure 2. Aubrey, 10 year old with SMA type 1

- Current Therapies include Spinraza and AveXis
  - Need to develop an exercise device to help regain muscle strength contingent on receiving the new gene therapies
- Giving Aubrey the ability to move her legs while in the Ki Mobility Chair
- No current devices on the market

Figure 3. Ki Mobility Chair

Design Criteria

- Must be an exercise device that can be easily attached and removed from a Ki Mobility Chair
- Device must be positioned above the frame
- Device must be usable in the supine position
- Device must be lightweight and easily storable
- Frame needs to support the weight of the patient's legs
- Budget of $100

Final Design

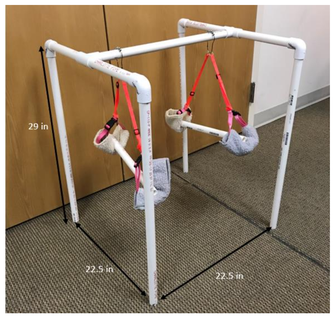


Figure 4. A ventral view of the final prototype

Figure 5. Aubrey using the final prototype

- Weight: 7.6 lbs
- ¾ in. PVC used throughout the design
- 29 in. high with a square base of 22.5 in. by 22.5 in.
- Modified dog collars model the four adjustable straps
- Dog collars with seat belt cushions used as leg holders to ensure comfortability for the patient and quick attachment to the legs
- This design is lightweight and easily storable since the legs can fold up
- This design supports the weight of the patient's legs

Final Design of Attachment

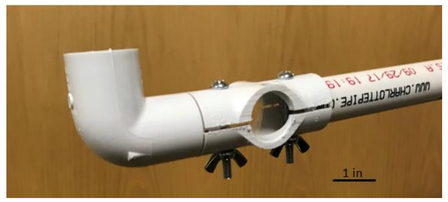
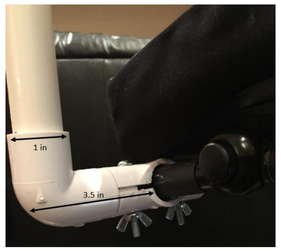


Figure 6. The attachment part that attaches the device to the wheelchair

Figure 7. The attachment part attached to the Ki Mobility Chair



- The attachment part consists of a four way connector, split in half, with two shaved sides
  - The two unshaved sides have holes in order to insert screws to tighten the attachment
- The four way connector is placed over and under the bar of the chair and tightened using the screws
- One open side has a small piece of ¾ in. PVC connected to a 90 degree PVC connector
  - The other side of the 90 degree connector will attach to the device
- The other open side is attached to a PVC bar that runs under the chair and attaches to another four way connector on the opposite side of the chair
  - This reinforces stability of the device
- This design is easier to attach and detach from the chair compared to the other two attachment designs
- This design allows the device to be positioned above the frame

Attachment Testing and Results

Figure 8. First design of the attachment

Figure 9. Second design of the attachment

- First Design:
  - Took too long to attach to wheelchair
  - Sharp edges
  - Easily supports the weight of the frame
- Second Design
  - Doesn't take very long to attach to wheelchair
  - No sharp edges
  - Doesn't effectively support the weight of the frame

Future Work

- Physical testing would be done in the future to get numerical results on how the device performs
  - Add weights to the PVC frame to get:
    - Beam deflection
    - Maximum load the frame could handle before failing
- Quickness of attaching and detaching the device would be looked into in the future
  - Attach and detach from the chair completely in less than 3 minutes
  - Brainstorm how to attach the device to the wheelchair in a time efficient manner
- The team would like to look into ways on making the device more aesthetically pleasing in the future
  - Spray paint the PVC frame black to blend in with the color of the wheelchair and hide the writing from the manufacturer
  - Straps and cushions in a color of the patient's choice to maximize customization

Acknowledgements

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References

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