

## **Angel Arms – The Development of an Exoskeleton Arm Assisting Device**

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**Introduction:** Spinal Muscular Atrophy (SMA) is a degenerative disease that results in the loss of motor neurons, which ultimately leads to muscle atrophy. SMA is classified as Type I through Type IV which reflects the age of manifestation. The developed device supports individuals with Type I and Type II SMA, where the toddlers lack the strength and control necessary to engage in age appropriate play and activities. The method of support passively counteracts the weight of the patient's arm and enables the remaining muscle strength to be used for movement. Existing products to SMA patients have not met the requirements for Type I and II patients in numerous aspects, specifically cost and patient customization. This work reports on the unique challenges and rewards of parent-toddler collaboration with the engineering-physical therapy design team in a time critical constraint.

**Materials and Methods:** The device was developed through an interprofessional partnership between the School of Engineering and the Department of Physical Therapy. The development of the arm augmentation project requirements emphasized the need for easy design and manufacturing modifications that accounts for each patient. The lack of muscle strength in SMA patients affects their growth rate and prohibits the use of standard anthropometric data. To account for an individual's measurements, all device linkages are designed to be rapid prototyped out of ABS plastic. To address the low cost and availability requirements, all accompanied parts are available to the public via online sources. Product development was facilitated by constant interaction with a Type I/II SMA patient to provide the necessary degrees of freedom, range of motion, and loading. The design and FEA analysis employed SolidWorks™. After development, several prototypes and the final product were rapid prototyped using a Dimension 1200es.



**Results and Discussion:** Promising data was collected throughout the development, verification, prototype testing, and validation stages. During development, worst case scenario was evaluated for loads applied by an arm weighing 1 pound. This value was based on the 20 month-old SMA patient. Accounting for the properties of printable ABS, the lowest factor of safety of all parts was 3. Rapid printing part orientation and the machine printing tolerance were included. Verification and validation testing was conducted. Dimensional stability and calculated loads were validated and verified through testing. Fine tuning is provided through the use of additional latex free bands. Collaboration with the patient revealed minor modifications to assure proper sizing. After alteration, the device was mounted on the patient. Despite the patient's weak muscles, she was able to move her arms with greater than 50% of normal range of motion and for an extensive length of time. She was able to reach out and touch someone's hand and bring her hand to her mouth, actions she would have struggled to accomplish without the device. A follow up visit revealed her excitement to use the device for a second time.

**Conclusion:** The developed device is a simple, low cost solution that provides patient specific customization to improve the quality of life for SMA patients. This work demonstrates the benefits of bringing together the knowledge and skills of the engineering and physical therapy professions that provides a solution to enhance the patient's quality of life.

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