

# **Assistive Device for Wheelchair Users to Pull Pants all the Way Up**

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## **Function:**

Muscular dystrophy (MD) is a genetic disease that causes progressive weakness and degeneration of skeletal muscles. A patient with Becker's MD, a type of MD caused by a mutation in the dystrophin gene [10], has physical limitations that make it difficult to pull up their pants all the way when getting dressed. The pants can be pulled up to the knees easily, and then a combination of leaning and pulling, along with frequent assistance, is needed to get the pants where they need to be. The total time taken is around 7 minutes. To minimize the time taken and eliminate the stress caused on the patient to pull up the pants, a two-part assistive device can be used. The first part of the system, the Lean and Lift device, is a stand-alone device that when positioned in front of the user, will allow the user to lean over the top to raise the lower body off the wheelchair. The Lean and Lift will be able to withhold a 230-lb, 6-ft-2-in male. The second part of the system, the Suspender device, will attach to the pants when at the knees and go around the shoulders. When the user is in the leaned-over position on top of the Lean and Lift device, the user will pull a string, attached to the suspenders, that will pull the pants up until comfortable. The amount of arm strength provided by the user with MD is limited, so the entire system will not require lifting more than 8.4 lbs. The time required to operate the device should not exceed 3 minutes.

## **Client Requirements:**

- Functional product that assists the process of pulling pants up while sitting in a wheelchair, especially from knees and above
- Support the weight and height of 220-230 pound, 6-foot-2-inch tall male
- Must be usable without fully standing up
- Materials must be durable enough to be usable for 5 years
- Budget must be within \$300

## **Design Requirements:**

### **1. Physical and Operational Characteristics**

- Performance Requirements:* The lean and lift device will allow the user to safely get out of a wheelchair without risk of the user falling or the device slipping on the ground. The lean and lift device will support a 230 lb weight and not cause any discomfort to the user on the upper body. The suspenders device will pull pants from knees to the waistline without the risk of coming unattached from the pants or sliding off the shoulders during operation. The lean and lift and suspenders system will pull the user's pants up without the need of assistance in about 3 minutes.
- Safety:* The device should withstand 230 pounds of force for 5 years, without the risk of failure. All mechanical parts must be without sharp edges or pinch points to prevent user injury. For possible electrical elements, the device should ensure operation on a low voltage to minimize the risk of electric shock. The device

should implement fire-resistant materials in areas where the risk of sparks or high temperatures is present. The device must adhere to relevant safety standards for machinery safety and risk management in medical devices. Clear user instructions should be given to the user to ensure safe and effective use.

- c. *Accuracy and Reliability:* The suspenders device should pull up pants from the knees to fully over the client's bottom without exertion on the client or any assistance. The lean and lift device should lift the user's lower body off the wheelchair without the risk of fall. The lean and lift device should hold up a force of 230 lbs during operation. The device should continue to pull up the client's pants up to 10 cycles daily and continue to function for at least 5 years without failure.
- d. *Life in Service:* The device should minimize the time taken to pull pants up from 7 minutes to around 3-4 minutes. The device is to be used every time the client puts on a pair of pants. The device should have easily repairable components with the intention that the device can be used for at least 5 years by the client without modification.
- e. *Shelf Life:* The device should remain fully functional for 5 years and its components can be replaced or fixed easily.

- f. *Operating Environment:* The device is intended for use in the home, mainly in the bedroom and bathroom. The device should be made out of materials compatible with an indoor environment temperature(20-25 °C) and humidity (40-60%) [10]. The lean and lift device may be free-standing, attached to the client's wheelchair, or mounted on a wall.
  
- g. *Ergonomics:* The device will accommodate a patient with a height of 6-ft-2-in and a weight ranging from 220-230 lbs. The device should be under 50 pounds and after the device is initially set up, no component should require more than 8.4 pounds of arm strength to operate. Large, easy-to-grab knobs and handles should be integrated into the design to minimize the force needed for usability. The device should have a textured surface for the components to be easily grasped if needed. The device should not cause any unnecessary strain or fatigue.
  
- h. *Size:* The product cannot exceed the size of the wheelchair by more than 1 foot around the wheelchair; so no larger than 4 ft tall, 6 ft wide, and 5 ft long.
  
- i. *Weight:* Any component of the device that the client needs to lift in order to operate the device needs to be under 8.4 lbs to accommodate the client's limited arm strength. The total weight of the device may be up to 50 lbs since it does not need to be moved by the client once initially set up with assistance.

- j. *Materials*: The device could be made out of several different materials depending on the design chosen. For the lean and lift device, Aluminum alloy is a possible choice for the legs and base. A cushion material should be used for the part of the lean and lift system where the user puts their weight on.
  
- k. *Aesthetics, Appearance, and Finish*: The color scheme of the product should prioritize clarity and visibility. High-contrast color combinations like white/black [1] should be used for controls and indicators. The device's shape should complement the user's body movements when pulling up pants and wheelchair configuration. For a handheld device, the texture should exhibit the following characteristics: soft, non-shiny, smooth, warm, and non-sticky to optimize the user's grip [2]. A handle bar will be attached to the lean and left device in a way that will reduce the risk of the user falling off.

## **2. Production Characteristics**

- a. *Quantity*: One prototype for individual use by the client is needed.
  
- b. *Target Product Cost*: The client desires a functional prototype within a \$300 budget.

## **3. Miscellaneous**

a. *Standards and Specifications:* The device will be a Class I medical device according to the FDA [3]. Relevant FDA regulations include:

- i. Electronic Product Radiation Regulation - 21 CFR 1000.1 [4]
- ii. Establishment Registration - 21 CFR Part 807 [5]

The device will also be required to follow Rehabilitation Engineering and Assistive Technology Society of North America (RESNA), which specifies standards for wheelchairs, wheelchair devices, and scooters [6]. Such regulations and standards include:

- i. RESNA WC-1 Wheelchairs – Volume 1: Requirements and Test Methods for Wheelchairs (including Scooters)
- ii. RESNA WC-2 Wheelchairs – Volume 2: Additional Requirements for Wheelchairs (including Scooters) with Electrical Systems

b. *Customer:* The client is Mr. Dan Dorszynski. He grew up in Wisconsin and has studied both civil and environmental engineering at Stanford. Mr. Dorszynski has Becker's muscular dystrophy and uses an electric wheelchair. The action of putting on pants is difficult, especially past the knees, as he often has to keep leaning and pulling, which takes him about seven minutes to do and a lot of effort. He typically wears athletic pants, such as golf pants that have belt loops. Mr. Dorszynski has voiced he doesn't mind if the solution is electric, manual, cloth, or any specific material/device.

c. *Competition:* There are a few similar items that aid people with pulling up their pants. One of the most popular products is one called Pants Up Easy. This device can either be attached to the wheelchair, wall, or portable. It is made up of two pads that lie above the user's shoulders so they can hoist themselves up, allowing them to pull up their pants. Pants Up Easy is very costly, ranging from \$1500 to \$3600, depending on the model [7]. Another is called the Wings-Pants Dressing Aid, which is a much cheaper option, retailing for \$49.50. The product holds the pants open and is easily adjustable by opening the release and pulling outward, allowing the user to slide up the device and pants simply [8]. Both designs are efficient, but costly and require sufficient arm strength.

## References

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