Inflatable Standing Aid Device

Design Team
Travis Fulton, Megan McGuire
James O’Keefe, Justin Tichy, David Venturoso

Design Advisor
Prof. Andrew Gouldstone

Abstract

The purpose of this project is to design a portable device which will significantly assist a user in raising him or herself from a seated to a partially standing position. A typical user would be anyone who needs assistance standing due to injury, illness, disability, or old age. The sponsor, Ethan Rabinowitz, initially proposed the concept of a portable device which was to be comprised of multiple chambers and could be inflated to bring the user to a standing position.

There are current products on the market to aid users in standing, but none which are truly portable. For this project a device has been designed, which provides gradual rise and portability. Three concepts were developed: mechanical lift, negative inflation and positive inflation. After building and testing prototypes, it was decided that positive inflation was the ideal solution. The group was able to make an air tight bladder in house comprised of canvas and rubber. This bladder underwent testing to insure durability, repeatability, and overall function. Compressed air was determined to be the best way to inflate the device and a carrying case which doubles as a cover was designed both for user comfort and aesthetics.
The Need for the Project

Currently there is no truly portable device to be used outside of the home for those who need assistance in rising from a sitting position to standing. The purpose of this project is to design a device which can raise a user from a seated to a partially standing position with minimal effort exerted by the user. Many people with disabilities do not have the strength or ability to rise from a seated position under their own power. This includes people who have become handicapped due to injury, illness, or age. Rather than rely on others to assist them each time they need to stand up, users will be able to use this device to independently stand as needed. There are some products on the market that help individuals stand, but most are limited to in-home use only.

The Design Project Objectives and Requirements

The objective is to make a portable device of no more than 5lbs that can raise a user 8 to 10 inches. The Design Objectives

The main objectives are to raise a user 8 to 10 inches while keeping them safe and stable. Reviews of a competitor’s device show it to have problems with launching users out of their seats rather than gently helping to raise them to a standing position. It is also a goal to make this device portable with the ability to be used outside of the home.

Design Requirements

The primary function of this device is to raise a user 8 to 10 inches vertically in order to get them to a position from which further standing is not difficult. It should be designed to raise an average adult with a maximum weight of 250 lbs.

This device is meant for use in both the home and public places, therefore it must be suitable for use in a wide range of seat types. The sponsor has specified that it will only be intended for use in chairs with armrests, for the safety and comfort of the user. The ideal product will collapse or fold to a small size and be no larger than a small bag. It needs to be lightweight so it is not a burden for the disabled to carry. The total weight of all the components of this apparatus must weigh no more than 5 lbs.
Design Concepts Considered

Three concepts were developed to provide lift to the user: mechanical advantage, negative inflation, and positive inflation.

Mechanical Lift

The concept of using a device with a mechanical lift system that incorporates springs or hydraulics was pursued. A prototype which translated a horizontal force into a vertical force was initially designed. The device consisted of two flat rigid surfaces hinged together on one end and supported by a vertical member which was allowed to rotate freely about a pinned axis. One end of this member was attached to the upper surface while the other rested upon a sliding track placed on the lower surface seen in Figure 1. The lifting range and mechanical advantage of this device was derived from two gas springs each supporting half the load. When in use, the user would sit upon the upper flat surface which would be initially raised at a 45° incline. The weight of the user would then compress the gas springs, allowing the rotating vertical member to slide along the track to its closed horizontal position. This potential energy of the compressed springs would remain until the force of the user’s body weight decreased during standing. The force of the springs would then act as an aid in initially raising the user from a sitting position.

After further investigation, this device and use of a mechanical advantage system was excluded from the final product design due to a lack of user control, safety, and size/weight concerns. While the idea of stored potential energy in a spring system seems feasible, it has proven to be difficult in similar products, resulting in the user being unintentionally forced out of the seat. Other problems including the final weight of the system and its lack of portability led to its exclusion.

Negative Inflation

The idea of negative inflation was to make a device which would stay partially or completely expanded under the weight of a user. This was done using polyurethane foam and encasing it in an air-tight flexible shell. The air was removed from this shell using a vacuum, effectively forcing the compression of the system. When the user wished to stand, a valve would open and the air flow in would allow the foam to return to its desired shape, and thus lifting the user.
It was determined that a very dense foam would be needed to keep its shape under the weight of the user. The denser the foam the larger vacuum force to compress it needs to be. After much research it was found that the only suitable vacuums which are powerful enough to compress this foam are loud, bulky, and require an external power source.

**Positive Inflation (selected)**

The initial idea proposed by the sponsor, Ethan Rabinowitz, was an inflatable pillow-like device powered by an air source such as a compressor or hand pump. He proposed a design utilizing round inner tube like chambers stacked vertically. A total of 6 tubes, each 1 to 4 inches tall would be used. Valves in between each tube would release once the tube below it had inflated.

Extending from the sponsor’s original concept of inflatable rings, another concept was a multi-chambered inflatable design. This apparatus, as shown in Figure 2, would first be inflated horizontally and then vertically to reach a total height of 8 inches.

**Recommended Design Concept**

The final design concept is a single chamber air bladder in the shape of a wedge filled with compressed air. The bladder and compressed air will be contained in a travel case that doubles as a cover. Due to the complexity of constructing a bladder of multiple air chambers, the final recommended design concept consisted of a single chambered bladder. This aided in prototype manufacturing. The option of using an outside vendor was considered, but the lead time and cost to make a bladder out of rubber was too large for small scale production. Instead the group used canvas fabric, which is very durable, and coated it with a liquid rubber urethane compound to make it air tight. Foam was also added into the bladder to help with air flow and comfort for the user when the bladder deflated. The final design can be seen in Figure 25.

Several ways for filling the bladder were considered, such as a portable air compressor and different compressed gas canisters. A compressed air canister was ultimately selected because of its high airflow and small size. The canister selected, which provides 5-8 uses depending on the user, can be filled at dive shops, hardware stores, hospitals, and paintball stores. The canister is filled to 3000 psi, but through the use of a regulator valve the outlet pressure is reduced to 30 psi.
The bladder will go through durability testing, cycling it from a deflated to a fully inflated state with a weight of 200 lbs on it to show the durability the bladder has and give an estimate of how long the bladder will last. Another test to be performed is overfilling the bladder with air, in order to simulate what would happen if a user did not turn off the compressed air in a timely manner. Weight testing will also be done to see how much pressure is needed in relation to the amount of weight on the bladder. Finally, timed testing will find a correlation between how fast the bladder fills to the pressure output of the compressed air canister.

Using the canvas with liquid rubber coating made bladder production on-site easy and affordable for the team. This is a robust way to produce the bladder, but not ideal for mass production. It is important to note that this design is desirable to the several potential users we questioned in our IRB-approved survey.

**Financial Issues**

If this product were to go into production the cost of making bladders out of rubber or plastic would greatly reduce, allowing for easier production of the device. For a single rubber bladder to be made out-of-house the cost was $642. With additional accessories that the company suggested the cost was raised to $1,477. This was too expensive for proof of concept and there was a 90 day lead time which was too long to wait for this project. Research was done into what it would cost if the bladders were to be bought in bulk. An exact number was not given, but the price per bladder would be reduced. The shape could also be changed to ease manufacturability, thus additionally reducing cost.

**Recommended Improvements**

Future improvements include material change, product testing with customers, and a more efficient air delivery system. Using a different material for the bladder may make the entire device easier to manufacture. If there had been time to have potential customers try out the device, improvements could have been made from their suggestions.

The compressed air tank works well, but having a more efficient air delivery system that is smaller and more lightweight is desired. Also, market research must be done into whether companies such as pharmacies and nursing homes would be interested in installing air compressor that could conveniently refill the air canisters. In addition, if nursing homes were to have air compressors installed, they could run compressed air lines throughout the home for patrons to use.