

## **AXIS**

### *Portable Folding Wheelchair Transfer Board*

Sherrie Yang, Elliott Davis, Mary Boyajian & Bogdan Dimitriu

---

#### **Mission Statement**

Our mission is to help promote user independence by streamlining the process of transferring in and out of a wheelchair. Our goal is to develop an affordable solution that helps reduce the possibility of falls and future medical complications.

#### **Problem Statement**

Individuals with spinal cord injury (SCI) face physical limitations to perform various functions from different body regions based on the severity and location of the injury. As a result, the upper body must work overtime to compensate for the lower body. This puts more wear and tear on the upper bodies joints and muscles. Additionally, the lower body becomes susceptible to injury from pressure points and further damage can occur without proper care. SCI injury location can result in a disproportion of lateral capability or strength. This can limit the overall ability and independence an individual will have. Specific injuries can limit the ability to perform tasks and can take much longer to rehabilitate for individuals that have a spinal cord injury.

Many individuals perform depression transfers, where they use their upper body strength to lift themselves up while they move short distances to perform the transfer. This is very hard on the body and over time can lead to repetitive stress injuries. Not everyone can easily perform this maneuver and many women have a hard time performing a depression transfer due to a weaker upper body strength and generally shorter arm lengths. Many individuals with SCI will eventually suffer from shoulders and upper body injuries as a result of performing depression transfers.

#### **Primary Research**

To conduct our primary research, we visited Rancho Los Amigos National Rehabilitation Center and spoke to four people: Denise Lau, Bobbi Tanberg, Lue, and Mike. Each of the four interviews proved to be very insightful. We first interviewed Denise, an occupational therapist who primarily works with patients with spinal cord injuries. We learned the different types of common transfers that people use. With upper body strength, individuals with SCI can complete a depression transfer, where they use their arms to push up, turn, and pivot. This method requires extreme upper body strength, but people prefer this method for maximum independence. However, long term use of depression transfers is very hard on the arms and shoulders. Thus, many therapists recommend the use of transfer boards to facilitate transfers.

In terms of the different types of transfer boards, most users currently use a simple wooden board. Although there are many boards, such as plastic ones with rollers, people prefer the simple one as the plastic one can cause pinching. Additionally, Denise mentioned that most users do not carry these wooden transfer boards with them as they are too bulky. Instead, they keep one in their home and one in their car. Thus, if there was a more portable transfer board that the users could carry around with them at all times, it would be extremely helpful in situations like public restaurants when transferring from a wheelchair to a dining chair, Denise mentioned that this is a common practice that helps promote belonging.

We also spoke to Lue and Mike, both peer mentors at Rancho. Lue is a T2 on his right side and a C7 on his left which means he has pronounced weakness on one side; for this reason, he suggested making the board lighter. He also explained that when his wheelchair tires get wet, his brakes are compromised and he has to use a transfer board. This is an additional reason why transfer boards are useful and why it would be beneficial to have a portable transfer board. Lue and Mike mentioned that patients use transfer boards immediately after sustaining their injuries, and though many patients return to transfer boards when they get older, most view the use of a transfer board as a temporary hassle. Aesthetics is a big concern in the population with SCI, because a sizable portion of them are young men who value their independence. We will address this concern by ensuring that our solution is sleek, portable, and efficient.

Mike suggested making the board foldable, to make it easier to transport, while Lue suggested adding a handle like a painter's palette. Transfer boards are also helpful for wheelchair users with shorter arms (typically true for women), which makes it harder to do depression transfers. Another positive quality of the transfer board is that it lasts a long time. Lue has only replaced his transfer board once in his 24 years of use. Thus, price points are not typically a limiting factor for users, as the costs are justified by the products longevity.

Bobbi Tanberg, also an occupational therapist at Rancho, mentioned that there should be a balance of smoothness and grip of the board. On one hand, if the board is too smooth the user might slip off, but if the surface is entirely non-skid, the user will not be able to slide along the board. We will take this into consideration as we analyze different materials, grips, and rails for the transfer board. She also suggested a C-shaped board instead of the rectangular shape to help maneuver users around the armrests on either the wheelchair or a destination chair.

## **Secondary Research**

There are 2.2 million users in wheelchairs in the US, with approximately 8,000 new cases per year<sup>1</sup>. Roughly 50% of those users are paraplegic and 50% are quadriplegic<sup>2</sup>. After suffering a Spinal Cord Injury, the first year's medical expenses are approximately \$228-775k<sup>2</sup> and only half of individuals are covered by insurance at time of injury<sup>2</sup>. 89.3% of all persons with spinal cord injury (SCI) who are discharged from the system are sent to a private, non-institutional residences<sup>2</sup>. Many patients are not be able to afford the professional medical assistance and must learn to take care of themselves.

## **Design Approach**

Initially, we were aiming to improve posture or add strength an individual with limited lower body support, or to make transferring easier. Our initial concepts (the swivel pole, posture support, and knee brace) had their potential benefits, but targeted very specific individuals or applications. For the swivel board, it would be very hard to make the device portable, thus limiting its use to stationary placements such as next to the bed or in the bathroom. For the posture support, individuals with SCI have varying degrees of trunk weakness. Thus designing a posture support would have to be highly customized to each individual. For the knee support, the target audience is a relatively rare case, as most SCI individuals do not have the ability to spasm their leg muscles. With these insights, we aimed to move towards improving a more robust solution: sliding boards.

## **Solution:**

Sliding boards help wheelchair users transfer in and out of their chairs. Both new wheelchair users and older ones generally rely on a sliding board to help with their transfer. Slide boards are more often used in a home setting. To address the aforementioned problems, solutions that help reduce or eliminate future medical complications are needed. Such solutions will improve overall quality of life, promote independence, be affordable, and improve the ease of performing daily tasks.

From our conversations with Denise, Bobbi, Lue, and Mike at Rancho Los Amigos, it became evident that many individuals do not make good use of the currently available sliding boards even though trainers highly suggest their use for both health and safety. This is because existing sliding boards are bulky, heavy, and difficult to transport. Thus, many individuals forgo this method in favor of speed. Those that use sliding boards often just keep them at home due to their size and weight. Thus, we want our solution to be as portable and sleek as possible.

## **Current**

Our current solution is a folding transfer board that is a folding plank made of plywood and consists of two halves joined together by a integrated hinge. When unfolded, the device locks into place and allows for use like a regular transfer board. Once opened the board will lock in place to prevent accidental closing while in use. On the bottom, there will be removable rubber traction grips that will help prevent slipping on smooth surfaces, allowing for multi-applicational use.

The design has smooth beveled corners, and edges which will provide a seamless transition for the user and prevents pinching between the board in the wheelchair. Our product reduces the overall length by approximately 50%, allowing the user to easily carry the device while in the wheelchair. The use of composite materials such as carbon fiber will also greatly reduce the overall weight of the transfer board, producing a solution that will be far lighter than current solutions on the market.

## **Design**

## **Functional Prototype**

Our current functional prototype is constructed out of wood and utilizes off the shelf door hinges. This allowed us to quickly fabricate the prototype for testing and evaluation purposes. Within our testing we have found that the design can support the weight of a person executing a transfer. The prototype has allowed us to gain insight into the use and feasibility of the concept at a minimal cost. The insight we have learned from developing the functional prototype has been used to incorporated into our final proposed design concept for the AXIS folding transfer board.

## **Cost**

One of our primary goals was to develop a solution that would be affordable. As part of our research we surveyed competing products within the market segment ranging from \$20 to \$220 and looked at their benefits and limitations. Based upon this market analysis and the insight we received from our interviews, we determined that current solutions lacked in several key areas. Primarily current transfer boards on the market lacked safety. Our interviewees reported that they had been pinched or cut by the use of transfer boards in the past. Individuals also avoided using transfer boards because of their size and weight, making it difficult to transport current boards on the market. Additionally there was reluctance to use currently available transfer boards due to their off putting, impersonal, and medical appearance.

Another insight we received was the long duration that users owned their current transfer boards. Lou for example had only replaced his transfer board once in 24 years. This leads us to believe that users and the market would accept transfer boards at the higher end of the current market segment if the products offered increased value.

Our solution increases user value and solves the issues of safety, size, weight, style, and personalization by creating a product that takes up less space, comes in several colors to match the user's personal style and is smooth for easy and safe transfers. In order to ensure that our transfer board is strong, we propose a carbon fiber construction (optionally with an aramid honeycomb core). While this makes the board light and strong, it also increases costs. This positions our board toward the higher end of the market, but we believe the added value and versatility justifies the increase in cost.

We propose a cost of \$130-150 for our transfer board based on our anticipation of what the market can support. With carbon fiber's increasing popularity, costs have been greatly reduced, while overall quality has increased. Composite molds are also far more economical compared to injection molds and would help keep manufacturing costs down.

### **Marketplace**

*Primary Market: SCI individuals in wheelchairs*

Currently, about 1.7% of the US population reported they are living with some form of paralysis. The leading causes are stroke, spinal cord injury and multiple sclerosis. Of the households that include people living with paralysis, roughly 28% make less than \$15,000/yr.<sup>3</sup> The proportion of quadriplegic (paralysis in all four limbs) to paraplegic (paralysis from the waist down) is roughly 50/50 split, slightly favoring a higher number of paraplegic patients.<sup>4</sup> The average lifetime cost for a person who became a paraplegic at age 25 to live with their condition was estimated at around \$428,000 whereas the same estimation for a quadriplegic shoots up to \$1.35m.

*Secondary Market: the elderly population*

There were roughly 46.2 million elderly persons - aged 65 or older - in the US alone in 2014 amounting to 14.5% of the population. Due to aging demographics, the number of elderly people (defined as above) is projected to reach 98 million (or 21.7% of the population) by 2060.<sup>5</sup> Many of these elderly people experience mobility issues. Many elderly have similar needs to individuals in wheelchairs such as need to transfer between a wheelchair and another place, thus constituting an attractive secondary market for our products. Unlike the primary target market, the elderly population tend to have less upper body strength. However, the transfer board will still be useable with the aid of a caregiver.

### **Significance**

This device will provide enhanced portability compared to a classic transfer board. Some of the potential users that we have encountered at Rancho have said that they would be more likely to use their transfer boards outside the home, especially for car transfers, if the device were smaller and more portable. Most transfer boards currently stand at over 25 inches length, which is necessary to ensure functionality for users. However, this length exceeds the typical floor-to-seat height of most wheelchairs (on the order of 20 inches), making this device ill-suited for portable applications. Our design would essentially reduce the overall size of the existing devices and thus enhance their functionality. Users would be able to carry the transfer board wherever they go, sliding it underneath their chair and pulling the board it whenever needed.

## **Acknowledgements**

Our team would like to specially acknowledge the help from our professors and advisors, Ken Pickar, Jeff Higashi, Andy Lin and Drora Shevy. We would also like to thank Denise Lau, Bobbi Tanberg, Lue, and Mike from Rancho Los Amigos National Rehabilitation Laboratory for the insight and understanding they provided for our project.

## **References**

1. <https://www.nichd.nih.gov/health/topics/rehabtech/conditioninfo/Pages/people.aspx>
2. <https://www.disabled-world.com/disability/para-quad.php>
3. <https://www.christopherreeve.org/living-with-paralysis/stats-about-paralysis>
4. <http://www.sci-info-pages.com/facts.html>
5. [https://aoa.acl.gov/Aging\\_Statistics/Index.aspx](https://aoa.acl.gov/Aging_Statistics/Index.aspx)