UNIVERSITY OF WISCONSIN – MADISON
DEPARTMENT OF BIOMEDICAL ENGINEERING
BME 301 – DESIGN

Assistive Transfer Device

Final Report

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Abstract

The goal of this project is to develop an assistive transfer device for use in a clinical setting with elderly or post-operative patients. Since most patients have difficulty lifting themselves onto an exam table, it is necessary to employ alternative methods to facilitate the lifting process. Current methods and devices are inefficient, demand much physical exertion by the medical assistant, or are uncomfortable for both the patient and assistant. The new device will be designed to safely transfer patients from the standing position to the top of an exam table. It will reduce the amount of necessary effort to lift the patient, and provide the patient with a sense of security during the lifting process. Additionally, the device will be easy to clean, user-friendly, cost-effective, and simple to store. After extensive brainstorming, several design alternatives were generated for transfer methods and lifting mechanisms. The alternatives were then evaluated using design matrices to determine which design was best suited for the project purpose. The scissor link, standing position design was ultimately chosen due to its compactness and simple operation. The proposed design was fabricated and assembled according to the client's specifications. This initial prototype was then tested for simple functionality and to establish the overall design as a viable proof of concept. The prototype was successfully able to lift 170 pounds, however; the after repeated usage, the frame failed while lifting from the lowest position. Though qualitative testing was carried out, the desired mechanical characteristics of the device were unable to be carried out. Future development of the device will include an improved hydraulic system, a reinforced frame, and friction reduction to all mechanical joints. In addition, the prototype will be run through a series of quantitative mechanical tests to fully understand the behavior of the lifting device.

Motivation and Problem Statement

In many medical situations, it is necessary to lift patients. This need for assistance could be due to reduced patient strength as a result of an extensively invasive operation, inherent weakness, or old age. As people age, their muscles degenerate, causing a reduction in their strength capabilities and increasing their force buildup time [1]. In addition to causing problems for the person in everyday activities (i.e. climbing stairs), it also makes difficult the routine examinations where a patient is required to climb up onto an exam table. This problem is compounded with more frail or obese patients. Generally, elderly or post-operative patients come to examinations in wheelchairs or with the assistance of a walker. In most cases, it is easier to help patients out of wheelchairs than to lift them up to the top of exam tables.

To facilitate lifting of elderly or post-operative patients, it is necessary to design a device that is capable of safely transferring patients from a standing position on the ground to a level where they can easily get onto an exam table. To reduce patient anxiety, the device will include handles or another similar structure for patients to hold onto as they are being transferred. Finally, the device will be easy to operate and will minimize the required effort by the patient and medical personnel.

Background

One of the most common methods for lifting patients is manual labor. In this method, trained medical assistant wraps their arms around a patient underneath the shoulder joint (figure 1). The assistant then carefully lifts the patient vertically. Carefully walking backwards while holding the patient, the assistant must then rotate slowly and lower the patient down onto the desired destination which is, in many clinical settings, an exam table. If the patient's lower body is partially incapacitated, it is often necessary for a second assistant to hold the patient while the other assistant steadies the patient's legs. If the patient is totally incapable of using their legs, they are then placed onto a hammock type sling in the lying position. Two assistants are then required to hold the two ends of the sling and lift the patient. Although manual lifting is mechanically simple, it requires a lot of physical exertion by the assistant. The level to which patients can be lifted is solely dependent on the assistant's strength. Because of the large effort required for the lifting, there is a significant risk of injury for the assistant and a risk of injury for the patient if the assistant drops them.

Figure 1 - Medical assistant lifting patient out of wheelchair [4]

To alleviate the required effort in patient lifting, several devices have been developed. The first and most commonly used lifting device is the Hoyer Lift (figure 2). This device uses a non-automated hydraulic system to elevate patients. It also includes several adjusting mechanisms to widen or narrow the supporting base and wheels for easy transport. The cost of a Hoyer lift can range from $600-2000 [2]. To lift a patient, the device is first strategically positioned near the patient's desired destination. The patient is then inserted into a nylon or cotton sling that supports their back and upper legs. After the patient is secured in the sling, the assistant elevates the patient by operating a foot or hand pump. When the patient is fully suspended in air, the assistant then rotates the patient over the destination and then releases the hydraulic system so that the patient is lowered slowly into position. Although the Hoyer lift lessens the amount of effort required by the patient and by the assistant, it can cause emotional unease for the patient since they are in full air suspension during the lifting process.   Additionally, several expensive modifications to the Hoyer lift are available. These devices include automated systems, a larger weight capacity, finer adjustment mechanisms, and different sling sizes.

Figure 2 - Elderly patient being lifted by Hoyer lift. [5]

Another commonly used device is the ambulation assistive device (figure 3). This device implements an automated hydraulic system to lift patients [3]. To

Figure 3 - Elderly patient using ambulation assistive device. [6]

facilitate storage and mobility, the device includes multiple wheels. The vast majority of the automated systems are designed for helping patients from the sitting position to the standing position (e.g. from a chair or wheelchair). During operation, the patient is inserted into a harness and their arms are strapped to the top of the device. When the patient is properly secured, the top portion of the device will elevate, bringing the patient with it. When the patient is brought to the standing position, the top of the device is locked, the base wheels are unlocked, and the patient can then use the device to steady themselves as they ambulate. During the lifting process, the patient is often uncomfortable due to the number of straps and harnesses that are required to keep the patient secured to the device.

Design Requirements

Before developing a unique device to assist in patient transfer, a list of constraints was established, taking into consideration functionality and user-friendliness. All the constraints considered can be seen in the attached PDS (Appendix A). The mechanical constraints are also summarized in table 1.

Figure 4 is an image of the exam table in the clinic, which is 32 inches tall. The bottom drawer is a 10 inch step that can be pulled out to assist the patients in getting onto the exam table. Unfortunately, many of the patients' legs are not strong enough to climb such a large step. Due to this, any step implemented in the design it must be 4 inches or less in height, which our client claims that the patients will be able to navigate.

Figure 4 - Picture of typical exam table present in vascular surgery unit of UW West Health Clinic

We are designing the device to help individuals at least 4.5 feet tall and with a maximum weight of 300 lbs. With use of anthropometric tables, we were able to determine that, on average, the knee of a 4.5 feet tall patient is located 15.4 inches off the ground. Therefore, our device will have to raise the patients a minimum of 15 inches. Our client requests that we build the device for a subject of 300 lbs because it is well above the average weight of the patients visiting the clinic. Any patient weighing much more than 300 lbs would have difficulty getting into the initial standing position from the wheel chair and the doctor would either examine them while in the wheel chair or would use the Hoyer lift to get them onto the table.

Qualitatively, the device also needs to be user-friendly during its operation. It needs to be simple, requiring very few steps to get the patient from the standing position to the table and back down. If a foot pump were to be implemented in the hydraulic lifting system, the required user input would be minimal—similar to the input needed for chairs used in most barber shops. To reduce patient anxiety during use, additional safety features would be considered such as additional straps or railings so the patient feels secure.

In addition to making the design user-friendly during operation, we considered the ease of storage in the design—another constraint our client feels important. First, the design needs to be as compact as possible for two reasons to allow for storage behind a table, or in the back of a closet somewhere when not in use and so it can easily fit up next to the exam table to be used. It would need to be easily moved from location to location, either by wheels or easily carried, which would require the device be less than 50 lbs in weight.

Table 1 - Summary of design specifications

Mechanical Design Constraints
Safely lift minimum of 300 lbs with a safety factor of 2.
Steps must be less than 4 inches off the ground.
Device must lift patient a minimum of 15 inches off the ground if from a standing position, 32 inches from seated or reclined position.
Total weight of device must be less than 50 lbs.
As compact as possible to allow for easy storage.

Design Alternatives

Considering the problem, we recognized that there were three ways to transfer a patient onto the exam table, from a reclined position, a sitting position, and a standing position. Our initial designs were used to determine which of these methods would work best for moving a patient from an initial standing position onto the bed.

Our first design, the Supine Transfer, is a simple mechanism utilizing a pivot point to recline a patient from a standing position. Figure 5 is an image of the Supine Transfer. The device would function similarly to a teeter-totter, rotating about one axis. The patient would stand on the base platform, leaning against the reclining surface. There could be straps around the feet or legs to allow for a safe motion. The nurse would then pull the handle downward, applying minimal force due to the naturally long moment arm. When in the reclined position, the device would lock in, allowing the nurses to then slide the patient from the Supine Transfer device onto a table. Additional safety features include a damper, attached to the base of the device causing the device to descend at a constant rate in case the nurse accidentally lets go of the handle before locking the table in place.

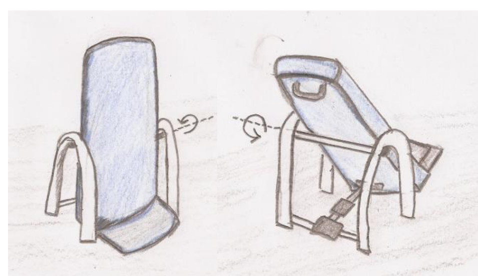

Figure 5 - Concept drawing of Supine Transfer method

The main concerns with this design are its size and overall ease of use. Once the Supine Transfer is level with the table, the nurse would need additional assistance to help slide the patient onto the exam table. It could, however, prove functional as an alternative exam table thus solving the underlying problem.

The second design is the Seated Transfer, shown in figure 6. It operates through the use of a hydraulic mechanism, manually or electronically powered. The patient would sit on the seat, which would be elevated until it is able to freely rotate over on top of the exam table. Once the seat is on top of the table, the patient can easily move themselves off the seat and onto the table. The seat itself can be rotated about its vertical axis and around the hydraulic column, to easily be adjusted to allow for easy transfer from the seat onto the table. Safety belts and possibly arm rests may be incorporated on the seat to reduce patient anxiety.

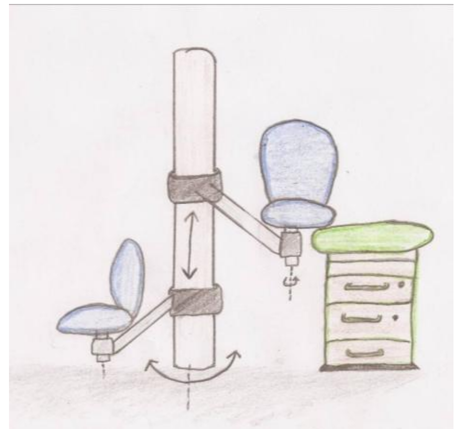

Figure 6 - Concept drawing of Seated Transfer method

The main concern with this design is the overall size. It would be difficult to store, and would be better suited permanent installation. It would, however, require only one nurse to operate making it is easier to use than the supine transfer.

The third design, the Standing Transfer, is shown in figure 7. It is a compact design that incorporates a platform that raises the patient while standing. It was designed to integrate a typical walker that the patient can use to initially step onto the platform and hold onto while the platform is raised. The walker would lock into the platform preventing the patient from sliding around while being lifted. Figure 7 shows the platform utilizing scissor links as the mechanism that lifts the platform, but this is not necessarily the case because any device allowing for the platform to steadily raise and lower would work. A hydraulic cylinder will most likely be incorporated into any of the designs.

Clearly this design has the most potential to meet the easy to store constraint, as it could be compressed down on itself, to a 4 inch thickness. The device would require a turn table, however, since it does not have a built in rotation mechanism like the Seated Transfer.

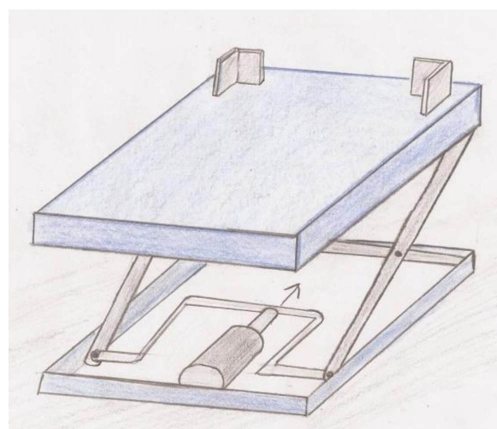

Figure 7 - Concept drawing of the Standing Transfer method

Table 2 shows the design matrix created to compare the three general designs of Supine Transfer, Seated Transfer, and Standing Transfer. The designs were evaluated based on their size, ease of operation, how well the device reduces patient anxiety, cost and ease of fabrication. Each were ranked on a scale of 1-5, where 1 is poor and 5 is excellent, with size, ease of operation and patient effort weighted twice as much as the others. The designs received comparable scores in most of these categories. Size and ease of operation were the two aspects that separated the scores of the design. The Standing Transfer received the best score in these two categories because it would be the most compact design. It is the easiest to use because it would be the lightest and most mobile design. It also has fewer steps required for operation than the Supine Transfer.

Table 2 - Transfer method design matrix

	Patient Anxiety	Size (x2)	Ease of Operation (x2)	Patient Effort (x2)	Ease of Fabrication	Cost	Total
Supine	2	6	4	6	3	3	24
Sitting	4	4	6	7	1	2	24
Standing	3	10	8	7	3	3	34
scale 1-5, 1 = poor, 5 = excellent							/45

Lifting Mechanisms

After evaluating possible lift orientations, we explored various lifting mechanisms that would be able to transfer the patient onto the exam table in the safest and most comfortable manner possible. The first type of mechanism which we developed implemented a forklift to raise the patient to the appropriate sitting height. This forklift design, shown in Figure 8, uses a pallet type platform with slots on the underside that a small industrial pallet forklift would be able to slide under in order to lift the patient. Although this design is very simple and only consists of two main components, using an industrial pallet lift would prove to be bulky and cumbersome in the small clinical exam room setting.

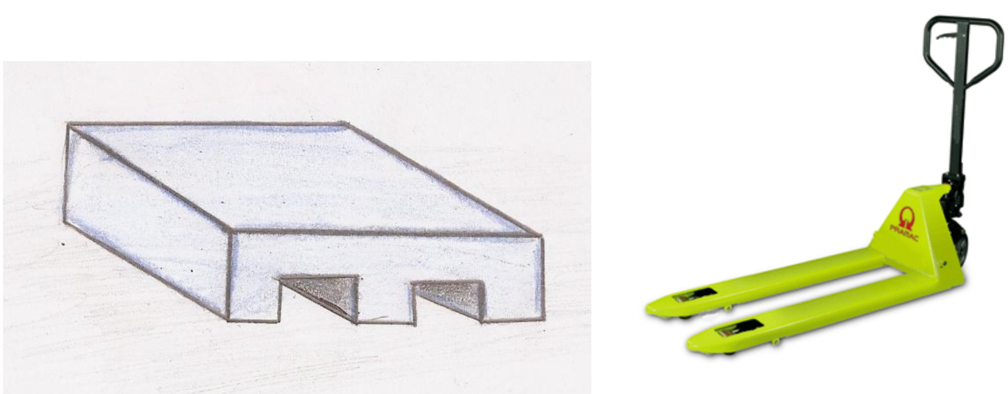

Figure 8 - Concept drawing of forklift-pallet lift mechanism

The next mechanism was called the Parallel Piston method. As seen in figure 9, it consisted of a platform and either two or four hydraulic actuators arranged around the perimeter of the platform. Placing the pistons around the perimeter rather than underneath the platform surface allowed for the standing surface to be lowered to the lowest possible position. This would allow the frail or incapacitated patient to step up onto the platform with relative ease. Regardless of the number of cylinders implemented in the design, the platform would need to be raised at a steady rate and each cylinder would have to be synchronized. Maintaining this synchronization would be the most challenging aspect of this design. In addition, the rotation of the top platform for patient positioning would be a challenge since we would have to work around each cylinder.

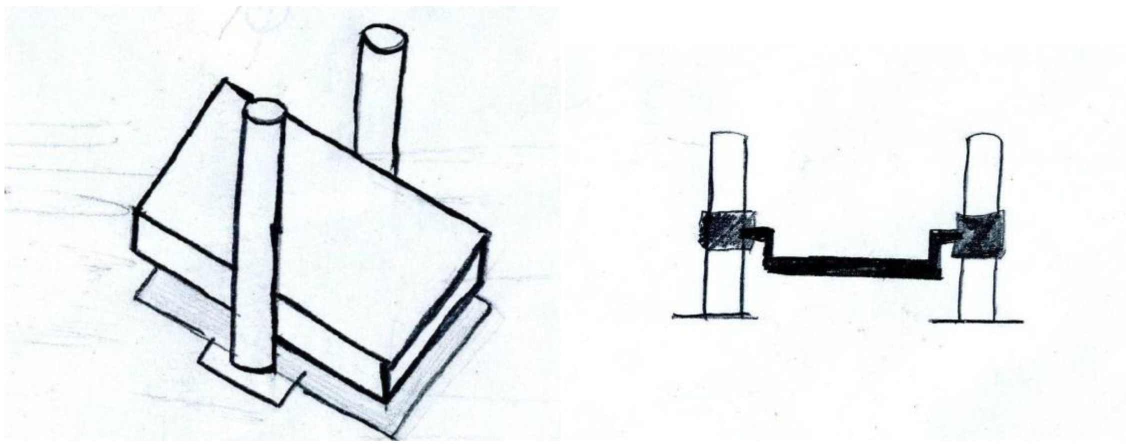

Figure 9 - Concept drawing of Parallel Piston lift mechanism

After further research, the scissor lift mechanism was discovered. This method, portrayed in figure 10, is the most common way to lift heavy loads without the use of heavy machinery such as a crane or forklift. These assemblies can be observed in many common lifting systems such as industrial box lifts and cherry pickers. The scissor link configuration allows for a heavy load to be held in equilibrium by a relatively low force applied at the bottom of the assembly; however, since the lifting ability is dependent on the scissor extension height, there is a considerable mechanical disadvantage when the links are at their lowest position. This is a key aspect to the design because we want to make the initial height as low as possible, resulting in a very large initial force from the hydraulic cylinder necessary to raise the platform.

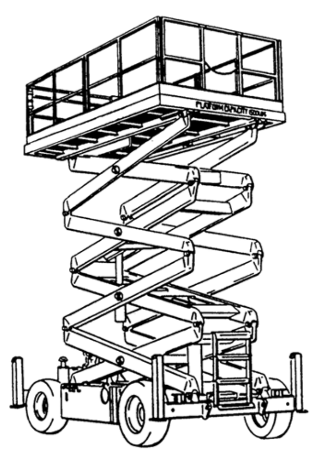

Figure 10 - Example of scissor link lift mechanism

Lift Mechanism Design Matrix

In order to evaluate the traits of each proposed lifting mechanism, a second design matrix was produced. As seen in table 3, each lift mechanism was scored in categories of safety, size, ease of operation, aesthetics, ease of fabrication, and cost. Each method was assigned a score of 1-5; however, the categories of size and ease of operation were weighted double due to their importance according to the client's specifications. By reviewing table 3, it is evident that the scissor lift won by a commanding number of points, because it is the most compact, efficient method and should drastically reduce the amount of physical labor required by the clinical staff and patients. The parallel pistons scored low due to the complexity of the hydraulic synchronization while the forklift method lacked in its size and unstable appearance. We believe the scissor method will be the least intimidating for the patient, as well as, provide the most stable and comfortable lifting process.

Table 3 - Lifting mechanisms design matrix

	Safety	Size (x2)	Ease of Operation (x2)	Aesthetics	Ease of Fabrication	Cost	Total
Forklift	3	2	6	1	4	3	19
Parallel Pistons	4	4	4	3	2	3	20
Scissorlift	5	8	10	5	3	4	35
scale 1-5, 1 = poor, 5 = excellent							/45

Proposed Design

The design we set out to purse this semester is based on a standing position during lifting and the scissor link method of lifting. It consists of a base for support, a pair of scissor links, a top platform, and a turntable. Figure 11 shows a SolidWorks model of the design. When the platform is completely lowered, the height is 4 inches, with the links fitting entirely inside the base. Using the scissor links to raise the platform, the height can increase to 15 inches.

In order to lift the platform, a hydraulic jack will be placed at the bottom of the links, applying a horizontal force on the free end of the scissor link. The amount of force that the hydraulic jack will have to produce is dependent on the amount of weight on the platform and the height the platform is raised to. The hydraulic jack will have to produce the most amount of force when the platform is at its lowest position. To pressurize the hydraulics, a manual foot pump will be added. A nurse will be able to pump the hydraulic fluid while having their arms free.

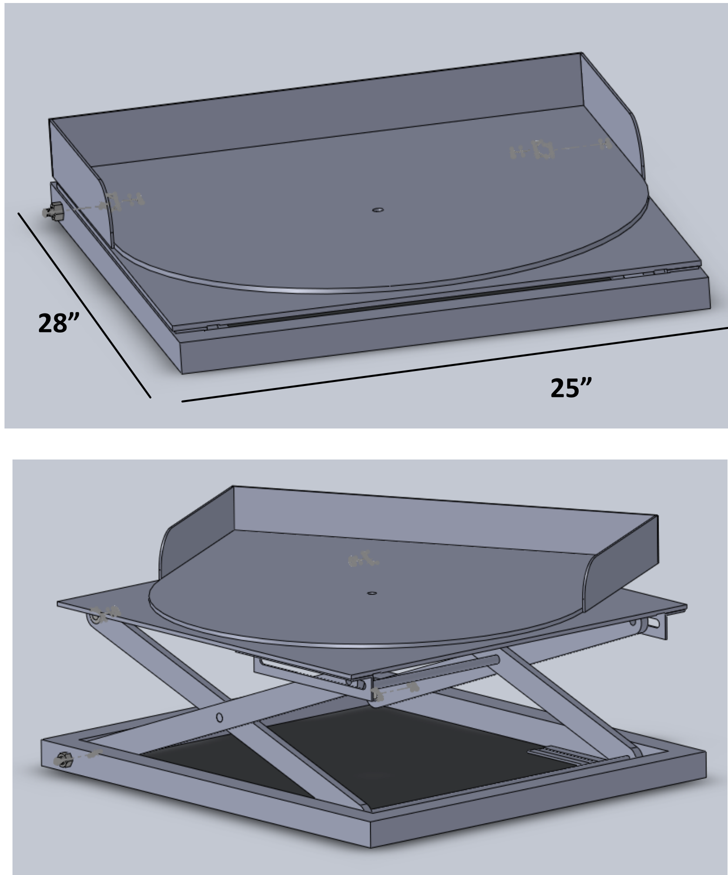

Figure 11 - SolidWorks models of proposed design. Top: compressed position; Bottom: slightly elevated position with turntable rotated

Final Design

Our final design has been adapted from our proposed design and is shown in figure 12. The base frame and top frame is constructed of 1.5 inch aluminum square tubing and is 28 x 24 inches. The scissor links are each 0.5 inch thick aluminum and are 25 inches long by 1.5 inches high. The back of the links are held in place with a bolt in a 0.5 inch hole in the top and bottom frame, while front of the links slide along a track in the top and bottom frame, also with a 0.5 in bolt. Welded within the top frame are two large aluminum cross bars to support the weight of the platform above. On top of the top frame is a 28 x 24 inch thin aluminum sheet to cover any gaps below the platform. A 12 inch turntable is bolted onto the cross bar supports and the diamond plated top platform is bolted to the turntable. The platform is 0.1875 inch thick aluminum and has rounded corners so that they do not protrude as the platform is turned. A small bar prevents the turntable to turn more than 90 degrees. Welded on top of the platform are two tracks to guide a walker onto the platform, and two clips to clip the front legs in place. Also, two buckle straps are able to tighten the back of the walker in place. There are four wheels on the side of the frame so that the device may be tilted on end and moved anywhere like a suitcase. Finally, on the lower frame, a pocket has been milled out to hold a hydraulic jack that pushes up the platform. On the back of the hydraulic is a handle for easy pick up and movement. The hydraulic is connected to the bottom of the links with a quadruple reinforced bar. The assembly is able to distribute the force to ensure that the system does not bend. When fully compressed the device has a height of 3.5 inches and can rise to 14 inches.

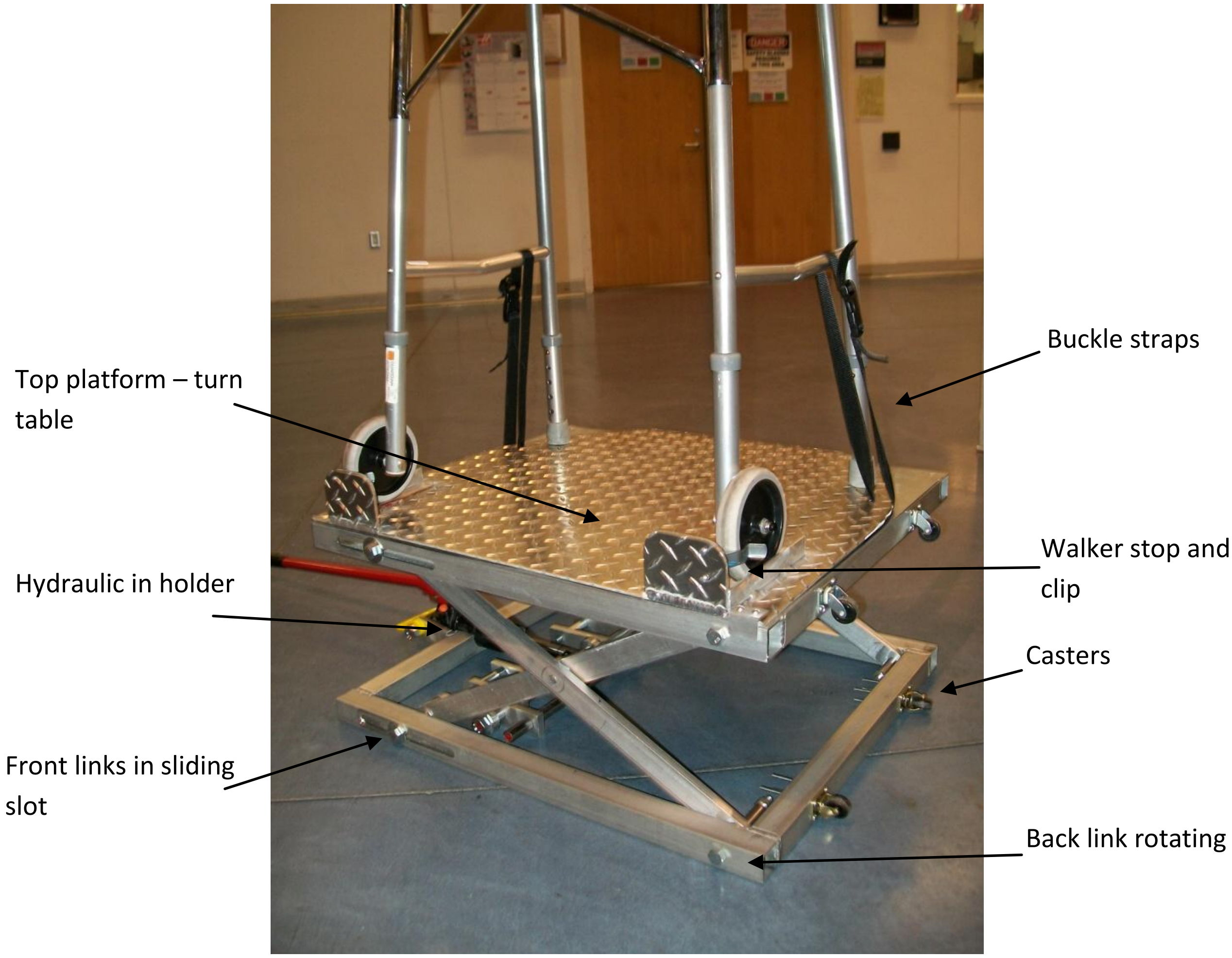

Figure 12 - Picture of final design, shown with walker strapped in place and slightly raised.

The dynamics of the design are simple and follow standard scissor lift mechanics. Figure 13 shows a side view with various design aspects labeled. The scissor links are bolted at position A so they can freely rotate as the platform lifts. The free ends of the links are in slots in order to slide smoothly and be secure. The arrows show that as the free ends move inward, the platform rises.

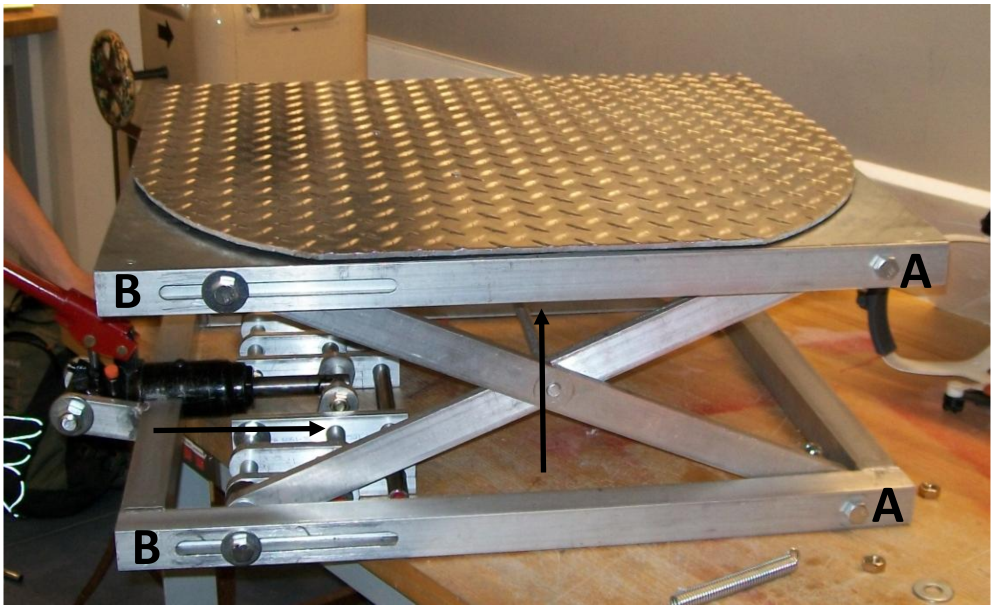

Figure 13 - Side view of device to show movement.

The device is made mobile by placing wheels on the side. By tilting the device on end, it can easily be pushed around and stored in a vertical position. To use the device, place it directly next to the exam table, with the turntable parallel with the bed. The nurse will help the patient out of their wheelchair with the aid of the clinic's walker. With the aid of the walker and nurse, the patient will step onto the platform. The nurse will secure the walker with straps and lock the front with clips. Slowly, the nurse will turn the patient so that their back is facing the bed and they are supported by the walker in the front. The nurse will use the hydraulic pump to raise the platform to a height that easily allows the patient to sit down onto the table. Then, to return the patient to ground level, the nurse will open the release value and the platform will lower slowly.

Device Testing

Since the device was designed to repeatedly lift patients, it was necessary to assess the framework integrity in the static state. After assembly, the device was loaded with various weights to observe how the aluminum frame withstood the weight. The device was loaded with 120, 150, 180, 270, 330, and approximately 450 lbs. The frame remained intact during the loading, fulfilling the safety factor requirement.

To observe functionality, the device was dynamically loaded with various weights as it was simultaneously raised and lowered. The device was first tested with no weight. It was then loaded with 25, 50, 120, 150 and 170 lbs. It failed when loaded with 170lbs, bending part of the bottom frame slightly when it was in its lowest position. It was determined however, that if the platform was raised slightly before heavy loads were applied, the frame would not deform as the device was lifted. It was hypothesized that the frame failure was largely due to the pocket used to house the hydraulic cylinder.

Because the pocket was so large, the strength of the frame near the hydraulic actuator was significantly decreased. This problem could be easily solved by reinforcing the frame in that area or by using a smaller hydraulic actuator.

In the future, there is much testing that could be done. It would be useful to determine if the calculated stress values are accurate and the assumptions are valid. To accomplish this, strain gauges could be mounted to the areas with the greatest stress. The measured strains could then be compared to the calculated values. The results could be used to determine if the device is safe for repeated use in a clinical setting. Finally, an updated SolidWorks model could be made. This model could be used to conduct stress testing so that any additional weak points could be located and tested further.

Future Work

The device is quite aesthetically pleasing, but mechanically there is plenty of room for improvement. Before any more prototypes are made it is essential that we use strain gauges in testing to determine how accurate our approximations and assumptions are. Once we have this data, we can adjust our device to optimize the structure size and weight—ideally make it less than a 3 in. step for patients. The first change that will be made to the design to accomplish this will most likely be changing the hydraulic system. The main issues with our current design all originate with how we transfer our force from the hydraulic cylinder to the cross-links. Incorporating two smaller hydraulic cylinders would eliminate the issue of bending the hydraulic crossbar. This solution would require development of a unique hydraulic system for the design in order to fit it entirely within the frame.

Enhancing the force transfer between the hydraulic system and the cross-links will go a long way to making a smoother ride, but to help overcome the initial jolt off the ground as the hydraulic system overcomes the static friction present in the device dampers will be incorporated. The team has already located a couple dampers that can fit inside the frame that might minimize the sudden acceleration upward.

Additionally, the team is interested in automating the device. The client originally requested the device to incorporate some sort of a foot pump, but by eliminating the foot pump there is more potential to make the device easy to store, with every component fitting inside the frame. The automation would also include an automated rotation of the top platform, making for a much smoother turn for the patient.

Conclusion

Overall, the design team was very pleased with the outcome of the semester. Though the device will not yet be implemented in the clinical setting, the prototype is a sufficient proof of concept. In the end, the device maintained a low step profile, an acceptable NIOSH lifting rating, a compact, mobile design, and a reasonable lifting capacity. Initial testing determined that the design was unable to handle the maximum weight capacity, but after a complete testing procedure, the team will be able to analyze the structural deficiencies within the frame and modify them to achieve higher weight capacities.

Additionally, the instability and friction within the design can be addressed in order to produce a medical lifting device that lives up to the client's safety requirements. The team hopes to continue this design in future semesters to produce a usable clinical device to fully meet the client's specifications.

References

In text:

[1] Abate M, Di Iorio A, Di Renzo D, Paganelli R, Saggini R, Abate G (September 2007). Frailty in the elderly: the physical dimension. *Eura Medicophys* 43 (3): 407–15.

[2] http://www.phc-online.com/Hoyer_Lift_Supply_s/44.htm

[3] http://litegait.com/md.html

Figures:

[4] http://www.corpmed.com/images/patient-transfer.jpg

[5] http://dehanmedequip.com/images/electric%20hoyer%20lift.jpg

[6] http://litegait.com/md.html

Appendix A – Budget

The total costs for the project materials are summarized in the table below:

BME Project Costs

Item	Location	Quantity	Price
Aluminum tube	McMaster-Carr	3	$102.75
Aluminum bars	McMaster-Carr	4	$63.24
Turntable	McMaster-Carr	1	$12.25
Shipping			$13.00
Car Jack	Harbor Freight	1	$26.36
Diamond Plate Aluminum		1	$70.99
Misc	Home Depot		$87.63
Nuts			
Washers			
Bolts			
Stock Aluminum			
Rods			
Misc	Home Depot		$39.22
Bolts			
Nuts			
Rods			
Misc	Home Depot		$32.14
Bolts			
Nuts			
Misc	Ture Value		$11.35
Wheels			
Bolts			
Nuts			
Misc	Ace Hardware		$16.41
Straps			
Wheels			
Aluminum Bar	McMaster-Carr	1	$15.81
Shipping			$4.75
Total			**$491.15**

Appendix B – Product Design Specifications

Assistive Transfer Device Product Design Specification (PDS)

5/5/10

Function: Develop an assistive device to safely transfer patients from wheelchairs to exam tables. Patients will be able to stand on or hold the device while simultaneously being lifted and rotated into position on the exam table. The design will reduce physical exertion by the patient or medical personnel.

Client requirements:

- Small base , able to fit through door-way / easy storage
- Lift a max of 300 lbs
- Simple to operate; automated or manual
- Easy to sterilize
- Mobile in clinical setting
- Avoid in-air suspension of patient
- Cost-effective
- Reduce patient anxiety during transfer

Design requirements:

1. **Physical and Operational Characteristics**
    a. *Performance requirements:*
        i. 3-5 minutes per lift
        ii. 10-15 lifts per day
        iii. Handle loads up to 300 lbs
        iv. Lift to height of 15 in
        v. Rotate patient 90°
    b. *Safety:*
        i. Safety factor of 2 – lift 600 lbs
        ii. Few pinch points
        iii. Stable
        iv. Slow, constant raising and lowering rates
        v. Lockable turntable
        vi. Attachable walker for support
    c. *Accuracy and Reliability*
        i. Consistent performance
        ii. Does not let patient slip, tip, or fall
    d. *Life in Service:*
        i. 10 years

        ii. Approximately 50,000 cycles
    e. *Shelf Life:*
        i. Oil joints
        ii. Replace hydraulic fluid
        iii. Non-corrosive
    f. *Operating Environment:*
        i. Room temperature
        ii. Used by nurses
        iii. Possible human fluids
    g. *Ergonomics:*
        i. Intuitive use/interface
        ii. Patient comfort
        iii. Non-abrasive materials
        iv. Minimal operator effort (<20 lbs)
    h. *Size:*
        i. Less than 3 ft wide (approximately 25 x 28 in)
        ii. Less than 4 in height when compressed (initial step height)
    i. *Weight:*
        i. Able to be moved on wheels
        ii. Less than 50 lbs
    j. *Materials:*
        i. Prototype – Steel, Aluminum frame
        ii. Casters
        iii. Canvas
        iv. Hydraulics
        v. Polymers – acrylic, Plexiglas
    k. *Aesthetics, appearance, and finish:*
        i. Paint – Blue
        ii. Safe appearance

2. **Production Characteristics**
    a. *Quantity:*
        i. *One prototype this semester*
    b. *Target Product Cost:*
        i. Less than $500

3. **Miscellaneous**
    a. *Standards and Specifications:* FDA approval
    b. *Customer:* Hospitals, clinics, nursing homes
    c. *Patient-related concerns:* Elderly, frail patients
    d. *Competition:*
        i. Hoyer Lifts
        ii. EZ way
        iii. Litegait