CHAPTER 13
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WHISPERLIFT INTEGRATIVE SEATING ENVIRONMENT

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INTRODUCTION

Our client has arthrogriposis multiplex congenita, a condition often manifested by missing muscles and ankylosed joints. She is able to walk, but has difficulty getting into or out of standard classroom seats. Elevating her hands to a school desk to manipulate writing instruments and books tires her because she must contort her body to use the standard seating and desks at school.

We designed a battery powered elevating seat that she can sit on and adjust independently. This gives her better access to desktops and computers. The seat has wheels so that she can take it from classroom to classroom. However, the design prevents rolling whenever the seat is elevated.

An additional problem is book and pencil retrieval. Most students carry these in backpacks that they either place beneath their desk or hang from their chair. Once seated, our client must ask a teacher or classmate to retrieve the correct item for the current activity. This design also includes a book and pencil holder that the client can load before she sits down. This fastens to the desktop within her reach when she is seated.

SUMMARY OF IMPACT

Our client liked the chair immediately. She enjoyed that it looks similar to other school chairs, and that its operation is quiet and unobtrusive. The control interface is intuitive and simple, so that both the client and teacher could operate it immediately. Its onboard battery permits operation away from electrical outlets.

The client is able to move this system between classrooms by herself. She no longer has to sit uncomfortably to write on the desk surface or use a keyboard at a computer. When she first used the

Fig. 13.1. Whisperlift chair with control cable.

Fig. 13.2. Book and pencil holder.

chair, her teacher said that it was the first time he had seen her sit with her back straight. The school

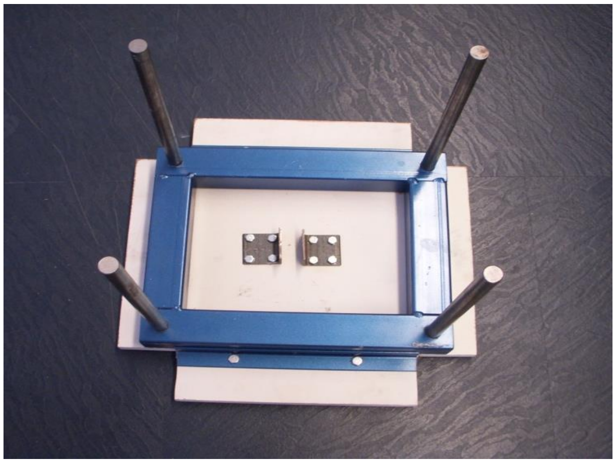

Fig. 13.3. Baseplate with guide rods.

supply holders have also increased the client's independence as they keep her school materials within reach at all times.

TECHNICAL DESCRIPTION

The lifting chair uses a standard school chair mounted on a wooden frame. Within the wooden frame is a guide system consisting of four 1" metal rods. These rods fasten to a metal plate that is, in turn, fastened to the plywood baseplate. This restricts baseplate motion to one degree of freedom relative to the chair frame.

Centered in this assembly is a linear actuator originally designed for hospital beds. This actuator has a 150 mm stroke and a 4000 N force capability and includes a controller and integral battery.

The chair has two modes: mobility mode and lifting mode. The mode is dependent on actuator position and requires no operator action other than to control the single actuator. The chair is in the mobility mode when the actuator is retracted. The baseplate is lifted from the floor and all the weight is on the four caster wheels. These permit the chair to be rolled from place to place.

In the lifting mode, the actuator extends the baseplate to the floor. This puts the weight of the chair and occupant on the baseplate, lifting the chair and its caster wheels from the floor. In this mode the chair won't rotate or move laterally, but its height is continuously adjustable.

Fig. 13.4. Chair in lifting mode.

Fig. 13.5. Chair in mobility mode.

The supply holders are made from wood and a commercially available desk pencil holder. Toggle clamps reversibly attach it to a desk or tabletop, permitting transfer from one desk to another. Moving supply holders along with the chair can create complications, so two tailor-made ones for the classrooms our client uses most were constructed.

The cost of materials and supplies of this design is $900.

ALL-TERRAIN TRANSFER DEVICE WITH DETACHABLE SEAT

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INTRODUCTION

The purpose of the Louisiana Outdoors Outreach Program (LOOP) is to provide a unique hands-on experience to educational and recreational outdoor programs, activities, and services to underprivileged youth. One activity is a canoe trip for students from local schools. Difficulties with students with limited strength, mobility, or motor control arise in three specific areas: 1) when transferring between a bus or van and the canoe, 2) ingress and egress from the canoe, and 3) seating support within the canoe.

The launch site terrain is often too steep, rough, and muddy for ordinary wheelchairs to easily traverse. Lifting the students to place them into the canoe strained the backs of the staff. Often additional staff would be required to support and stabilize the student continuously during the ride.

The All-Terrain Transfer Device (ATTD) addresses these main concerns. It is a wheelchair with two major parts: a wheeled base and a removable seat with trunk and leg support. The wheeled base permits transport over rough or soft ground. The seat provides grips for the staff to hoist the seat with the student from the base to the canoe. The seat provides back support and stability for the student during the canoe ride.

SUMMARY OF IMPACT

With the new ATTD system, the staff is no longer required to carry the clients to the canoes or support them during their canoe ride. This reduces physical strain on the staff while simultaneously giving the clients more freedom and independence. Ease of transfer into and out of the canoe is also enhanced by the provision of lifting handles.

Fig. 13.6. All-Terrain Transfer Device.

Fig. 13.7. Staffer demonstrating seat portion in a canoe.

The seat itself requires no fastening in the canoe. For safety and convenience it will float in water. It easily accommodates the mandatory life jackets. The low profile of the seat permits paddle use. An added benefit is the seat's portability for use during picnic stops during the ride.

TECHNICAL DESCRIPTION

The ATTD consists of two major components: the wheeled base and the chair frame. The wheeled base, shown by Fig. 13.6, contains the all-terrain wheels on a rectangular wooden frame, handles for pushing the device on land, and a place to hang the wheel chocks. The chocks are a simple and obvious way to keep the base from rolling on a slope.

The base is a simple wooden frame made from 2" x 4" and 2" x 6" (nominal) stock. The joints are fastened with carriage bolts. Uprights in the rear support handles that are convenient for pushing. The frame has a crosspiece and lugs that engage with the seat. This prevents improper placement of the seat on the base and provides a secure fastening so that the seat will not slide off the base during transport. Both the base and the seat are marked with orange cues to help guide proper alignment when the seat is being placed on the base. The front two wheels are fixed, but the rear two roll on casters. This provides adequate maneuverability and far better steering than having all four wheels on casters.

Fig. 13.9 shows the seat. The bottom and back are pieces from a commercially available deck chair with the frame removed. These are secured in a frame made from 2" x 2" wood members.

The seat structure contains a leg rest that supports the legs during transport and transfer, so that legs don't bump into obstructions or get caught beneath the seat.

Fig. 13.8. Wheeled base with chocks in storage position.

Fig. 13.9. Seat portion of transfer device.

Nylon rope loops attached to the frame allow for seat lifting by the staff. These loops are an improvement on the originally designed rigid lifting handles because they are lighter and fold out of the way between lifts. PVC pipe (1.5") forms the handles on each. They are filled with polymer foam to provide buoyancy and to keep them from slipping on the rope.

EVACUATION COT DESIGNS

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INTRODUCTION

A local nursing home has an evacuation plan to transfer its residents and emergency staff to a remote site, a church gymnasium. The home had over a hundred trundle beds for the residents for the evacuation for Hurricane Katrina. This was a very stressful event complicated by the beds themselves. Problems with the beds include that they are low to the floor requiring the staff to bend or kneel to service the residents, and would tip over if a person were to sit on the edge. The legs also sometimes fold, collapsing one end of the bed, and the beds are also unable to accommodate the various necessary head elevations for many residents.

The home is concerned about large costs in replacing all the existing beds. Designs need to be cost effective and repeatable by the facility staff using their technical knowledge and skills and available tools and materials.

This design includes a two-part solution. The first part is a modification of the existing trundle beds to make them more safe and usable. The second is a modification of a commercial cot that has head elevating capability. For each of these, manuals and templates for the staff to use in making the modifications are included.

Existing cot stability is enhanced by removing the original caster wheels and replacing them with 2" x 3" wooden feet. These extended the legs to the full width of the bed stabilizing it so that weight put on the edge of the bed no longer overturns it. The feet also add to the height of the bed, raising the patients to a more comfortable position for the staff to give proper care.

A commercial folding cot with head elevation capabilities is used for that requirement. Handrails are added to ensure safety for use by the facility's residents on feeding tubes.

Fig. 13.10. Modified trundle bed showing new feet, wing nuts, and bungee cord.

SUMMARY OF IMPACT

Many of the residents have sufficient mobility to get into and out of bed independently, and the staff generally encourages this. When the beds tipped or collapsed, there was the danger of injury, so independence was discouraged during the evacuation. The bed modifications alleviate this problem.

The simple modifications to existing cots for the head elevation requirement are a perfect solution. Upon presentation, Professional staff and administrators stated "This is great. It meets all our needs."

This two-part solution is also economic for our clients.

TECHNICAL DESCRIPTION

<u>Modification of the Existing Bed</u>

When deployed, the existing trundle bed measures 74" x 31" by 11" high. It has casters on the center two of four legs for ease of transport when folded, and they are inset a half foot from the edge of the bed.

Fig. 13.11. Modification of the new cot.

Fig. 13.12. Rail attachment hardware.

Fig. 13.13. Portion of template for shaping the bed rail. The rail is shown in black.

The stability of the bed is improved by removing the center casters and adding wooden studs to provide feet on all four legs (Fig. 13.10). These feet, made of 2" x 3" stock are attached using hanger bolts through existing holes in the steel frame. Lock washers and wing nuts allow the feet to be secured without the use of tools. The addition of these feet, along with the home's selection of a thicker mattress, raises the bed to a more comfortable height.

To prevent the collapsing of the legs at the head and foot of the bed, eyelet screws are attached to the wooden studs and a bungee cord wrapped around the frame is secured by the eyelet screw. This, plus the removal of the casters on the center legs, reduced the tendency for the legs to fold under.

Casters are added to the sides of the center feet to enable rolling of the bed when it is folded. These casters do not touch the floor when the bed is deployed.

An instruction manual is included so the staff may assemble, disassemble, or alter the beds as needed.

The parts for modification are $27.30 per bed.

Modification Of The New Cot

For the head elevating feature required by the tube-feeding residents, the MedSled Products Surge Cot #4 is used. It has a built-in adjustable head elevator, low maintenance requirements, is not excessively expensive and is collapsible for storage. Its design includes feet on the outside four corners, so it is inherently more stable than the original trundle beds. It accepts the home's preferred mattress, and its dimensions (78" x 32" by 18") make it suitable for both the residents and the staff.

Our design requires no mechanical modifications to the cot itself. Since the design of the cot makes it difficult to change the head elevation while the bed is occupied, a nylon strap that would operate the latch of the elevator mechanism, while the staff member was supporting the head frame, is included in the design. This modification makes changing head elevation of a patient quick and easy for a single staff member.

This cot lacks one important feature: a side rail that the residents may use as a handle for sitting up or stabilizing entry or exit from the bed. A rail of 1" PVC pipe that can go on either side of the cot is also included. The PVC rail is stiff and strong enough for this application. The rail attaches to the frame using standard piping support hardware. In order for the staff to replicate the rail, a full-sized wooden template that holds the piping in shape is included. The commercial cot lists at $189.95, and the cost of the parts required to adapt each cot is $20.23, for a total of $210.18 per unit.

COMPACT LIFT DEVICE WITH RECUMBENT SLING

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INTRODUCTION

Our client has quadriplegia caused by spinal injury. He is usually assisted by family members who are unable to lift him without a hoist. He wishes to travel with his family using several modes of transportation, but the lack of a suitable lift for transfers hinders the process. He requires a lift that can be easily transported by both private and commercial vehicles. Since his power chair is semi-recumbent, he needs a sling system that enables him to remain recumbent during a transfer.

Most patient lifts are too heavy and cumbersome to transport easily. Those that are light and collapsible do not accommodate our client's size and sling constraints. Fig. 13.14 shows our lift design. The structure is similar to a Hoyer lift, but we added two major features: a hinge on the base of the mast enables the mast to fold between the support legs, and an angled boom that curves around the hydraulic jack during stowage.

Maintaining recumbence during transfer requires a new sling and cradle design (Fig. 13.15). The design includes an 8-point adjustable cradle system and a two-part sling. Having the sling in two parts makes it easier for the caregivers to place it under our client. Each sling part has four suspension points for good stability. The two parts clip together for safety and comfort during transfer.

SUMMARY OF IMPACT

This system design meets the goal of enabling our client to use both private and commercial transportation. Weight and size of commercial lifts preclude easy transport by air or automobile as well as difficulty in handling them between transport modes.

This system enables the family to lift and transfer our client as needed. The system folds and stows without tools. In the folded position it meets the weight and size limits for checked luggage on airlines. Further, it rolls easily on its casters and can be lifted into an automobile by one person.

Fig. 13.14. Computer rendering of the collapsible hoist frame in both its stowed and deployed configurations.

TECHNICAL DESCRIPTION

The lift device uses a combination of 2" x 2" x 3/16" square aluminum tubing for the main structure. Steel components are fabricated from 1/4" plate and 2.5" x 2.5" x 3/16" square tubing. The steel components connect the structure and provide attachment points for casters, the hydraulic jack, and other rigging and attachment points. All hinge joints (leg swivels, mast to base, and boom to mast) are fitted with 1/4" hitch pins as axles. Removable, ball-detent hitch pins lock in place each of these hinges. The metal framing provides a strength factor of safety of 3 for our client.

The wheels support the load with a large safety factor, yet have a profile low enough to fit under our client's wheelchair and most commercial beds. The wheels at the tips of the legs swivel, but those beneath the mast do not.

Standard 80/20 T-slot aluminum extrusions and hardware, widely used in industrial prototyping, form the frame of the cradle. A shop specializing in awning manufacture fabricated the sling. A commercially available hand operated 2-ton hydraulic jack with 15" travel provides the lifting force.

An eye-bolt at the tip of the boom with a heavy duty quick connect chain link permits connection of the cradle to the lift.

When folded, the lift will fit into a 20" x 12" x 60" volume. This meets the common length limit of 62" for checked luggage. Fabrication largely with aluminum permits meeting the weight limits.

The overall cost of the system excluding labor is approximately $700. This includes the sling ($150) and jack ($80).

Fig. 13.15. Hoist with cradle in its folded or travel configuration.

Fig. 13.16. Team members demonstrating the hoist and sling. Note the 8-point sling cradle and the straps connecting the two parts of the sling.

HYDRAULIC CHANGING TABLE

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INTRODUCTION

A local elementary school has several students who need special care including diaper changing and other hygienic procedures. These students spend significant time reclining on floor mats. This makes it difficult for the staff that must either lift the students onto a changing table or service them while they lie on their mats.

This design focuses on a changing table and transfer system to make it easier for both the staff and the students to accomplish this task. A commercial lift table with a foot powered hydraulic jack forms the mechanism of the changing table. The top and base of the table are lengthened and provided with a mattress pad and safety rails.

The mattress pad is stiffened internally along its edges with PVC pipe and provided with pull straps (Fig. 13.19). This allows the mattress to serve as a transfer pad. For lifting from the floor, the student is slid onto the transfer pad. Then the transfer pad is slid onto an air mattress. Inflating the air mattress raises the student to the lowest height of the changing table. Pulling the pad from the air mattress to the lift is a simple lateral transfer. Then the lift is pumped to a height convenient for the staff. This procedure is reversed to place the student back on the floor.

SUMMARY OF IMPACT

The device is used primarily for one student, a 14 year old boy with severe disabilities. He cannot ambulate or sit without support. He generally lies on a floor pad throughout the day. With the new system, his aides no longer have to stoop or kneel to change him. They also found that, until he gains more weight, that our transfer pad may be used directly between his floor pad and the changing lift. In addition, the changing table's wheels provide for easy transport from room to room and to evacuate in case of emergency.

Fig. 13.17. Team members demonstrating changing table in its raised position.

Fig. 13.18. Table in lowered position.

At home, the student plays in an oversized infant's playpen. The student's mother would like a similar table that she can use at home.

TECHNICAL DESCRIPTION

The lifting table is modified from the Hydraulic Scissor Table Cart (Model 93116, Harbor Freight Tools, Camarillo, CA). This table is rated to lift 1000 pounds from 11" to 34.5". The table rolls on 5" casters.

The original table width and length is 20" x 32". This is extended to 72"L x 30"W. Two 2" x 2" 11 gage lengths of steel structural tubing were cut to 69" each and fastened to the 2.125" metal skirt of the existing table top using four 5/16" steel socket-head bolts each. A Samsonite Premium Commercial folding table top (Mfr PN CSC36170PTS1-36170PTS1-1) is fastened to the steel extensions via four 5/16" steel socket-head bolts.

For stability, two lengths of the 2" square steel structural tubing are cut to 61" and affixed to the lower rolling frame of the existing cart using five 5/16" black steel socket-head bolts each. To relocate the fixed casters of the original cart, a 29" length of steel tubing is fastened to the upper surface of the lower metal extensions with two 1/2" bolts. 1/8" thick metal plates are cut and welded to the lower surface of this 29" metal crossbar to serve as mounting surfaces for the fixed casters.

To eliminate play in the existing scissor-legs and cope with the added moment produced by increasing the table overhang, the scissor tracks are bolstered using metal inserts. The upper tracks are reinforced with 1/8" thick 1" x 1" angled black steel fastened to the inside of the track via five countersunk #8 bolts each. The lower tracks are reinforced using 1" wide 14ga Aluminum flat-bar bolted to the lower surface of the track using four #8 bolts each.

For safety, three 1" x 6" Douglas fir planks serve as railings along the tabletop edges. Two are fixed. A third side is fastened to the tabletop using four heavy duty hinges bolted through the table. This side is able to fold 180 degrees to increase access to the table surface during transfers. It is held in the

Fig. 13.19. Fold-down side rail with gate latch

upright position by a heavy duty universal gate latch. A small pin is mounted to the hinged plank and a self-latching hitch mounted to the nearest fixed railing receives the pin as the hinged plank reaches the upright position. The latch is located to be within reach of the operator and not easily accessed by someone on the table surface.

A 2" thick vinyl covered foam mat is modified as follows. Two lengths of schedule 40 PVC are hand-sewn to the inner seams of the vinyl covering. Nylon straps are fastened to the PVC and extended through the vinyl covering to the opposite side, under the other length of PVC and through the opposite seam. They then loop back through the seam and return to attach to the original length of PVC. This forms the handles of the continuous nylon strap. The same is done for the opposing side. When in tension, the nylon straps tighten and transfer forces to the PVC opposite the handles in tension. Reactionary forces cause the PVC to move upward and in the direction of tension, forcing the vinyl mat to "cup" slightly. This action makes sliding the mat easier, and "hugs" the student more securely in place while the straps are pulled.

The air mattress and pump are standard and are available commercially.

The cost of replicating this design is $860, excluding labor.