CHAPTER 9
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TREADMILL TRAINING FOR CHILDREN WITH DEVELOPMENTAL DISABILITIES

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Client Coordinators: Charlie Gaddy Center
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INTRODUCTION

Children with cerebral palsy (CP) and other developmental disabilities typically receive physical therapy to facilitate motor development, enhance their independence, and maximize their potential. CP is a heterogeneous condition, encompassing a broad spectrum of developmental disabilities resulting in abnormal development of movement and postural control. As a result, a variety of treatments have been developed to either "normalize" the child's gait, a manner of walking or moving on foot, or to help the child develop a gait that will be the most efficient for that child. For the child with spastic cerebral palsy who is just beginning to walk, the objective is to counter or minimize the negative long-term effects of spasticity and weakness that prevent the greatest degree of independence. To overcome this problem, therapists generally try to emphasize balance training and gait preparatory tasks during crawling, sitting and standing.

Treadmill interventions with and without a harness and counterweight system have been used for children with Down Syndrome and CP. In both diseases, children learn to walk later than children without disabilities. Treadmill intervention without a harness and counter-weight system helped children learn to walk on average 100 days earlier than they would have otherwise. With a counterweight system, children showed improvement in gross motor function within three months.

This project addresses the current problems with existing commercial treadmill/harness systems. These systems are expensive, have limited ability to adjust load-bearing, and have handle bars which teach children a negative habit of supporting themselves with their arms while learning to walk. This design is significantly less expensive, provides a more adjustable load-bearing system, and eliminates the unwanted handlebars (Fig. 9.1).

Figure 9.1. Treadmill Training System

SUMMARY OF IMPACT

Once acclimated, the children involved will enjoy this method of therapy. It is fun for them and encourages them to walk, as opposed to previous methods of treatment, with which they lost interest quickly. The device also makes it easier for the therapist to support the walking child. Working without the harness system is awkward and tiresome for the therapist who must bend over the child and hold him up. The harness allows the therapist to concentrate on facilitating the movement of the child's limbs without having to worry about supporting the weight of the child or controlling the direction of walking.

TECHNICAL DESCRIPTION

The device consists of an aluminum frame spanning a horizontal treadmill. The frame is constructed of two-inch square aluminum tubing. The dimensions are: height 68 inches, width 36 inches, base 30 inches. Two 45 degree trusses span the vertical legs and top horizontal bar. The harness is suspended from the two trusses.

We developed two methods for suspending the harness. The first method is a counterweight system, involving a system of pulleys and a 10L Ballast Bag to offset a portion of the weight of the child. The components are referred to in lines 8-15 of the list of materials shown below.

The second method is a bungee cord system in which the cords attach the harness to the two trusses on the frame. The number of bungee cords used determines the amount of load that the child must bear. The more cords used, the less weight supported by the child. Load testing was performed on the cords to develop a mathematical relationship between the force and the change of length of the bungee cord. The components are referred to in lines 16-18 of the list of materials.

After testing, the second method using the bungee cords proved to be more practical. It is easier to connect the harness to the frame, adjust the force supporting the child, and put the equipment away for storage. The length of the cords is measured before the child is in the harness and directly after the child is in the harness to get the total deformation to calculate the force. When this support system is used in conjunction with the treadmill, we are able to measure such parameters as velocity of treadmill, child's step length and number of steps, and distance traveled. The specific parts included in the frame are shown in Figure 9.2.

The approximate cost of the project is $700.

Line	Level	Part Name/Description	Qty.	B/M*	Material Code
1	1	Treadmill	1	B	
2	2	Teekoz Harness	1	B	
3	1	Frame	1	M	Aluminum
4	2	2" Aluminum Square Tubing	33 ft.	B	Aluminum
5	2	2" OD Square Vinyl Caps (pkg 25)	1	B	Polyethylene
6	2	Teekoz Harness	1	B	
7	2	Eye Bolt	2	B	Galvanixed Steel
8	2	Pulley System	1	M	
9	3	1/2" Galvanized Cast Iron Sleeve	2	B	Cast Iron
10	3	1/4" Solid Braided Polyester Rope	50 ft.	B	Polyester
11	3	1/4" Swivel Latch Hook Pulley (2-1/2")	1	B	Zinc-Plated Steel
12	3	Open Pattern Galvanized Steel Thimble	2	B	Galvanized Steel
13	3	Fibrous Rope Clamp	2	B	Molded Nylon
14	3	Safety Snap	1	B	Zinc-Plated Steel
15	3	10 L Water-Filled Ballast Bag	1	B	1000-Denier Cordura Nylon
16	2	Bungee Cord System	1	M	
17	3	Adjustable Plastic Hooks	20	B	Plastic
18	3	5/16" Shock Cord	50 ft.	B	Bungee Cord

*B/M = Bought or Manufactured

Figure 9.2. List of Materials.

ELECTRICAL SWING FOR CHILDREN WITH CEREBRAL PALSY

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INTRODUCTION

A center provides a year-round educational and therapeutic program for children from infancy to five years old with cerebral palsy. Since there are only a small number of teachers at the center, devices are needed on the playground that allow children with physical limitations to participate in play activity with minimal assistance. An electrical swing was designed to allow children with disabilities to experience swing motion with little assistance.

SUMMARY OF IMPACT

This device allows teachers at the center to limit the amount of time associated with pushing children in the swings by activating a power switch that turns on the swing. Once the swing is given an initial push, the swing will move forward and then backward in a continuous motion. This device integrates swing motion and adapts basic swing design to accommodate children with cerebral palsy and various other disabilities.

TECHNICAL DESCRIPTION

The major laws concerning the swing design were based on North Carolina state statutes that became effective in April 2001. These statutes directly reflect standards set by ASTM. The main design requirements for the swing included a sturdy frame in which the swing supports were attached to the frame two feet apart. Each swing support had to be two and a half feet from the end of the frame. Other requirements included: 1) swing seats should be made of plastic or soft flexible material, 2) the edges of swing seats should have smoothly finished or rounded edges, and 3) protective pillows should be added to the sides of the swing seat to secure the child's head (Fig. 9.3).

Figure 9.3. Design Team with Electrical Swing.

The electric swing has two major components, the swing seat and the motion structure. The base of the motion structure consists of rectangular one-inch square tubing (Fig. 9.4). A limit switch is mounted on the square tubing, and the tubing is attached to the swing frame, already present at the center, by two 5/16-inch U bolts. Also attached to the rectangular tubing are two J-bars that support two tubular solenoids. Two roller bearings are also attached to the bottom of the square tubing to support the structure. A rotating bar passes through the two roller bearings to add motion to the swing. Circular sprockets are attached on each end of the rotating bar. Two shaft collars are attached to the rotating bar in between the two roller bearings. The first collar has a protruding peg that is connected to two solenoids by a three bar linkage made of hinges. The second collar has a protruding peg that activates the limit switch. The second collar also has a thumbscrew, which allows the shaft collar to be adjusted easily.

The swing seat consists of a GRACO car seat with various modifications. The seat is a hard plastic structure with a locking clip, harness strap, harness buckle, crotch strap, and crotch buckle. A red vinyl weather resistant covering was added to the exterior of the seat to add cushioning and make the seat waterproof. The original five-point restraint system in the original seat is reduced to a three-point restraint system that consists of a center locking seatbelt and harness. A vinyl covered bobby pillow is also added to the chair to reduce head movement and is attached to the chair at the shoulder restraints. Two braces are added to the bottom and back portion of the to chair support the seat. Two ¾- inch pieces of square tubing are attached on both sides of the back brace of the chair and are connected to the sprockets on each end of the rotating bar. A 1/8-inch piece of flat stock connects the bottom brace to the square tubing at a predetermined angle.

Once the swing is given an initial push, the peg on the first collar hits the limit switch. When the limit switch reaches a certain position it changes state (normally open to closed) and allows the current to pass through and activate the two solenoids. The activation of the solenoids pulls the activating peg from the first shaft collar and causes the swing to pull back, thus providing continuous motion.

The total cost of materials and supplies was about $350.

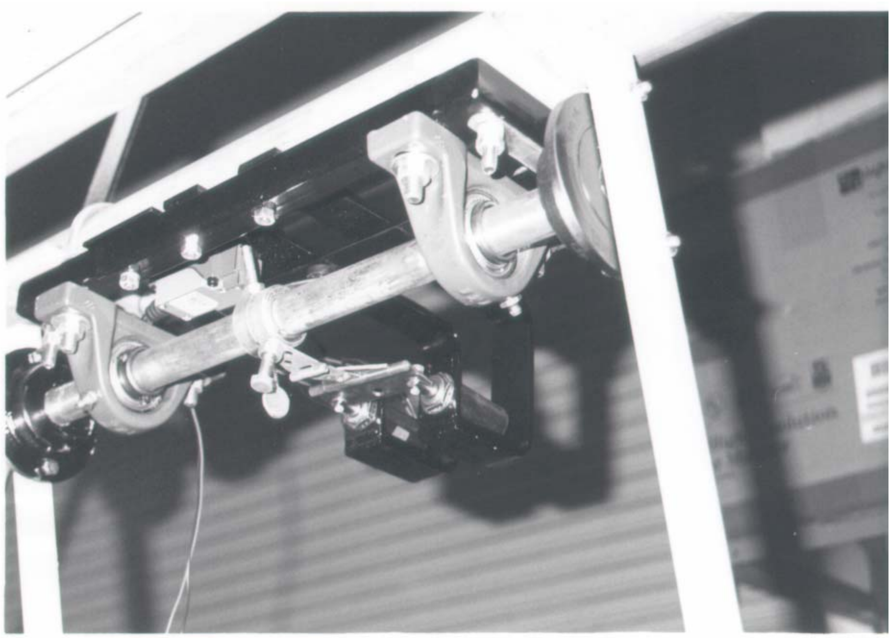

Figure 9.4. Motion Structure for Electrical Swing.

FULLY AUTOMATED POWER WHEEL WITH SEATING HARNESS

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INTRODUCTION

The purpose of this project was to modify a Fisher Price Power Wheel to accommodate pre-school aged children with cerebral palsy. Modifications made the Power Wheel more adaptive for a child with difficulty reaching, limited muscle use, and mental retardation. Specific modifications made in this design include: (1) new seating with seatbelt for additional support, (2) removal of an extraneous light bar for easy entrance, (3) addition of a gear motor to control steering, (4) replacement of a steering wheel with an adjustable tray table, and (5) adaptation of a joystick.

SUMMARY OF IMPACT

The major goals of this design included: (1) safety considerations for a child with cerebral palsy, (2) inexpensive modifications, and (3) appearance to appeal to the child. This modified Power Wheel will make it possible for children with cerebral palsy to participate in one of the play activities enjoyed by children and will increase their sense of independence.

Figure 9.5. Modified Power Wheel.

TECHNICAL DESCRIPTION

The modifications involved converting manual steering consisting of a steering wheel and forward/reverse motion with a foot pedal to joystick control. The torque exerted on the steering shaft to turn the Power Wheel under standard conditions was determined to be 19 inch-pounds and the gear motor was sized accordingly. The gear motor was linked directly to the standard steering mechanism and wired to the joystick. Switches were used to limit the rotation of the wheels.

The frame of a standard joystick was used to create a new joystick with a distinctly different design. Instead of using potentiometers, as is standard in joysticks, snap action switches were used to control the voltage across the steering and drive system motors. The switches were mounted on a polyethylene plate. The joystick was housed in a modified, watertight plastic box.

A tray table was constructed for easy access to the joystick. This tray was made of PVC and a thick plastic top. It rotated to allow easy entrance and exit from the Power Wheel. The sound and light bar was removed and replaced by the tray.

The standard Power Wheel seat was completely removed and replaced with a child car seat. This seat was chosen to fit exactly within the space provided and was modified by removing excess belts and straps. The seat was attached to the car with belts that were secured underneath the car. This seat provided substantial padding for comfort and protection of the user.

The final cost of this design was approximately $430, which included $260 for the Power Wheel and $170 for the modifications.

SUPER DUPER COZY COUPE

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INTRODUCTION

A child's toy car, the Cozy Coupe, was modified for use by children with cerebral palsy. A previously developed device that enables children with cerebral palsy to walk on their own, the Snug Seat Pony Gait Trainer, was also used. The design involved combining the functionality of this device with the aesthetic appeal of the Cozy Coupe. The car was designed for children ages one and a half to five.

SUMMARY OF IMPACT

The Cozy Coupe is one of the most popular toys with children at a center, but because of its present design, children with cerebral palsy are unable to use it. Design modification in the Super Duper Cozy Coupe address body support and leg extension range needs of children with cerebral palsy, making it possible for them to more fully participate in play activities.

TECHNICAL DESCRIPTION

The construction of the Super Duper Cozy Coupe involved the combination of the Snug Seat Pony Gait Trainer with Little Tikes' Cozy Coupe II. The functionality of the Pony Gait Trainer was to be preserved, so the primary adaptation was to the structure of the Cozy Coupe. The cab of the Cozy Coupe was the area that was primarily modified. The original seat in the Cozy Coupe was cut out and essentially replaced by the Pony Gait Trainer (Fig. 9.6).

Figure 9.6. Super Duper Cozy Coupe.

The Cozy Coupe is made of plastic. Felt was used to cover the coarse edges of the cut plastic. After the seat was removed, the Cozy Coupe was placed on top of the Pony Gait Trainer replacing the Cozy Coupe seat. To compensate for the higher seat positioning of the walker, the body of the Cozy Coupe was raised. To accomplish this, 12 gage galvanized sheet metal supports were placed at the front and rear end of the Cozy Coupe to connect the car to the Pony Gait Trainer. Using hinges, the roof of the car was made retractable allowing easier child entry into the car.

Front Support

The front support was designed to bear only the weight of the car. The walker supports the child's weight. The shape of the front support was designed to prevent wobble, and a brace was added to the front support for extra stability. The shape was also designed to allow legroom for the child.

Rear Support

The rear support was designed to bear only the weight of the car and to not inhibit the child's legroom.

Retractable Roof

The roof was modified to be retractable and to provide easier access for children to the cab of the car (Fig. 9.7). Hinges were replaced on the front roof columns to allow the rear columns to snap in and out of position. Flat plate hinges were used to allow a full 180° rotation. The flat plate hinges must be placed in the same plane to function properly. A small-machined attachment had to be added to the car to create a flat plane. Two four-inch by 1½ inch pieces of galvanized sheet metal were bent at a 90° angle and attached to the front columns to create a plane for attaching the hinges. The hinges were then rounded and covered with yellow electrical tape for safety purposes.

Cosmetic Tires

Cosmetic tires were designed to enhance the aesthetic appeal of the car. These were constructed using a machine that formed plastic wheels from a Styrofoam mold created by the design team. The wheels were made in halves from the mold and then fused together to create a hollow wheel, which are not shown on the car.

The final cost of this design was approximately $135.

Figure 9.7. Retractable Roof on the Super Duper Cozy Coupe.

TOUCH-N-GO: A REMOTE CONTROL DOOR OPENING DEVICE

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INTRODUCTION

A remote controlled door-opening device was designed for a child with muscular atrophy due to a degenerative disease that limits the individual's dexterity and strength.

SUMMARY OF IMPACT

Individuals with muscular atrophy are dependent on those around them to help with everyday activities. Touch-N- Go will allow these individuals to have the liberty to come in and out of their homes at their own discretion. Current products on the market, although very efficient, are extremely expensive. This design provides the necessary functions while being affordable.

TECHNICAL DESCRIPTION

Several specifications were made for the design based on consultations with the client's parents. These include:

(1) The client should be able to activate the device from either side of the door, (2) The door speed should be set so that the door opens and closes at a safe speed, (3) The device should allow control of the duration that the door is open, and (4) The door should also be able to be operated manually.

Figure 9.8. Sensor for Touch-N-Go Remote Door Opening Device.

The design consists of several parts: a louver motor, cable/spindle assembly, electric strike plate, transformer, pneumatic device, and a remote control system. These parts could all be placed on any existing door. Touch-N-Go was designed for use on an exterior, solid wood door. The device consists of an electrical and a mechanical system.

The remote control system consists of a wall-mounted sensor with a handheld remote (Fig. 9.8). The sensor connects directly to the power source, and the transformer and motor are connected in parallel to the sensor. The louver motor, which requires 120V AC power, is a unidirectional motor that resists burn out. When the motor overloads, it shuts off automatically. A 120V AC to 24V DC step-down transformer is wired to the remote control system. The transformer is needed because the electric strike requires 24V DC power to operate. The purpose of the strike plate is to open the door without having to twist the doorknob.

The shaft connected to the motor rotates when powered, and the spindle is mounted on the shaft so that it also rotates. A steel cable of 0.69-inch diameter and 3-feet length is fastened at one end to the spindle and at the other end to the doorplate. The doorplate is a ¼-inch thick steel plate with a 90º bend at the top of the plate. The cable connects to a hole in the corner of the bend (Fig. 9.9). When the spindle rotates, the cable winds around it, pulling the door open.

Once the door is open to 90º, the cable is completely wound up. The door remains open as long as the power is supplied to the motor. When the individual presses the off button on the remote, the power supply is cut off. The pneumatic device then overrides the mechanics of the motor and closes the door. The pneumatic device used in this design is a standard heavy-duty storm door closer.

Figure 9.9. Door Plate with Motor and Spindle.

The total cost of the system is $255.

LIGHT SWITCH ADAPTER FOR PATIENTS WITH MUSCULAR ATROPHY

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INTRODUCTION

A light switch adapter was designed and constructed to assist a patient with muscular atrophy in activating and deactivating a standard large-faced toggle light switch. Because the client's disease is degenerative, the product had to be designed so the patient can use it as long as he is mobile by way of an electrical wheelchair. In other words, as long as he can use the controls on his wheelchair to maneuver himself, he will be able to use the adapter.

SUMMARY OF IMPACT

Muscular atrophy affects strength and movement abilities of the voluntary muscles. Although the thoughts, emotions, and overall mentality of persons who has the disease are not affected, an overwhelming frustration may result due to the lack of independence. The patient understands how to perform everyday functions but does not have the strength or fine-motor ability to do so. The main purpose of this device is to help keep the patient as independent as possible for as long as possible. It also gives the patient an opportunity for physical accomplishments.

TECHNICAL DESCRIPTION

The light switch adapter is designed to activate a wide-faced toggle light switch (Fig. 9.10). Torque, created by the operator, activates the adapter when pressure is applied to one of the two four-inch by six-inch plastic pads of the device. The left pad activates the light switch while the right pad deactivates the switch. When a force is generated in a perpendicular direction on the plastic pad, the vertical levers made of the ¾-inch aluminum angle transmit torque. This torque rotates 3/8-inch aluminum rods that make contact with the switch by means of one-inch flat aluminum tabs that are welded to the rod.

Figure 9.10. Light Switch Adapter.

The angles made by the activating tabs relative to the activating arms must be properly aligned to assure activation of the wide-faced toggle switch. The angle between the arms and the flanges is adjustable by means of 3/8-inch stops to assure that the device will work on other wide-faced toggle switches.

Loosening the screws on the stops and moving the arms to the desired angle help adjust the arms. A four-inch by three-inch mounting box, built from one-inch angle aluminum, holds the activating device onto the wall. This box is attached to the wall by five drywall anchors. Each arm has a compression spring attached to rubber bumpers on the wall. This is to prevent the arms from coming in contact with and causing damage to the wall.

The cost of the Light Switch Adapter is $99.

H.A.R.O.L.D.: HELPFUL ANALOG REMOTE OBJECT LIFTING DEVICE

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INTRODUCTION

Toys, from action figures to Playstations, are integral to a healthy and happy childhood. What if a child does not have the ability to reach down and pick up a dropped toy? The helpful analog remote object lifting device (H.A.R.O.L.D), a radio-controlled car modified with a motorized scoop, was developed to help children with Spinal Muscular Atrophy (SMA). (Fig. 9.11).

SUMMARY OF IMPACT

SMA is a disease that affects the proximal muscles near the spine. These particular muscles control voluntary movements such as crawling, walking, torso bending, and head and neck control. These physical limitations may prohibit children from reaching down to pick up their toys from the floor. A child may be unable to return to an upright position after bending forward to retrieve items. Any time a child with SMA needs assistance in

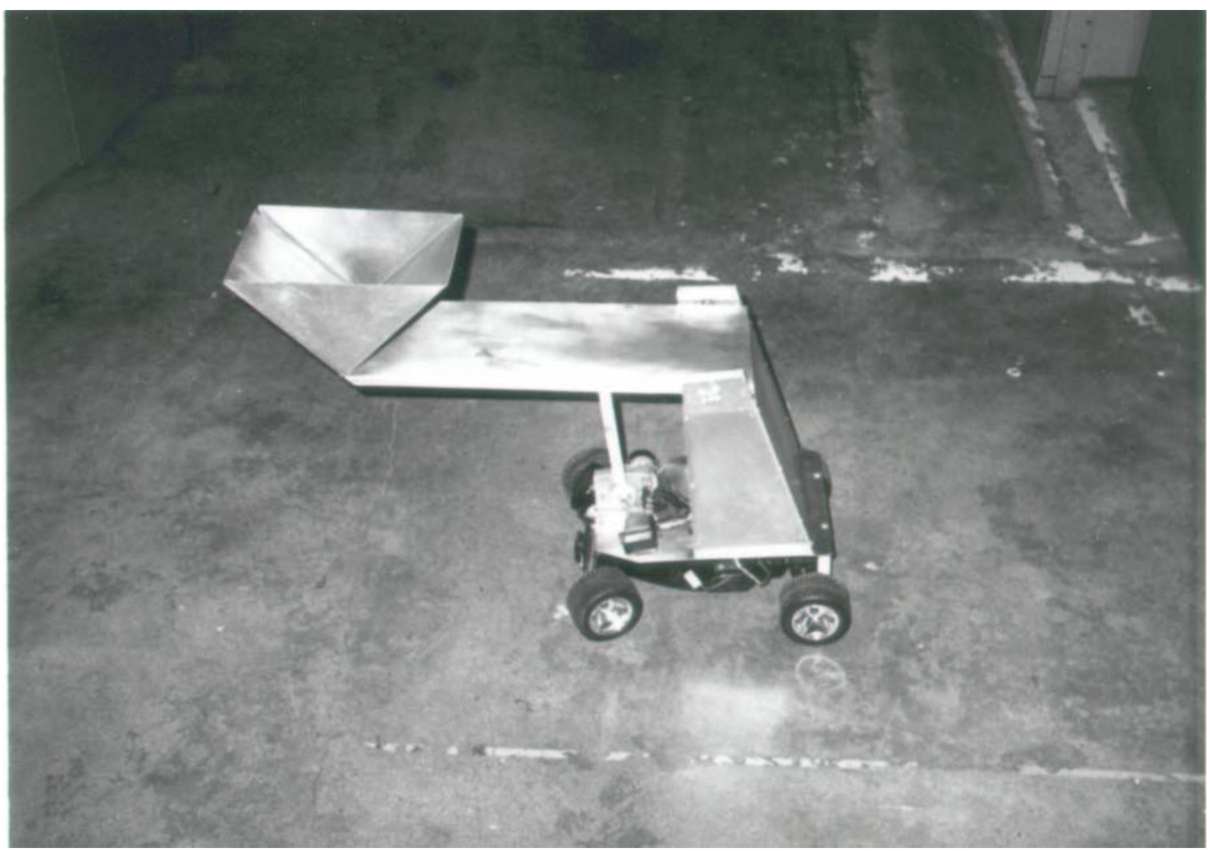

Figure 9.11. H.A.R.O.L.D: Helpful Analog Remote Object Lifting Device.

retrieving his toys, he can rely on H.A.R.O.L.D.

TECHNICAL DESCRIPTION

Our solution to retrieving dropped toys involves modifying a remote controlled car that is capable of capturing a toy then raising it (Fig. 9.12). H.A.R.O.L.D is constructed using an electric radio controlled car kit with a lift assembly attached to the car frame. The front-loading bucket attaches to vertical supports. These supports are pop riveted to a secure platform. The bucket ramp pivots about an axis at the top of the vertical supports. The bucket is raised by means of a lever attached to a rotating cam that is connected to a DC motor. Rechargeable batteries power both the car and the bucket. Any toy can be captured and raised to a height appropriate for a child to reach it. To prevent the motor from continued operation, limit switches are incorporated into a circuit. This circuit uses diodes to prevent current flow in both directions. This prevents the motor from short-circuiting. The circuit cuts power to the DC motor. This safety precaution extends the life of the motor.

The circuit includes two single throw single pull limit switches, two diodes, and an alternating power supply. When the cam raises the lever to a certain point, one switch is thrown, and power is cut off. Reversing the polarity starts the motor back in the opposite direction. Once the lever reaches a specific point, the other switch is thrown, and power is shut off. Changing the directions of the remote toggle switch starts the process all over again.

The total cost of H.A.R.O.L.D. was approximately $700.

Figure 9.12. Design Group with H.A.R.O.L.D.

SWINGING SEAT FOR CHILD WITH CEREBRAL PALSY

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INTRODUCTION

Outdoor playground equipment has been universally used to provide children with fun and exciting recreational activities. Swings are commonly seen at playground sites and tend to be a favorite among children. However, swings require upper and lower body movement, which hinders participation by children with cerebral palsy. Therefore, a swing was designed to accommodate the needs of a child with cerebral palsy.

SUMMARY OF IMPACT

The specially designed swinging seat is an excellent, innovative way for children with cerebral palsy to experience fun, outdoor activities. Since the client's family had other children without cerebral palsy, the swinging seat was designed to accommodate them as well. Additional seats included one regular

Figure 9.13. Swing Chair.

child's seat and one regular infant seat. With these additions, other members of the family could enjoy the swing as well.

TECHNICAL DESCRIPTION

The swing chair and the swing seat were specifically designed for a child with cerebral palsy (Fig. 9.13). The child's safety, recreational needs, and level of comfort were considered in the project design.

Pressure treated wood coated with additional water sealant was used for the swing set frame to provide protection against all weather conditions. To ensure stability, an "A" shape design was used on the ends of the frame. In addition, the frame was reinforced with EZ frame braces® and EZ frame brackets®. Heavy-duty swing hangers were attached to the frame using carriage bolts and were secured with two nuts to prevent loosening. The swing hangers were spaced to allow for the 22 inch width of the swing. On each side of the swing chair, two plastic coated chains were joined using an "S" hook and attached to the beam with an additional chain.

Aluminum was chosen for the swing seat frame because of its durability, resistance to corrosion, and strength. The main frame was fabricated from 1¼ -inch angle with one-inch square connectors and reinforced with side supports made of one-inch flats. One-inch hinges were attached to the base of the seat to allow for the adjustable leg support. The adjustable leg support consisted of one, one-inch flat with one hole joined with a nut and a bolt. Unlike commercially available swings, this design allowed the user to enjoy a range of positions. In addition, aluminum mesh was laid in the interior of the aluminum angle and secured with rivets. Certified technicians welded all aluminum materials to create the backbone of the seat.

To achieve an optimum level of comfort, a three-inch thick chaise lounge cushion was modified to fit the needs of the client. Six inches of material were taken from the bottom of the cushion to properly fit the swing seat. Also, four two-inch slits were made in the top third of the cushion to accommodate a harness. Two backpack shoulder straps and one waist belt were joined to create the harness design. The harness, which was commercially used for backpacking purposes, was modified to fit the dimensions of a small child. The harness was secured to the cushion by fastening one side of the two-inch webbing to the harness clips, passing the webbing through the cushion slits and riveting it to the aluminum mesh. This technique provided a secure fit and a maximum level of safety for the client while swinging.

The final cost of the project was $700.

MANUALLY OPERATED DEER HUNTING TREE STAND FOR INDIVIDUALS WITH PARAPLEGIA

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INTRODUCTION

Hunters use their arms and legs to climb up trees and hunt from traditional tree stands. However, deer hunters who have paraplegia, the paralysis or loss of movement and sensation to the lower part of the body, are unable to use this type of tree stand because of the inability to climb with their legs.

SUMMARY OF IMPACT

The design criteria allow a hunter with paraplegia to use his upper body strength to manually elevate himself with a pulley system to a position 10 feet above the ground. This elevated position is desired because it allows him to be hidden while giving him a broader vision of the terrain and wildlife. Thus, he is able to aim at the target with more accuracy.

TECHNICAL DESCRIPTION

The tree stand was designed to lift a 250-pound hunter 10 feet in the air. It consisted of three main components: a ladder, a manual winch, and a chair (Fig. 9.14). Several safety features and accessories were also included in the design.

The 28-foot aluminum extension ladder consisted of two 14-foot sections. The section of the ladder that was used for this design was the wider of the two sections, which had a skid-proof base. The selected ladder can hold 350-pounds, which is more than adequate to hold both the weight of the client and the aluminum chair, which total approximately 300

Figure 9.14. Deer Hunting Tree Stand.

pounds. Several modifications and additions were made to the ladder. A small flange was bolted to the bottom of the chair to keep it from running off the end (Fig. 9.15). Another large flange, which serves as a stopper, an anchor for a ratchet strap, and a place to attach the winch's steel cable, was attached to the top of the ladder.

The manual ratchet winch had a 1400-pound weight limit. The winch was bolted to an aluminum base positioned on the right side of the chair to accommodate the right-handed dexterity of the client. The winch system was used to lift and lower the client along the ladder's height by winding and unwinding a steel cable. A lever switch on the winch determined the direction of motion. The switch was in the up position for ascension and in the down position for decline. The steel cable was looped around an eyebolt that was attached to the large flange at the top of the ladder. The cable then passed through a pulley system and wound around the drum of the winch. The pulley system consisted of two pulleys that were attached to the chair frame. The purpose of the pulley system was to change the direction of the force pulling on the cable and to move the position of the cable from the right side of the chair to center of the chair.

The frame for the chair was made of 1¼ inch square aluminum tubing. It had a width of 22-inches and depth of 15-inches. These measurements were calculated, researched, and proven to be ergonomically correct for the client. A seat cushion to accommodate long periods of sitting was purchased and attached using two aluminum flanges for support. Diagonal beams were included in the design to distribute the forces applied by the client and the tension from the winch's cable. Flanges were bolted to two slider bars on the rear of the chair to act as a track system along the legs of the ladder. The sliders were lined with high-density polyethylene strips to reduce friction caused by metal-on-metal contact.

Several features were added to the tree stand to ensure the safety of the client. A ratchet strap device was used to secure the stand to the selected tree. The strap was attached to the large flange at the top of the ladder. A seatbelt was also added to the chair for safety purposes. Also, square plugs were inserted into the open ends of the tubing to eliminate sharp corners.

Finally, the stand was painted to camouflage it. This procedure was necessary to allow the tree stand to blend into the wood scenery, a necessity to allow for successful deer hunting. Other accessories including padded elbow rests, a cup holder, and a storage bin were also added to increase the comfort-level of the user. The final cost of the project was approximately $460.

Figure 9.15. Side View of Deer Hunting Tree Stand.