CHAPTER 2
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A Recreational Tandem Tricycle for Severely Disabled Children

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INTRODUCTION

The particular child who acted as the motivating force of our project is Heron. Heron is a seven year old girl suffering from severe cerebral palsy (CP). One of the physical manifestations of her condition is severely elevated skeletal muscle tone. Her tone is bilateral, symmetrical, and generalized. Due to the high level of tone in her skeletal muscles, Heron is unable to manage even gross motor control tasks. Heron formerly enjoyed bicycling for several years but has since outgrown the standard bicycle seat that she had used.

Figure 2.1. A Recreational Tandem Tricycle.

SUMMARY OF IMPACT

As stated above, children with cerebral palsy can exhibit elevated skeletal muscle tone. This elevated muscle tone often limits the child's mobility to that of a wheelchair. In her case, therapeutic external stimulation such as vibration was found to reduce her elevated muscle tone and was therefore applied by her physical therapist on a daily basis. Although the tandem tricycle is more correctly classified as a recreational device, the child may actually benefit therapeutically from the vibrations that are generated during its use. In addition, the tandem tricycle provides an extra mode of freedom away from the confines of her wheelchair. This will be very beneficial to the psychological development of the child, providing access to an outside environment that would otherwise be less fun and less accessible.

TECHNICAL DESCRIPTION

The device consists of three main components:

- base bicycle frame
- front chassis
- front seating system

As originally constructed, the base bicycle frame was taken unaltered from a standard, twelve speed mountain bicycle. The original design required no permanent alterations to the bicycle, only the removal of the handlebars and front fork, and replacement of the rear brake with a more robust hydraulic brake. A custom link was designed to connect the base bicycle frame and the front chassis consisting of tubular steel. The link was welded in construction and mounted to the bicycle frame via a shaft mounted to the existing front fork housing. The front of the link was pinned to the rear of the front chassis via a vertical $\frac{1}{2}$" bolt. This bolt was welded directly to the axle of the front chassis and served as the rotational axis of the front chassis relative to the bicycle frame. Once constructed, however, it was found that this system was very unstable for the person powering the tricycle for two reasons:

i) When a turning maneuver was performed there was a tendency for the base bicycle frame to tip toward the *outside* of the curve. Upon examination, it was determined that the slight backward tilt of the not-quite vertical bolt set up a kinematically constrained side-to-side tilting movement of the bicycle frame. This effect was apparent because in a tricycle arrangement all three wheels must always touch the ground. (This fact was utilized to our advantage by later tilting the chassis turning axis slightly forward, which then caused the frame to tilt toward the inside of a curve while turning!)

ii) The linkage between the front chassis and the base bicycle frame (which was approximately 22”) was acting as a large lever arm. The force created by the dynamic motion of the driver's shifting weight was translated through the lever arm, to the horizontal bar. This force put a large stress on the horizontal bar and its weld points, resulting in significant flexure of the members. In addition to the wrong-way banking (tipping) problem, this made the tricycle dynamically unstable and unsettling to ride.

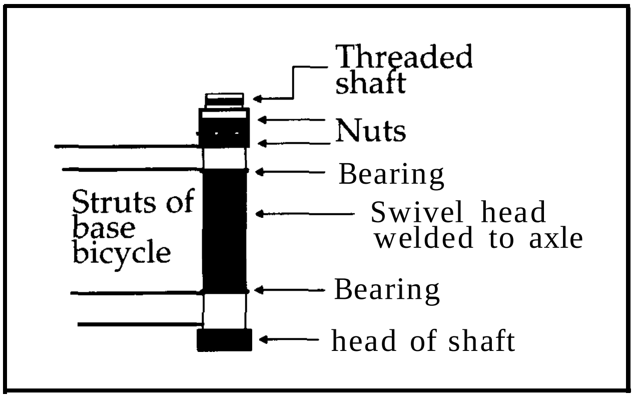

Figure 2.2. Swivel assembly on underside of front chassis.

In response to these problems, a new, structurally more rigid and more direct connection was designed between the bicycle and the front chassis. The modified design requires that the base bicycle frame be permanently altered. To achieve the **new** connection, the bicycle frame was cut and the portion from the driver's seat forward removed. A swivel head was welded to the front chassis via a modified “bosse” arrangement above the axle. The modified bosse arrangement allowed the swivel head to be welded at two points instead of **one** and reduced stress on the axle joint. To solve problem (i), the swivel head was oriented 6” forward of vertical to enhance the banking capabilities of the base bicycle through turns, **that** is the base bicycle now properly leans toward the *inside* of the curve. To solve problem (ii), two new frame struts were welded to the base bicycle frame and extended downward to meet the swivel head, forming a linkage system. The linkage system was designed to allow smooth turning of the front chassis. See Figure 2.2 for an illustration of the linkage system. The second component of the design is the front chassis. This serves as **the** base for the seating system. The major (highly stressed) components of the front chassis were constructed out of $\frac{1}{8}$" wall rectangular steel tubing. The steel rectangular struts support the seat and handlebars of the system. The axle was designed to carry most of the induced stresses, as such, the axle is made from “maraging” steel. Maraging steel is a superior alloy with tensile breaking strengths in excess of 300,000 psi. To gain additional strength and resistance to bending, the axle was welded into the steel rectangular struts of the front chassis. The front chassis also incorporates the handlebar, cable-actuated brakes for each independent wheel, and seat struts (which support the seating system). Both these were fabricated from 1” outer diameter chrome moly tubing.

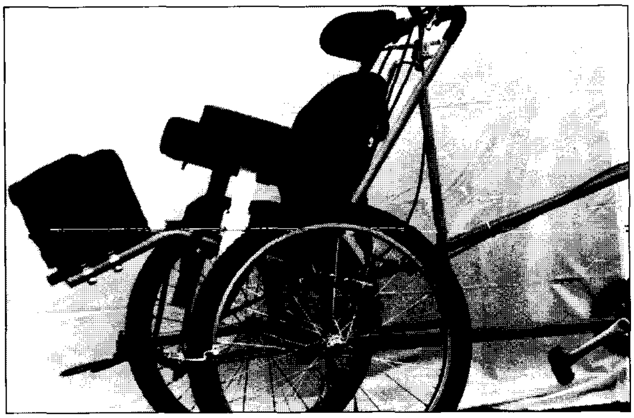

Figure 2.3. Another view of the Recreational Tandem Tricycle.

The last major component of the design is the child's seating system. The seating system pivots on cylindrical seat struts attaching to the front chassis; thus the seat position adjusts from horizontal to an angle of 50”. The seating system consists of the following commercially available products: 1) Jay cushion, 2) Jay back, 3) Jay seat board, 4) arm rests, 5) head rest, and 6) foot rest. Also included is a pelvic seat belt with pads and a padded over-the-shoulder nylon webbing harness. All components of the seating system are fully adjustable. The final design was found to be a great success! The cost of the tandem tricycle was approximately $2000 for materials, with an additional $1000 needed for specialized grinding and welding.

A Kitchen Mobility Aid for a Cerebral Palsied Client

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INTRODUCTION

A kitchen mobility aid has been designed and developed for a cerebral palsied youth. The device is fashioned after a walker, with four wheels, tray and supports, and a braking mechanism (Figure 2.4 and Figure 2.5). The braking mechanism is a spring-loaded plunger type device that sits in the fork that supports the rear wheels. It is designed in such a way that the cart is always braked. To release the brakes and allow the client to move the device, the client squeezes the brake levers. Thus the device is fail-safe-should she lose her balance, she will release the brake levers and automatically brake the device. This also allows her to support her weight on the cart without having to manually “lock” the wheels. The brakes are installed over two rear stationary wheels, and caster wheels are incorporated in the front for maneuverability.

SUMMARY OF IMPACT

The client is living with her family, and is making plans to move out on her own. Before receiving the new kitchen mobility aid, she had been attempting to use a weighted down grocery cart to enable her to function in the kitchen. She needed the grocery cart to lean heavily against so that her legs could be used for propulsion. The mass was necessary to make the cart more stable and less apt to “run away” from her as she leaned against it. The disadvantage of the grocery cart was its lack of maneuverability and bulkiness that prevented her from gaining access to countertops. Often times it was easier for her to place things on the floor and push them between locations in the kitchen as she crawled from place to place.

The new device will offer her greater mobility in the kitchen, and will increase her safety as the braking mechanism will help to prevent falls. The tray is large enough to transport reasonable loads, and is removable so it can be washed. A denim laundry bag was also made to hang in place of the tray. It is expected that the kitchen mobility aid will increase her ability to function independently when she moves into hew own apartment.

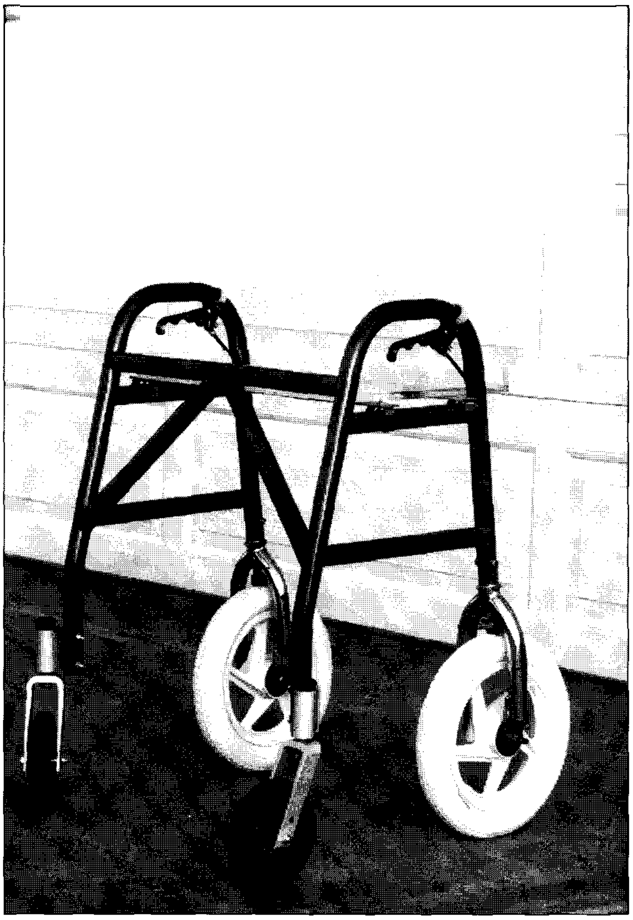

Figure 2.4. Kitchen Mobility Aid for a Cerebral Palsied Client.

TECHNICAL DESCRIPTION

A kitchen-aide device was designed for a cerebral palsy patient. The requirements for the device were that it be maneuverable, safe, and able to carry a reasonable load (this was decided to be 15 lbs in addition to the client’s body weight). The client expressed some concern as to the possibility of falling, which led to the requirement of having the brake operate in a fail-safe mode. She also requested that the height be approximately 31”.

The frame was fashioned of $1\frac{1}{8}$" outer diameter chrome-moly tube, and was patterned after a standard V-brace walker. The rear stationary wheels utilize the forks and tires from a child's scooter. The fork has an outer diameter of 1” and is inserted into the frame leg and bolted in place. Quickie caster wheels with a diameter of 6” are bolted to the front legs of the frame.

The brake is a plunger-type mechanism mounted between the struts of the fork for the rear wheels. A capped piece of $\frac{3}{4}$" Copper tubing is used to house the plunger, which consisted of a 3” spring inside of a short length of $\frac{1}{2}$" brass tubing. The brake cable runs down the inside of the frame leg, through a hole drilled into the top of the capped brake assembly, and fastens to the bottom of the spring via a washer. The brake cable was fastened while the spring was under slight compression to assure that the plunger would be pressed into the wheel. A $\frac{1}{2}$" rubber foot is placed over the end of the brass tube and secured with a clamp, to provide more friction with the tire. It is important to note that the brake does allow some slippage when the mobility device is loaded and pushed horizontally. If the brake was not allowed to slip somewhat, the likelihood of the walker tipping over is increased.

The tray is supported by two flat mild steel bars of $1\frac{1}{2}$" width. A utility clip is bolted to the bottom ends of each bar. Both bars are then snapped on to the top side braces of the cart frame. The tray is a $18" \times 12\frac{3}{4}" \times \frac{3}{8}"$ piece of acrylic, with 1" sides of the same thickness but made of Plexiglas. Magnetic strips are fastened to the bottom of the tray to fix the tray to the supports. This enables the tray to be removed for cleaning, or to be replaced with another carrying mechanism (such as a basket or laundry bag). The supports for the tray can also be removed as desired by the client (they merely clip on), enabling the cart to be used like a walker if she so desires.

The cart was tested by a volunteer to ensure that the hand force required on the brake lever to release the brake was not too great. While the required force was minimal, for safety it was decided to place the brake levers backwards on the handles of the frame. The resulting angle of the brake lever made the brake easier to grab with the palms resting on the handle, as the client's would be. It was also determined that the magnetic strips on the tray may need to be replaced with a different mechanism. The tray extends four inches past the support towards the rear of the frame. This provides a moment arm so that when enough force is applied to the edge of the tray, the magnetic strips lift off the front support. When tested, it was found that a force of 5 lbs placed only on that four inches did not cause the tray to come off the support.

The final cost of the device was approximately $975.

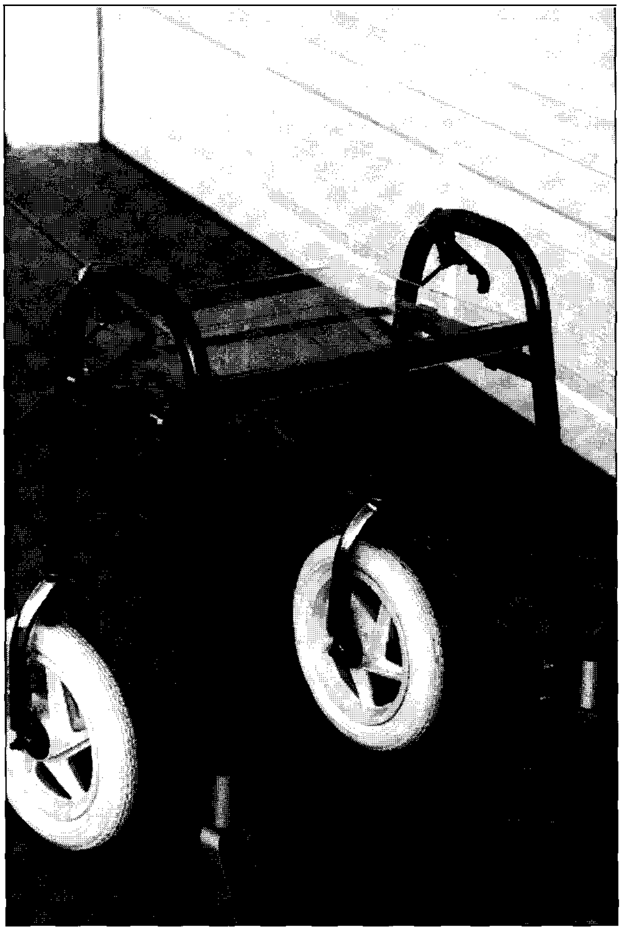

Figure 2.5. Another view of the Kitchen Mobility Aid for a Cerebral Palsied Client.

Bathtub Lift for a Large, Physically Disabled Person

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INTRODUCTION

A bathtub lift was designed to assist in bathing a large physically disabled individual by lifting and lowering them into the tub. The device consists of four components: a base, clamping mechanism, swing arm, and an electric winch. The base is C-shaped and clamps onto the tub sill with a mechanism that can be adjusted for tub sill width and height. Welded to the base, is a post with a hinged, triangular arm. The winch is also mounted high on the post, making it inaccessible to anyone seated in the bathtub (important to prevent the possibility of electric shock).

The wheelchair bound individual is able to wheel forward into a position directly underneath the end of the swing arm, attach a hook to a user-supplied harness, and winched upward. Once at the desired height, he can be swung over the edge of the tub by pivoting the swing arm. Lowering into the tub is accomplished by simply pushing a switch.

SUMMARY OF IMPACT

Though this device was designed with a wheelchair-bound individual in mind, it is adaptable for any physically disabled person whose size or weight makes it difficult to maneuver into a bathtub. Also, many other potential users of the device lack sufficient trunk muscular control to balance themselves, so their trunk must be held in an upright position while bathing. This device is presently able to assist individuals in bathing others, but should not be used for self-bathing due to the fact that an electric switch is used to raise and lower the winch (electric shock danger).

TECHNICAL DESCRIPTION

The main design constraints are: 1) the bathtub lift must be able to be used with any bathtub; 2) the device must be able to lift and lower a person weighing in excess of 200 lbs.; 3) many potential patients are unable to support themselves, so the device should be able to keep the trunk in an upright position; 4) the lift must be wheelchair accessible; and most importantly, 5) the device had to be safe.

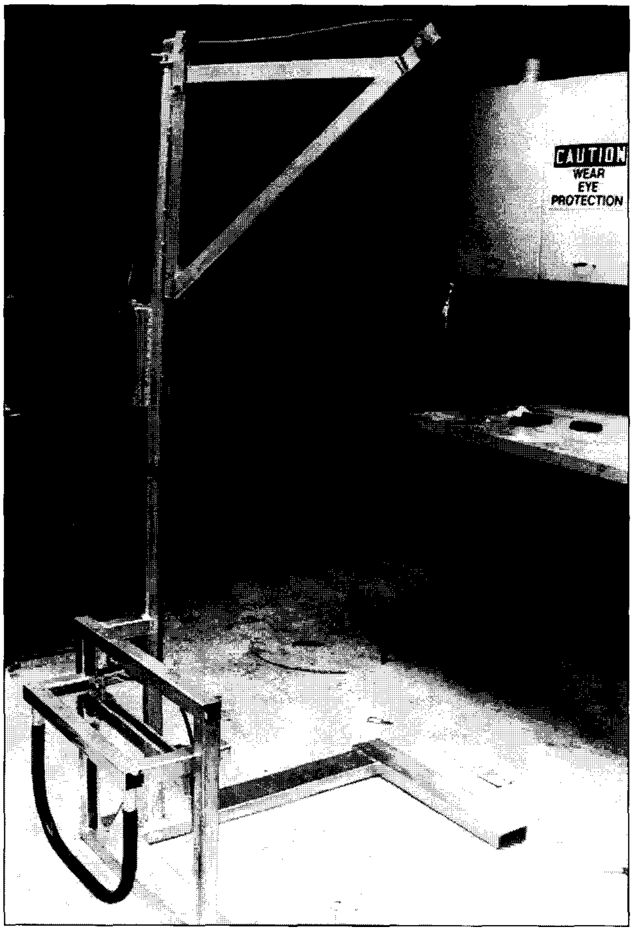

Figure 2.6. Bathtub Lift for a Large, Physically Disabled Person.

The bathtub lift has four main components: the base clamping mechanism, swing arm, and winch. The base is constructed of 1"×4" steel channel, welded into a square C-shape, with each arm 24” long and 30" wide. Welded onto an arm of the base is the tub sill clamping mechanism, which is made of $1\frac{5}{8}$"

Vari-Strut steel channel. The clamping mechanism frame consists of two 20" uprights with a 24" long upper cross-member. Vertical adjustment is provided by an additional inner cross-member $20\frac{5}{8}$" long, welded to two corner brackets, which slide vertically inside the rails of the uprights, allowing the inner cross-member to be adjusted to the height of the tub sill. To adjust for tub sill width, a piece of plastic coated 1" conduit with two 90 degree bends extending downward 12" was welded to each end of another $20\frac{5}{8}$" member. Perpendicular to the conduit, are two 8" arms which slide horizontally across the top of the inner cross-member, and are secured in place with two 90 degree brackets.

The swing arm is comprised of a $1\frac{1}{2}$" I.D. steel pipe, 76" high, welded 6" from the edge of the base. Two 4"×6" triangular gussets are also welded onto the base and pipe for additional strength. At the top of the post is the triangular arm, 18" high by 24" long, constructed of $1\frac{1}{2}$" square steel tubing. The arm is linked to the post by two hinges constructed of $\frac{5}{8}$" I.D. steel pipe, and held by two $4\frac{1}{2}$" long stainless steel pins. The winch mounting plate is welded onto the post 54" from the base, and held in place with three quick-mount studs. The winch is a Dayton 115V AC electric winch, rated for a load of 3000 pounds. The winch cable passes over two $2\frac{1}{2}$"×$\frac{1}{2}$" pulleys; the first welded on top of the swing arm post; the second welded on the end of the arm.

A preliminary test was conducted with a 200 pound volunteer, and revealed *one* necessary design modification. When the swing arm was swung over the tub and the winch activated, the cable came in contact with the inside of the pulley cover on top of the post. This was rectified by a "fairlead" made of $\frac{1}{4}$"×$1\frac{1}{2}$" steel, using four 2" clevis pins and four $1\frac{1}{2}$"×$\frac{1}{2}$" diameter polyurethane bumpers.

The total cost of the bathtub lift was approximately $400, with the major expense being the winch ($255).

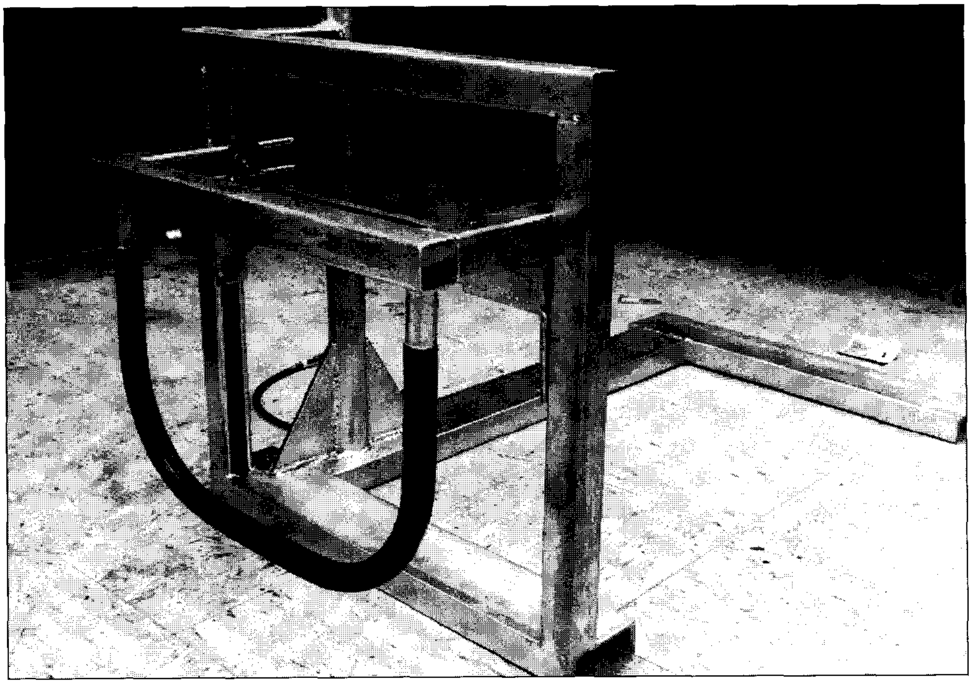

Figure 2.7. Closeup of Bathtub Lift for a Large, Physically Disabled Person.

A Portable Exerciser for the Rotator Cuff Muscles

Designer: Su Mun
Client Coordinator: John Figy
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INTRODUCTION

A shoulder joint exerciser has been developed to strengthen the shoulder muscles of paraplegic wheelchair riders. It consists of a main bar that is placed behind the shoulder, a back rest which anchors the main bar from rotating, and arm rotators in which the elbow is placed. The forearm is rotated about the axis of the humerus to perform the exercise. The arm rotators slide along the ends of the bar to accommodate various arm lengths. Additionally, there is a constant rotational friction that can be increased or decreased if the user desires.

SUMMARY OF IMPACT

A common dysfunction addressed by physical therapy is dislocation of the shoulder joint. To balance and prevent such injury, the rotator cuff muscles can be exercised. To do this, the arm is abducted to the side at 90” with the elbow flexed 90”. Then, the forearms are rotated forward and backward about the axis of the humerus. Usually, the motion is executed using dumbbells while the shoulder is placed under a mechanical stabilizer. The stabilizer prevents the shoulder girdle from rotating with the forearms. The dumbbells tend to strengthen the forearms significantly, drawing the user’s focus away from developing the shoulder joint and the rotator cuff muscles. The new device eliminates the use of the dumbbells and continues to stabilize the shoulder girdle from moving improperly during the exercise.

Physiologically, the internal rotation will strengthen the subscapularis, a powerful defense against dislocating the shoulder joint forward. The external rotation will primarily strengthen the infraspinatus and teres minor, while stretching the latissimus dorsi. The infraspinatus and teres minor prevents backward dislocation of the joint.

The fact that the device is portable provides several benefits. First, the design allows greater accessibility to the wheelchair users. Second, it may lessen the frequency of visits to the physical therapist. Third, in comparison to the cost of therapy, the device is economical. And finally, the device eliminates the development of other muscle groups (such as the forearms) and focuses more on the rotator cuff muscles.

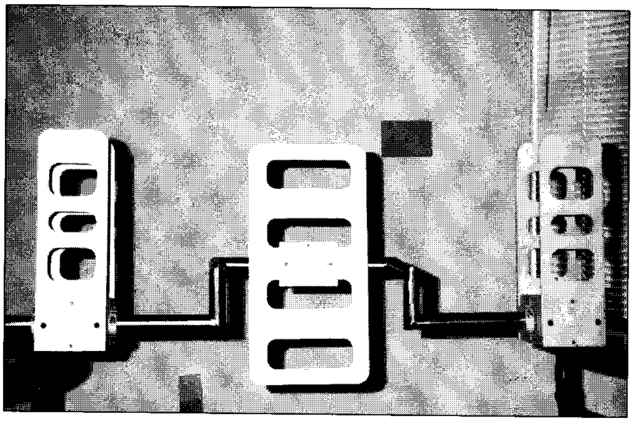

Figure 2.8. A Portable Exerciser for the Rotator Cuff Muscles.

TECHNICAL DESCRIPTION

The devices consist of four, main parts: the main bar, back rest, arm rotators, and collars. The main bar is made of 1” OD, 0.095” thickness carbon steel pipe. Viewed from the front, the bar is 13” long at the center, bent forward at 90” at both ends and extends 6”. Again, at both ends, the bar is bent 90°, but downward and extends 5”. Finally the bar is bent 90” to the sides and extends 13” on each side. The bends fits around the shoulder and prevents movement of the shoulder girdle (acting as a mechanical stabilizer).

The back rest is made of 16"×80"×$\frac{1}{4}$" aluminum sheet, and at the center, a saddle clamp, or a collar is attached to it by screws. Then, the clamp is placed firmly around the center of the main bar. Four lightening holes of 2"×5$\frac{3}{4}$" were cut out of the back rest to reduce the weight.

The two arm rotators are 4"×4"×3" aluminum blocks with 4"×12"×$\frac{1}{2}$" aluminum sheets (with three lightening holes of 2"×2$\frac{3}{4}$" to reduce the weight) screwed to the front and back of the block. The blocks are cut-in-half down the center, parallel to the sheets. Each half had channels (semicircular in cross section) milled out of it so that when the two halves were put together, a 1" diameter (ID) hole was created that fits around the main bar. The holes were lined with brass to reduce frictional wear during rotation around the bar. The two halves thus act as a saddle clamp around the main bar and are held one to another by machine screws. Tightening or loosening of the screws increases or decreases the rotational friction, thus adding to or subtracting resistance, respectfully.

Finally, the collars were placed on the inner and outer side of the arm rotators to prevent sliding along the bar during use. It also is like a saddle clamp: two blocks with were fitted around the bar and held together by machine screws.

The device was tested on a volunteer. A suggested improvement to the design would be to lessen the weight even more. The material cost of the device was approximately $200.

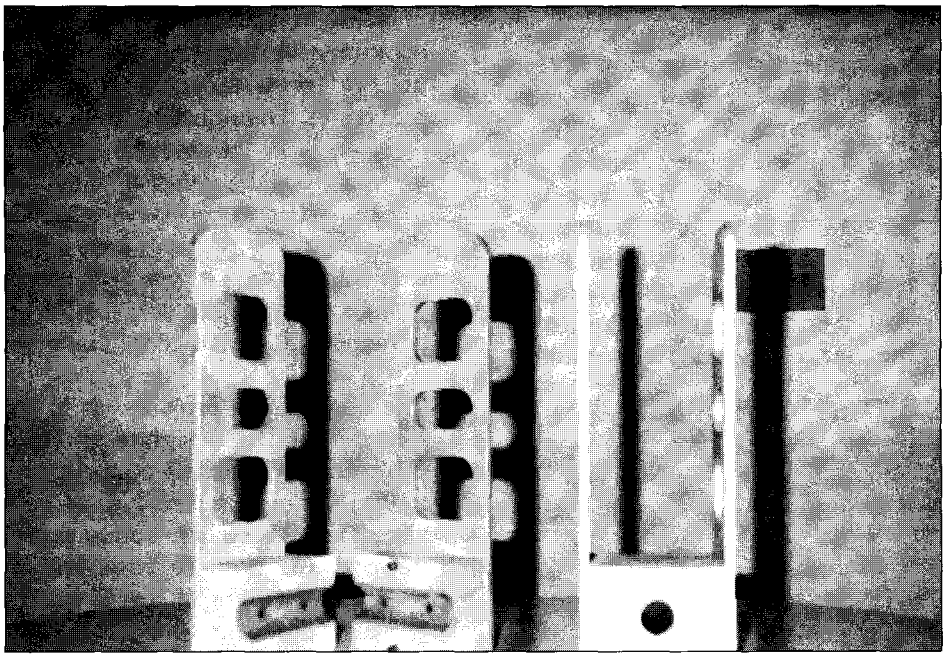

Figure 2.9. A Closeup view of the Portable Exerciser for the Rotator Cuff Muscles.

Wheelchair Accessible Reverse Pec-Dec Machine

Designer: Kevin Noreus
Client Coordinator: John Figy
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Supervising Professor: Dr. Gay T. Yamaguchi
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INTRODUCTION

The Wheelchair Accessible Reverse Pec-Dec Machine is an exercise machine for the wheelchair-bound person. The device was built for the Adaptive Weight Room of the Student Recreation Center of Arizona State University. The Adaptive Weight Room is isolated from the central weight room and specializes in providing weight training for the disabled, as well as rehabilitation training for injured students. The room is under the supervision of coordinator and therapist John Figy, who expressed the need for this particular machine. A current Reverse Pec-Dec Machine does exist, but does not allow access to the wheelchair-bound person. For the wheelchair-bound person, the machine does not allow for the user to position himself correctly to perform the exercise. The legs or leg attachment of the wheelchair is obstructed by the frame of the machine, which keeps the user from getting in position.

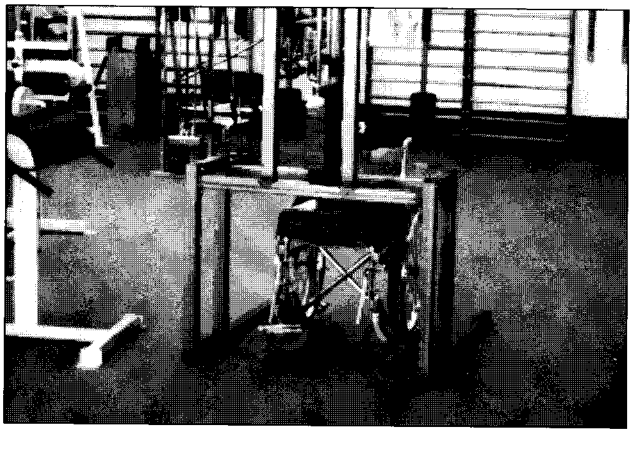

Figure 2.10. The Wheelchair Accessible Reverse Pec-Dec Machine.

SUMMARY OF IMPACT

The movement developed by this machine is important to the wheelchair-bound person. The motion of the reverse pet-dec exercise involves extending the arms outward from the body laterally in the coronal plane. With the arms bent upwards at the elbow, the motion is to retract or to "square" the shoulders. This is done by starting at a position slightly above parallel, and moving the arms backwards in the sagittal plane behind the back. This motion develops the muscles of the upper back, which as a group, stabilize the scapula. Strengthening these muscles in retraction helps hold the scapulae in position and prevents them from excessive protraction, or forward curvature of the shoulders. This movement is important to wheelchair-bound persons because the common tendency is to slouch, which causes the muscles that support protraction of the shoulders to be overdeveloped and the muscles that support retraction of the scapulae to be undertrained, resulting in poor posture. An exercise program under the supervision of a therapist can be administered to overcome this problem.

The goal of this project was to modify the current Reverse Pec-Dec design to provide access of the machine to a wheelchair-bound person. Most importantly, the new design had to be wheelchair accessible. The wheelchair-bound person must be able to perform the exercise with ease and make adjustments (movement of chest pad and changing resistance) without difficulty. The device had to incorporate the same range of motion used on the existing device. The device also had to be adjustable to the height of the user, as well as the shoulder width of the user, and its resistance had to be adjustable in small increments of weight. Since this motion is not a power movement, light weight, as well as the ability to increase or decrease the resistance in small increments, was necessary. In order for the machine to be used in the Adaptive Weight Room, the machine also had to be free standing. All of these constraints were met in creating the final design.

TECHNICAL DESCRIPTION

The basic components of the Wheelchair Accessible Reverse Pec-Dec machine include an arm pad unit, which also creates the range of motion for the machine. The arm pad unit is attached to a cable system and weight stack which provide resistance for the movement. An adjustable chest pad is included to hold the user in place while performing the exercise. The basic arm pad unit and cable system in the existing device were not modified.

To make the device wheelchair accessible, a new wider base was designed and the weight stack was elevated above ground 30 inches. This allows the user to wheel into the machine, feet first, and assume the appropriate position to perform the exercise. The weight stack was able to be raised to this height due to the small range of motion required during the exercise; using the existing device, the maximum displacement of the weight stack was found to be only 12 inches. The elevated weight stack is the single most important feature of the design, allowing wheelchair access to the machine.

Two factors were included in the design to allow users of different heights to use the machine. The chest pad must fit firmly on the user's chest and the user's arms must rest properly on the arm pads. To accomplish this, the chest pad was made with vertical as well as horizontal (anterior-posterior) adjustment capability. The arm pads are extra long (16") to accommodate users of various heights. To account for users of various shoulder widths, a similar strategy was followed. Each arm pad is 9 inches wide and the spacing between arm pads was also 9 inches. This is just enough room to allow a person with wide shoulders to enter, and is narrow enough to allow a user with narrow shoulders to easily reach the pads. A 100 pound weight stack is used with 5 pound increments. By adding a $2\frac{1}{2}$ pound "throw on weight" to the top of the weight stack, weight can be increased in increments of $2\frac{1}{2}$ pounds. The device is free standing and can be bolted into the floor for stability.

Other alternative designs considered for this device included: (i) extending the arm pad unit outward enough to provide adequate leg room, and (ii) a design requiring the user to "back" his wheelchair into the machine. The design chosen was superior to these designs because it utilized a minimum of materials and the feet first entry made the device easier to use. Structurally the device is extremely stable with almost no chance for failure. The arm attachment extends only 20 inches from the top of the machine and is extremely lightweight. No significant bending moment is applied to that joint. The device was constructed by Freedom Machine, Inc. They specialize in rehabilitation exercise equipment and are experienced in putting together machines of this type. The frame was constructed with a high strength steel used on all of their equipment. Cable systems were attached using current Freedom Machine design. Arm and chest pads are foam pads with vinyl covering. After frame was welded, the machine was heat treated to increase the strength of the machine, as well as provide a smooth finish. The final product was painted white and delivered to the Adaptive Weight Room in the winter of 1992.

Although the final design of the Wheelchair Accessible Reverse Pec-Dec Machine meets all the design criteria, improvements are still possible. If the width of the arm pads can be adjusted manually, a better fit can be made for all users. The suggested criteria for this would include elimination of play and flexure in the bars of the arm pad, and increasing the ease with which adjustments are made. If too much effort is required to adjust the machine, the machine will not be utilized. Another improvement involves the gear ratio. Since there is a very small range of motion, there is little vertical movement of the weight stack. The cable system could be modified to produce a large weight displacement for a small shoulder movement, with the anticipated improvement in the smoothness of machine operation.

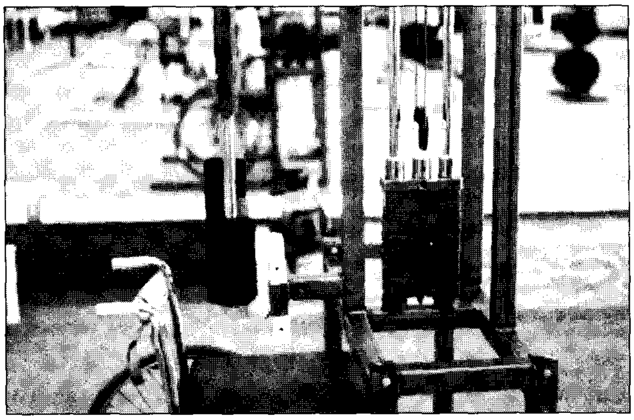

Figure 2.11. Another view of the Wheelchair Accessible Reverse Pec-Dec Machine.

Disabled Rock-Climber's Knee Orthosis

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Client Coordinator: Gabe Berbic
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INTRODUCTION

An externally worn knee orthosis has been designed for the physically challenged which enables those with weak or paralyzed legs to participate in the sport of rock-climbing. The device consists of a modified knee orthosis with an attached appliance consisting of four metal support bars, a ratchetting joint made with technology appropriate to the sport, culture, and environment, and a lock release mechanism. The orthosis is worn on the leg with the appliance located lateral to the actual knee.

During normal rock-climbing, the act of raising one's foot upward to a toehold is almost always followed by a concurrent raising of the body and a straightening of the leg. The appliance described herein allows the disabled individual to simultaneously release the locking mechanism, raise the knee manually with the hands, and place the toe on the hold. The ratchetting mechanism re-engages automatically upon release by the hands. As the climber pulls himself upwards with the hands and arms, the orthosis prevents the leg from flexing further so that the climber can support much of his weight on the leg. The ratchetting mechanism of the orthosis allows knee extension to proceed freely but prevents knee flexion. Thus the climber can aid the knee in extending by pushing on the leg with the hands, or if the hold is large enough, by simply unloading the leg and pulling the trunk upward.

SUMMARY OF IMPACT

Disabled athletes who have lost the use of one or both legs need not exclude themselves from rock-climbing and rappelling activities. An extraordinary case in point was Mark Wellman's ascent of El Capitan, a 3500 foot vertical wall in Yosemite National Park. Mark Wellman's method, however, involved ascending a rope rather than the rock. The disabled rock-climber's knee orthosis designed here enables rock-climbing to be performed in its purest form, that is, the rock itself is climbed without reliance on artificial hand and footholds. Rather than have the legs hanging as dead weight, this device allows significant body weight to be transferred to the legs so that the upper body can rest. The disabled rock-climber's knee orthosis will allow certain disabled persons to become involved with the increasingly popular sport of rock-climbing, whether at indoor "rock gyms" or outside at rock-climbing areas.

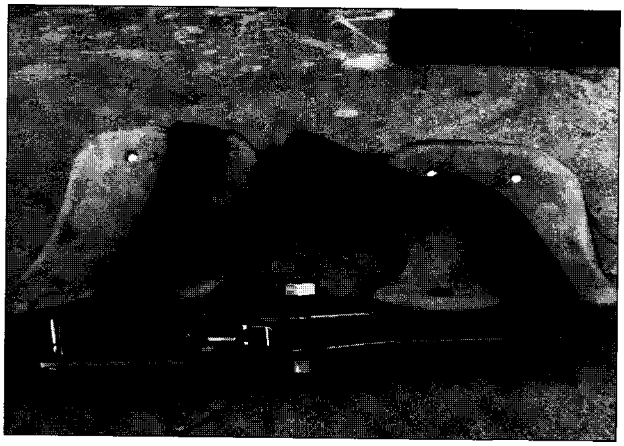

Figure 2.12. Disabled Rock-Climber's Knee Orthosis.

TECHNICAL DESCRIPTION

The knee joint was designed with a particular student-client in mind, but could be both beneficial and recreational in a variety of activities. The main design philosophies guiding the development of the knee orthosis were to: 1) allow for actual rock-climbing (not rope climbing) by allowing the legs to be used in weight support; 2) use the legs as an asset rather than letting them drag; 3) be efficient and reliable in function; 4) be comfortable, light in weight and sleek; 5) be aesthetic in appearance; 6) utilize appropriate materials for the mountaineering environment and subculture; and 7) be easy to build and maintain. All of these items were met in principle, and can be easily improved upon with subsequent design iteration.

The knee orthosis consists of upper and lower leg pieces (from a standard orthotic knee brace) which wrap around the leg and are secured with hook and pile straps. These leg pieces are connected to each other by rigid plastic struts which extend halfway up the thigh and halfway down the calf on both medial and lateral sides of the knee. The lateral strut with built-in joint was removed and replaced with the designed apparatus. This apparatus incorporates a toothed, spring-loaded steel cam (extracted from a mountaineering rope ascender) that engages with a fixed rope wrapped about a pulley. The arrangement creates, from standard climbing hardware, a ratchetting joint that only allows the leg to extend unless the cam is disengaged by a manual tug on the release cable. A $\frac{3}{8}$" bolt serves as the axle of the pulley and defines the axis of the joint. The pulley itself is sandwiched between rigid steel struts bolted to the leg pieces above and below the joint. The cam is also pinned to the steel struts creating a robust and positive locking mechanism. A 7mm rope is wrapped snugly around the top of the pulley and tied to the two bottom $\frac{1}{4}$" bolts.

When the cable is released, the spring forces the cam to engage the perlon rope wrapped around the pulley. Loading the knee in flexion causes the cam to jam more tightly against the rope and thus prevents further flexion. After the outer sheath of the rope becomes worn with repeated flexion-extensions, it can simply be retied in a slightly different position to expose a fresh rope surface. A 1” tubular webbing handle attached to the support bars just above the knee joint is used to pull the leg up onto higher ledges. The lock release cable is also attached to the handle to release the lock as the leg is hoisted higher. A bilateral user raises one leg at a time using the other extended leg to rest upon. After lifting one leg to a higher ledge, both arms are used to pull the climber up. As the climber proceeds upward the bent leg can straighten under the action of gravity, or it can be forcibly straightened by pushing downward with the hands. During rests, the knee orthosis will support body weight at any knee flexion angle without collapsing.

Tests were conducted by volunteers. It was determined that the posterior straps for the upper leg piece did not keep the upper leg piece tightly fitted to the thigh. This allowed the knee to flex more than desired even though the joint locked properly. This problem should be alleviated in future designs by adding a curved posterior plate to the upper leg-piece that will serve to distribute the load borne by the posterior thigh over a greater surface area.

The final cost of the disabled rock-climber’s knee orthosis was approximately $100 above the cost of the knee orthosis (one was donated for this project by Prosthetic Orthotic Associates, Scottsdale, AZ).

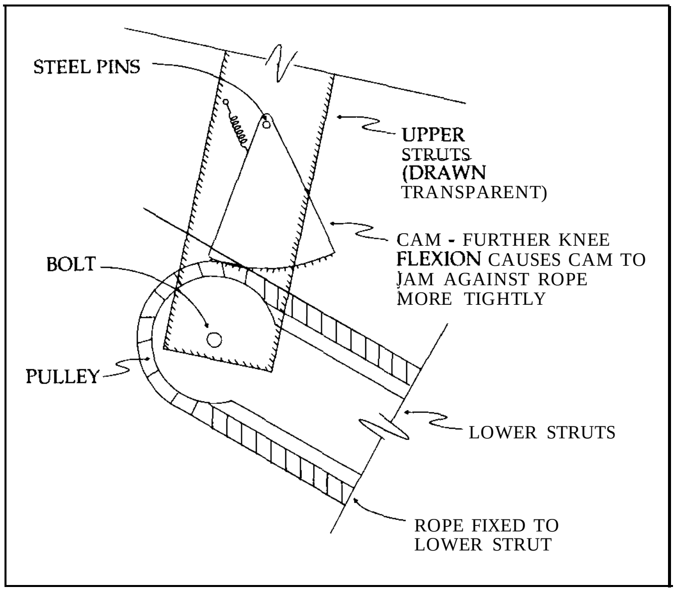

Figure 2.13. Diagram of Disabled Rock-Climber’s Knee Orthosis.

A Busybox for a Disabled Child

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INTRODUCTION

A busybox is a device that contains activities to help children with their eye-hand coordination, academic skills, and social skills. This busybox design contains three sections; each of the sections is removable. The first section consists of numbers and holes. The child puts the correct number of pegs into the holes corresponding to the number. The second section contains three shapes that are inserted into the correct location. This section also contains a zipper and different colored pictures. The zipper will help the child's fine motor skills and the colored pictures will help her learn her colors. The third section contains clothes buttons of different degrees of difficulty. In addition, there are two Morse-code buttons. The Morse-code buttons are for the teacher and student to play a game to help the child's memory and concentration.

SUMMARY OF IMPACT

This busybox was designed for Lisa, a seven-year-old first grader. Lisa is both academically and socially slow. In addition, her eye-hand coordination is also impaired. The busybox has proven to be beneficial since it was designed to look more like a toy than an educational device. Because of the enjoyable design, all the other children (in addition to Lisa) also want to play with the box. Lisa is now more self-motivated, as opposed to being externally motivated (that is, teacher motivated).

It is also important that the busybox be easily modifiable as Lisa's needs change. Due to this requirement, all of the busybox sections are readily changeable. The colored pictures on the box are attached with Velcro, and therefore can be changed daily. The colored pictures are designed so that Lisa can write the letter corresponding to the first letter of the picture; these letters are easily erased. When Lisa is finished using the box for the day, all of the pictures, pegs, and shapes are easily stored inside the box. This reduces clean up time, and more importantly, reduces the chance of losing items.

The busybox was designed to be used with teacher-student interaction. This is very important since the box improves Lisa's mental and physical skill, but her social skills also need improvement. Therefore, through cooperative learning with the busybox, it is hoped that Lisa will be able to better interact with the other students in her class.

TECHNICAL DESCRIPTION

The busybox was designed with a particular learning disabled student in mind. The main design requirements are: 1) safety; the teacher or student should not get hurt from the use of the busybox, 2) ease of use by both teacher and student, and 3) readily adaptable. Moreover, the device should encourage the development of the student's social and academic skills, stimulate the student's thinking, and be fun for the student to use.

The busybox is rectangular in shape, with dimensions of 13"×19"×3". The busybox was made from $\frac{1}{2}$" plywood; plywood dividers separate the sections. The plates from each section can be easily removed and replaced by closing the latch which holds them in place.

Each peg is $\frac{3}{8}$" in diameter, a size that can be easily grasped by the student. The holes are drilled at $\frac{3}{8}$" to provide moderate difficulty in placing the pegs in the holes. The numbers are standard 3" stickers made for external use. The square peg is 2"×2"×2", and the triangle peg is 2" wide and 2" deep. The circle has a diameter of $2\frac{1}{2}$" to prevent it from fitting into the square. The three buttons are of varied size and difficulty and can be easily changed. The Morse-code buttons consist of a 9-volt powered piezoelectric buzzer that is attach to a pressure switch.

The battery and speaker are attached directly to the bottom of the plate.

The busybox frame was made by the wood shop at ASU. All the attachments and the wood stain were applied by the student designer. Prototype tests were done in the classroom with a preliminary version of the busybox, and used to improve the eventual design.

The final cost of the busybox was approximately $65.


S. VALENTA