CHAPTER 3

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"Ice Crampon Crutch Attachments"
Adaptive Ice Climbing Equipment
for an Above-Knee Amputee

Designers: Wade Meyer, Lars Chrisman, Erik Stam
Faculty Advisor: Dr. R. J. Conant
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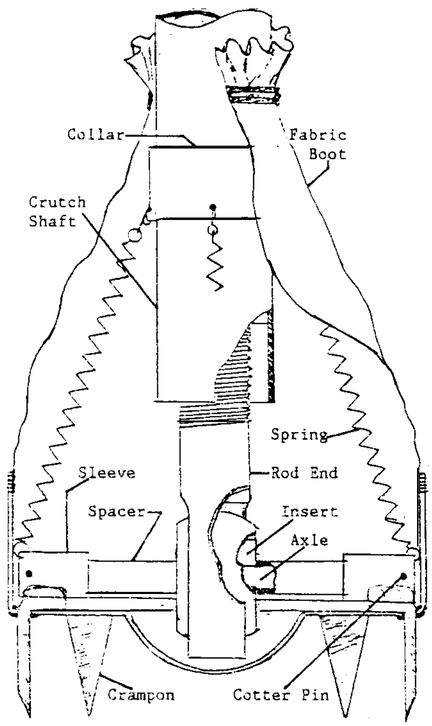
INTRODUCTION

The ice crampon crutch attachments are designed to allow an above-knee amputee to pursue the sport of ice climbing by providing positive, no-slip contact with an ice or hard packed snow surface. This is accomplished by modifying standard ice crampons so that they can be attached to the base of a pair of Loftstrand crutches. In order to maintain maximum contact with the ice surface the crampons are not mounted rigidly to the crutch but are allowed to pivot, much like a human ankle. Springs return the crampon to a neutral position after pivoting.



VIEW LOOKING FORWARD

SUMMARY OF IMPACT

Our client had the following comments:

"The crampons allow me to ski terrain which can only be reached by climbing and hiking. For the first time I have the mechanical means which allow me to climb major peaks such as Mount Rainier, Dinali and peaks in Nepal.

I have never had adaptations which I felt were dependable and designed for maximum use in harsh conditions. These crampons are lightweight and give a sense of security and dependability. These are important factors, especially when I'm in a situation where the lack of these factors can be dangerous and physically and mentally draining.

Finally, the ability to climb large mountains and ski steep terrain is in keeping with my love for adventure and the excitement of pushing myself to a new limit. These are important elements in my life."

TECHNICAL DESCRIPTION

This device was designed around a pair of Salewa 2 piece adjustable crampons. The rear piece was discarded, leaving 8 points to contact the ice surface.

Previous ice climbing by our client was done with a pair of crutches with crampons welded to them. Since the crampon was rigidly attached to the crutch, the crampon could not pivot to conform to the slope of the surface. Consequently, on moderately steep slopes, where maximum contact is desired to provide the greatest support, not all of the points of the crampon were in contact with the surface. The weld joint between the crampon and the crutch was also an area of high bending stress, and both crutches ultimately broke at this location. In order to avoid these problems it was decided to allow the crampon to pivot at its attachment point with the crutch. It is essential that the pivot point be located as close to the ice surface as possible. Otherwise, the vertical forces acting at the pivot point through the crutch will tend to roll the crampon over. A 5/8" rod end with spherical bearing (obtainable at bearing supply houses) was chosen as the pivot device over other devices (such as a ball and socket or a universal joint) because it enabled the pivot point to be located at the top of the crampon . . . essentially on the ice surface.

The rod end is attached to the crampon by an axle which passes through the spherical bearing of the rod end and through sleeves welded to the crampon. Spacers keep the rod end centered on the crampon and the axles are retained by cotter pins through the sleeves. The amount of movement of the crampons in the roll direction is determined by interference between the axle and the rod end housing. In order to maximize this movement a 5/16" axle is used and the bore of the spherical bearing is reduced from 5/8" to 5/16" with an insert.

Four springs attached to the crutch shaft and to the front, back and sides of the crampons serve to return the crampon to position perpendicular to the crutch shaft when it is lifted from the ice surface. Spring tension is adjusted by sliding the collar attaching the springs to the crutch along the length of the shaft.

The crampons and rod end assembly are covered with cordura nylon fabric to keep snow and ice out of the pivot mechanism. The portion of the cover on the underside of the crampon also serves to distribute the load when the crampon is used on snow, thereby limiting the amount that the crampon sinks into the snow.

Ice crampons typically are made from hardened steel and come with a hard epoxy finish. Welding of hardened steel results in a weak weld joint and also weakens the parent metal. Therefore prior to welding the epoxy finish should be burned off with an oxy-acetylene torch, and the crampon then annealed. After welding the crampon is austenitized and tempered to regain its original strength.

The cost of the ice crampon crutch attachments is about $220.00, excluding the Loftstrand crutches. Of this amount about $120.00 is for parts and the remainder for labor.

"Touch Window Lower-Case Letters and Shapes"
Drill and Practice on Lower Case Letters
with A Touch Sensitive Device

Designer: Jim Gartzka
Rehab Professional: Linda Botten, OTR, Occupational Therapy
Associates of Bozeman & Livingston
Supervising Professor : Donna McClelland
Computer Science Department
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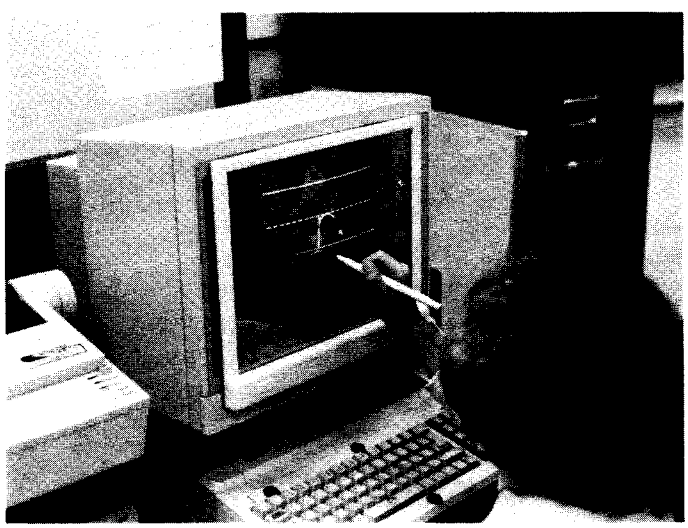
INTRODUCTION

The Touch Window Lower-Case Letters and Shapes programs display a lower case letter or a shape on the monitor of an Apple II computer. A person then traces a letter or shape. The program tests the trace to determine if the person has followed the correct pattern and if the pieces have been traced in the correct order and direction. A successful trace is indicated by the picture disappearing and a happy face being displayed.

The programs will be used by children or adults with mobility impairments to practice forming the lower case letters of the alphabet.

SUMMARY OF IMPACT

Clinically, this tool is very effective. It provides the child with a sensorimotor feedback approach to learning. The see, they hear, they feel. They must hold their pen using a mature pencil grip, place adequate pressure, and evidence good visual motor control to do their letters correctly. This is important feedback for these children with motor difficulties. Children enjoy working independently and this allows them that freedom but still gives them feedback as to whether they have completed the task accurately.



TECHNICAL DESCRIPTION

The Letters and Shapes programs use a Touch Window (manufactured by Personal Touch, a Division of EDMARK Corporation) as the input device. This touch sensitive device fits over the monitor on any Apple II series computer. The Touch Window attaches to the monitor with Velcro tabs and plugs into the game port. If there is no external game port on the computer, most Apple dealers can provide an adapter for a minimal charge. Personal Touch markets a Toolkit for the Touch Window that provides the interface programs for developing software utilizing the Touch Window.

The Letters and Shapes programs were developed on an Apple II-Plus computer using BASIC to create the graphics images and control programs. Adding the interface code with the Touch Window was carried out on an Apple IIGS using the Toolkit.

The programs are stored on five diskettes. Each diskette is bootable with four diskettes providing portions of the alphabet (a-g, h-n, o-t, and u-z) and the fifth diskette providing the shapes. To use any of the programs, insert a Letters/Shapes diskette in the disk drive. Turn on the computer (or perform a warm boot) to load the program. An introduction message will be displayed followed by a request to "Press any Key". The next screen is a two option menu (Run the program or Quit). If the Run option is selected, the next screen is a calibration screen for the Touch Window. This is the same calibration screen that is used with all programs using the Touch Window. Two plus signs will be displayed one at a time. The person touches each spot to complete the calibration. The program is now fully loaded and the hardware is calibrated. The next screen is a menu of letters or shapes. After the person selects one of the letters or shapes, the object is displayed.

The letters are displayed between two solid lines with a broken line mid-way between them. This is patterned after the paper used by children when they start learning to form letters. The person must know the correct starting position and direction for tracing each letter. (The definition is according to the D'Nealian writing style.) If the person lifts the pencil, a beep is heard. If the person moves outside the error limits for forming the letter, starts in the wrong location, omits a part of the letter, or traces the pieces in the incorrect order or direction, a different beep is sounded. This tells the person to restart the letter. Upon completion of a successful trace, the screen goes blank and then a happy face is drawn.

After successful complete of a letter, the person can press any key to trace the same letter again or can press the ESC key to return to the menu of letters. The ESC key can be used at anytime to return to the menu.

Running the shapes program is identical to the letters programs except in the following areas:

a. When the shape is displayed, the starting point for tracing the shape is shown on the screen.
b. All horizontal lines are traced left to right.
c. All vertical lines are traced top to bottom.
d. All curved areas are traced clockwise.
e. When a mistake is made, the picture is erased and then displayed again. This tells the person to restart the trace.

The Touch Window currently sells for about two-hundred dollars. To obtain the Letters and Shapes programs, contact Nancy Procter, Department of Mechanical Engineering, Montana State University, Bozeman, MT, 59717. The only cost for the programs will be a handling fee to cover purchasingdiskettes, reproducingdiskettes, and mailing.

"TRI-SCOOTER"
A Mobility Device for a Child
with Arthrogryposis

Designers: Debra Follensbee, Dean Markiss, Cary Munger
Rehab Professional: Arlene McKinnon, RPT
Bozeman Physical Therapy Center
Supervising Professor: Dr. R. Jay Conant
Department of Mechanical Engineering
Montana State University
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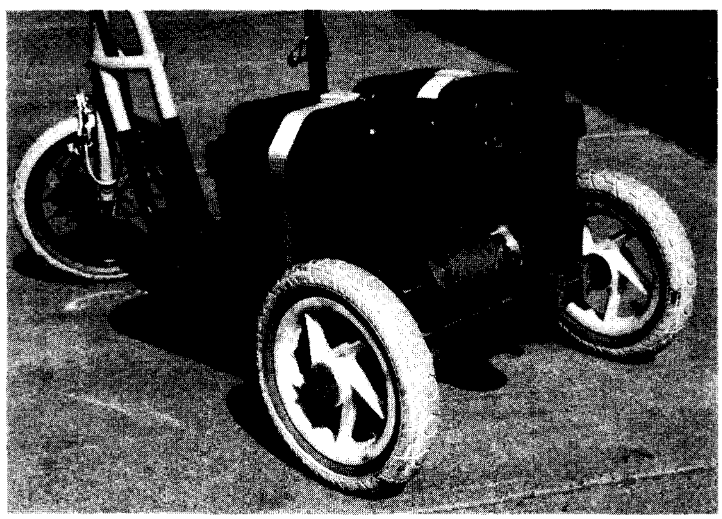
INTRODUCTION

The Tri-Scooter is a mobility device that can be used by handicapped individuals who have difficulty in using a standard wheelchair because of reasons resulting form the inability to bend the leg at the knee, thus making indoor maneuverability in a seated mobility device awkward and difficult. The tri-Scooter is also ideal for handicapped children since this mobility device is much less stigmatic than the standard wheelchair. In addition, the fact that the device is powered and yet simple to operate provides reliability and independence to its handicapped operator.

Commercially available devices that meet the requirements of the handicapped individual with "fused" knees are virtually nonexistent, and devices that do exist that might be adapted for this use are expensive to purchase and are too complex for their intended use.

SUMMARY OF IMPACT

The child for whom this scooter was designed has already demonstrated success with the operation and steering of the scooter and has also stated that she is very pleased with the scooter. This child will be able to use the device for school outings such as field trips and possibly some mobility within the halls of the school building, for recreational activities such as outings with peers and family, and for activities that will increase her independence such as going to the store by herself. The design of the device makes it a sturdy and rugged device so that this child will be able to use the scooter for many years.



TECHNICAL DESCRIPTION

The three wheel scooter in this design is an alteration of a commercially purchased two wheel scooter found in any bike shop or department store. The rear wheel is cut off and an additional wheel purchased to allow for the creation of a three wheel cart. The existing frame is modified by the addition of lightweight chromium-molybdenum tubing (used in bicycle frames) to allow for the structural support of the wooden base. Due to the desired seated position, rather than the standing position used in the scooter, the entire steering assembly is removed and re-welded in a lower position. The scooter is designed to be 25 inches at the widest point which allows more than ample room to easily navigate through doorways and yet provides sufficient stability against tipping. The scooter has an overall length of 50 inches so that it can access any normal wheelchair lift. The seat is designed to be adjustable in height to increase the usefulness of the mobility device over time.

A D.C. electric motor powers the left rear wheel via two sprockets (tooth ratio=3:1) and a chain. The electric motor draws its power from two 12 volt deep cycle batteries. The batteries are encased in battery boxes which protect the user from acid spills, prevent accidental battery terminal shorts, and allow for easy removal of the batteries for transportation of the mobility device. The battery boxes are strapped to the scooter during use with quick release straps to prevent slipping.

Propulsion is achieved by pressing a button located on the left grip of the handlebars. The switch is spring loaded so that the user must constantly hold down the button to allow power to reach the motor. This will cause the scooter to stop should the left hand be removed from the handlebars thus introducing a safety factor if the operator momentarily loses control of the device while in motion. A disc was machined for the button surface to create a larger contact area and allow the operator to use the palm or fingers to press the power button.

Braking is performed with the right hand using a standard braking system, found on all bicycles, provided with the commercial scooter. The brake-on-the-right, power-on-the-left configuration was chosen since the this child's right hand is her stronger hand and thus a brake on this side is safer.

To insure that the child will not be required to dismount the scooter to overcome obstacles, a forward/reverse switch is incorporated between the handle bars to allow for increased maneuverability especially inside buildings.

The Tri-Scooter is designed with two speeds to allow the scooter to have inside-outside usefulness. A switch toggles the system between 24 volts (series batteries) and 12 volts (Parallel batteries). When the motor is powered by the twelve volt system it travels at speeds between three and four miles per hour, which is adequate for any indoor application. In addition, the increased current provided by the parallel connection will increase the power output, of the motor allowing for increased performance and pull on hilly terrain. When the motor is powered by the 24 volt system it can achieve a maximum speed of 6.8 miles per hour. This speed is too fast for indoor applications but is convenient for outdoor uses when traveling from point to point.

A key switch added to the scooter cuts the power to the motor and thus insures that the device will not be tampered with when not in use.

A standard automotive battery charger was altered to allow the mobility device to be plugged into a charging system without the need for connecting and disconnecting battery cables.

The overall cost of this device, not including labor! is approximately 500 dollars. The major expenditures, in order of decreasing cost, are the batteries, the scooter, the motor, and the charger. These components account for well over half of the overall cost of the mobility device.

The overall weight of the device is about 150 pounds with the two batteries accounting for over 100 pounds. Thus when the batteries are removed the device can be easily placed in a van or pickup for transportation.

"Support Walker"
A Walker Designed for Handicapped Children that are too Small for Commercially Available Walkers

Designers: Paul Chausse, Keith Meadows, Jim Olszewski
Rehab Professional: Linda Botten, OTR, Occupational Therapy Associates of Bozeman & Livingston
Project Adviser: R. Jay Conant
Mechanical Engineering Department
Montana State University
Bozeman, MT 59717

INTRODUCTION

The Support Walker is an adaptation to a commercial walker for non-handicapped children. Because there are no commercially available walkers for small handicapped children, they are forced to wait until they are bigger before they can start developing the muscles and coordination needed to walk. This device allows these children to begin learning to walk at the same time non-handicapped children begin walking.

The Support Walker consists of a commercial walker that has a backboard and a trunk support built onto it for upper body control. The trunk support is connected to hinges that allow a person to open and close the supports around the child. The hinge is attached to the backboard with velcro so that it can be adjusted to the proper location on the child.

This device will primarily be used in therapy to help the child develop his muscles and coordination. Once he has developed these skills, the device can be used in the home to aid the child in moving around the house.

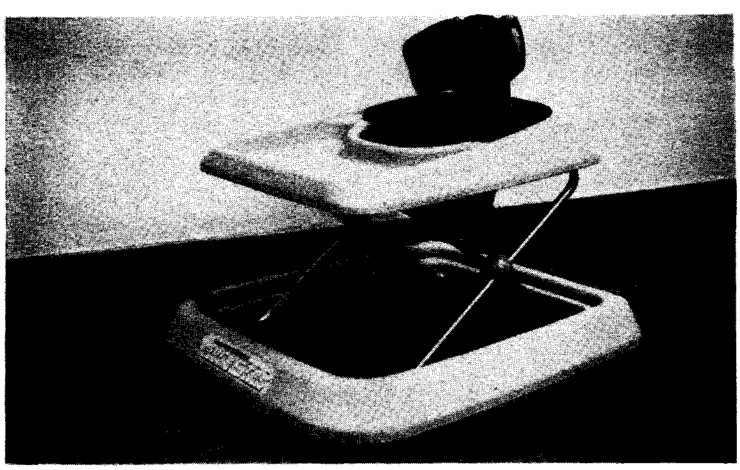
SUMMARY OF IMPACT

The child for whom this walker was designed has cerebral palsy which does not allow him to walk or stand independently. This is due to decreased stability of his upper trunk and hips, and decreased strength of his legs and ankles.

Therapeutically supported dynamic standing would improve his stability and stimulate the extensor musculature allowing him increased stability throughout his body. Currently there is no appropriate commercially available standing device to suit his needs.

The walker which was adapted for this child enables him to stand erect with proper support, to place weight symmetrically on his feet and to improve his visual focus to look upright. He not only has improved his ability to bear weight but also has improved his upper trunk extensor muscle tone to keep his head erect.

This walker will continue to be beneficial as he begins to shift weight in standing, and to gain strength in his legs as he bears weight on his feet.



TECHNICAL DESCRIPTION

The walker itself is a standard commercial walker for small children that is available in most department stores. The only requirements that this walker must meet are the maximum weight and the tray surrounding the child.

First, the child must not exceed the maximum weight that the manufacturers set for the walker. There are a variety of walkers available and a walker should be chosen to allow the child some growing room. Second, the tray surrounding the child must be durable. The reason for this is that the backboard is connected directly to the back of the tray and it must be strong enough to support it.

The backboard consists of a 4" x 10" x 1/8" steel plate. Seven and a half inches from the top of the backboard is a 1" x 2" x 3/4" steel plate welded perpendicular to the first piece. The backboard is then padded and bolted to the back of the walker.

The trunk support is made up of two pieces of 1/8" aquaplast thermoplastic and two hinges. The thermoplastic is approximately 3" wide and 7" long. When the thermoplastic is set in hot water it becomes very pliable and can easily be formed to the child's upper body. As it cools it then becomes rigid and stays in its predefined form. The thermoplastic is then riveted to the hinges which have been welded together. The hinges are used so that the rigid thermoplastic can easily be opened and closed around the child. Sleeves have been attached to thermoplastic pieces. Velcro has been attached to the sleeve which is used to connect the two pieces of thermoplastic. This provides the necessary upper body support to keep the child in an upright position.

The trunk support is then connected to the backboard with the use of velcro, A strip of velcro has been attached to the length of the backboard and to the hinge. This has been done so that the trunk support can be adjusted to the proper location on the child.

The seat of the walker has also been modified for this device. Using the seat that comes from the manufacturer, the child sits too deep in the walker for the trunk support to function. Therefore, the seat has been modified in such a way that the child sits higher in the walker. The seat is also adjustable so that the height of the child and the trunk support can be located in the optimum position for therapeutic reasons as well as the comfort of the child.

The final modification of the device is to the commercial walker itself. In some cases it may be necessary to raise the walker. In this case, spacers can be placed on the underside of the tray, between the tray and the cross member bars. Three inches should be the maximum needed. If more is needed, the child will fit into a commercial walker.

The total cost of the support walker is two hundred twenty-nine dollars and thirty-nine cents ($229.39). The seat modification had a total cost of eighty-three dollars ($83): eight dollar for material and seventy-five dollars for the upholstery work. The backboard had a total cost of fifty dollars ($50); forty dollars for the steel and machining costs and ten dollars for the upholstery work. The trunk support cost a total of forty-six dollars and thirty-nine cents ($46.39): eleven dollars and sixty cents for the thermoplastic, thirty dollars for the labor of the therapist to form the thermoplastic and four dollars and seventy-nine cents for the hinges and strapping. Finally, the commercial walker that was used had a total cost of fifty dollars. The cost of this device can easily be reduced in many areas. The cost of the walker itself may be reduced by buying a different brand. The machining and upholstery costs can be reduced by having non-professional people perform the necessary tasks.

MECHANICAL WHEELCHAIR RESTRAINT
A Mechanical Device for Locking a Wheelchair in the Driver's Position of a Van

Designers: Alan Johnson, John Clairmont, Jason Cunningham
Rehab Professional: Mike Mayer, Director, Summit Independent Living Center, Missoula, MT
Supervising Professor: Dr. R. J. Conant
Department of Mechanical Engineering
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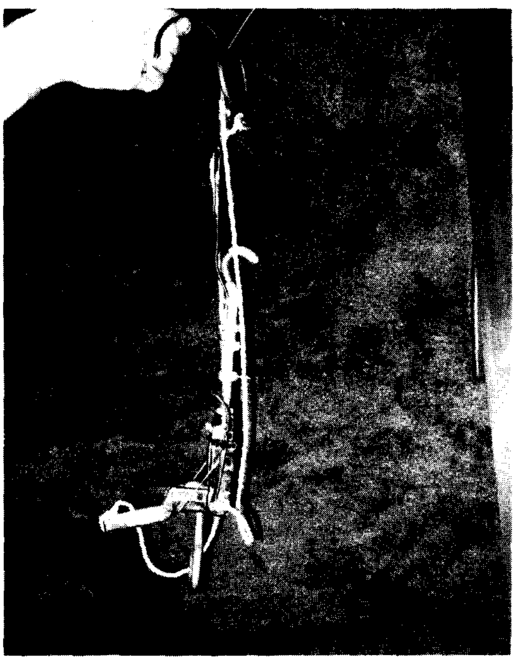
INTRODUCTION

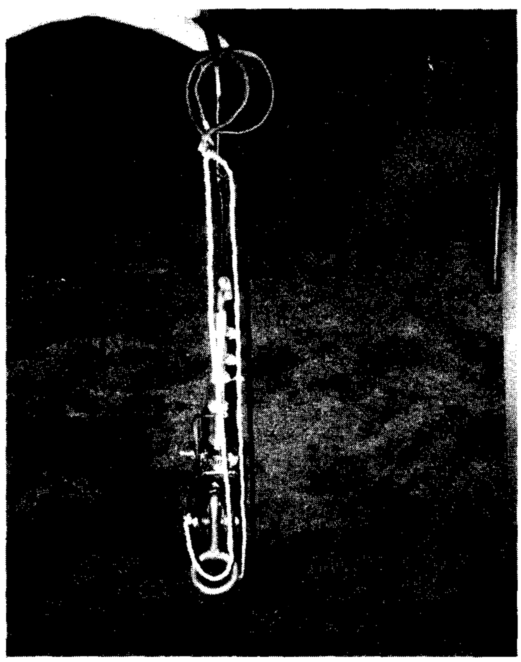
The wheelchair restraint is a device which is used to hold a manual wheelchair stationary in the driver's position in a van. The primary component of this device is a Golden-Boy over-center locking mechanism. The upper end of the apparatus mounts to a bracket on the chair between the user's legs. The lower end hangs down to the van floor. When the chair rolls into the driver's position (i.e. up to the steering wheel), a grommet slips ***over*** a floor mounted hook. The user then simply pulls up ***on*** a handle which activates the locking mechanism. When the user is ready to move away from the steering wheel, a second handle is pulled which activates a release mechanism.

The device will be used by a person with advanced quadriplegia. Commercially available hydraulic and electric devices did not meet the requirements of this gentleman.

SUMMARY OF IMPACT

Our client made the following comments regarding this device: "I am pleased with the outcome of the project. The new tiedown design allows me to fasten my chair down and release it much more quickly than was possible before. I find that I do not waste nearly as much time in operating the tiedown. Any device that saves me time or energy definitely enhances the quality of my life. The new tiedown design to date has proven very satisfactory. I am sure that it will continue to do so in the future."





TECHNICAL DESCRIPTION

The wheelchair restraint apparatus consists of 3 separate parts. The first part is a hook which is mounted to the floor of the van. This hook is 3/4" in diameter at the base and tapers to 1/4" at the tip. Due to the limited vertical clearance of the user's wheelchair (the bottom of the solid footrest is less than 2" above the floor), the hook was designed to be 1.5" high with an inside diameter of 1". The base of the hook is threaded and fits through a 3/4" hole in the floor of the van. It is held in place by a lock washer and nut.

The second piece of equipment is a Golden-Boy over-center device. Certain modifications were made to this device to facilitate its use. The first is the attachment of a grommet to the bottom of the device. When in the secured position, this grommet attaches to the hook that is mounted in the floor. This grommet has an inside diameter of 1.35" and is constructed of .25" steel. The next modification is the mounting of a stopping mechanism which prevents the lever arm from falling past a position where it would no longer be parallel with the floor. This enables the grommet to be in a set position while the device is moving forward to attach to the hook. Attached to the end of the lever arm is a nylon rope which is used to lock the device. The rope is threaded through a series of eyelets mounted on the threaded shaft of the device. These eyelets insure that the rope doesn't become entangled with the apparatus or the release line. The release rope is attached to a lever which is mounted on the device with a hose clamp. When the handle on the release line is pulled, the release mechanism pushes the lever arm out of the locked position. The release rope is also threaded through a series of eyelets similar to the locking rope. The last modification to the over-center device is the attachment of an extended handle to the threaded shaft with two small hose clamps. This enables the user to more easily hook the device through a plate that is mounted on the wheelchair.

The third and final part of this apparatus consists of a .25" thick steel triangular plate mounted to the user's wheelchair. This plate is mounted between the user legs on a bar that extends across the frame of the wheel chair. The plate has a hole drilled in it through which the over-center device is attached.

For the device to operate correctly there are a few steps that must be followed. First, as the user maneuvers the wheelchair into the van, he must place the hook on the end of the over-center device through the hole in the triangular plate. This is accomplished by using the extended handle. After this is done, the user moves the wheelchair forward into its final position. While the user is maneuvering forward, the grommet slides along the floor and comes to rest underneath the hook. The final step in securing the wheelchair is pulling on the handle of the locking rope. This pulls the lever arm up and locks the over-center device. The handle on the release rope is pulled after the user has reached his final destination. Then the user can back the wheelchair out of the driving position.

The cost of the total apparatus is $250. This includes the cost of the Golden-Boy over-center device and also machining costs.

The modifications to this device were designed with a particular user in mind. Since this is the case, the apparatus may have to be varied to meet the needs of different users.

"Spring-Assisted Leg Extender"
A Device to Rotate and Lock/Unlock Leg Braces Used by a Young Child

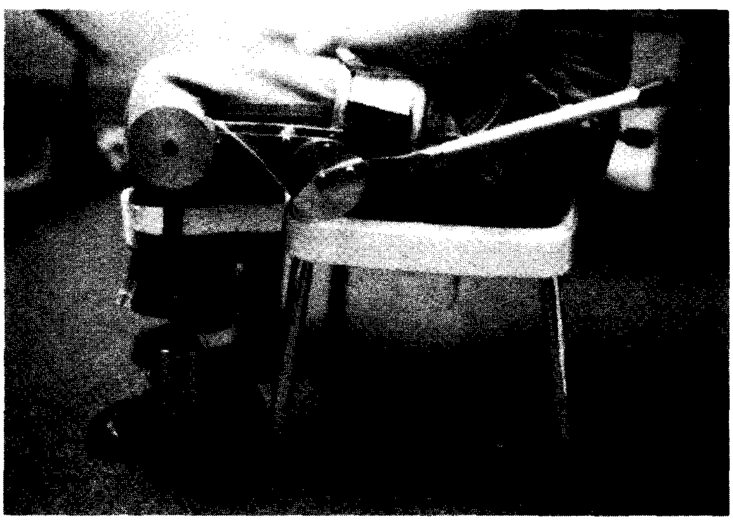
Designers: John Roy, Curt Rauscher, Charles Whittington
Rehab Professional: Arlene McKinnon, RPT
Bozeman Physical Therapy Center
Supervising Professor: Dr. Michael K. Wells
Department of Mechanical Engineering
Montana State University
Bozeman, MT 59717

INTRODUCTION

The spring assisted leg extender is a device that enables a young boy with mental retardation who walks with the aid of leg braces and a walker to extend and lock the braces independently. A lever system was designed that is attached to the standard bale lock brace. When the child is in a sitting position the lever is pushed forward causing the knee to extend and the brace to lock.

SUMMARY OF IMPACT

The client has had the knee locking devices in place for several months at this time. He is demonstrating both an understanding and a capability of locking his knee braces using this device. The child will consistently perform this activity when cued to do so and seems to enjoy the activity. A training program has been initiated to enable the child to not only lock his braces independently but to rise to a standing position independently. This design has met the criteria set for it and is allowing this child to work toward the goal of independent initiation of gait.



TECHNICAL DESCRIPTION

The locking devices are designed to attach to a pair of leg braces that use a standard bail lock. As seen in the drawing, the device consists of a lever which 'attaches to a cam that pivots about a point on the upper part of the brace. The cam pulls on a cable which is attached to a pulley mounted on the knee joint of the brace. A torsional spring which aids in the locking of the brace is contained in the pulley.

The locking device is designed to be used from a sitting position. When a force is applied to the lever the cam rotates (counterclockwise, as seen in the photograph), causing the cable to rotate the pulley (clockwise, as seen in the photograph). This action loads the spring which is located in the pulley housing. When the spring is fully loaded, continued application of force to the lever raises the lower portion of the brace toward its locked position. As the brace approaches the locked position the stored spring energy assists in the actual locking of the brace. After the braces are locked the levers can be returned to their starting position, which is parallel to the upper portion of the leg brace. The total rotation of the levers needed to lock the brace is about 100 degrees.

The pulley housing and its cover are made of aluminum. The torsional spring, which is contained in the pulley housing, is made of high carbon steel. The housing cover protects the user from getting fingers pinched in the spring. The pulley is attached to the knee joint of the braces and makes use of the existing hole in the brace, although a longer bolt is required to accommodate the thickness of the pulley housing.

The cable is a standard bicycle cable. The end of the cable that attaches to the pulley uses the connector supplied with the cable while the other end, which attaches to the cam, is fitted with a prosthetic cable end connector. A nylon sheath covers the cable.

The cam, which is made of aluminum and attaches to the upper portion of the brace through an existing hole, serves to keep the force required at the lever somewhat uniform as the lower portion of the brace is raised.

The lever consists of two parts. A stainless steel extension with one end threaded attaches permanently to the cam. The handle is made of aluminum and threads onto the extension. It can be detached from the extension when not needed. Because it is detachable the handle can also be readily replaced to accommodate growth in the user.

Each locking device weighs about a pound.

Total cost of the two locking devices is around $100.00, not including labor costs .