CHAPTER 18
UNIVERSITY OF MICHIGAN

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TELEREHABILITATION DEVICE FOR RECOVERING STROKE PATIENTS:

Designers: Bailey Fagan, Nicole Flavell, Mike Nikodemski, Tim Wilkins
Client Coordinator: Susan Brown, Associate Professor, School of Kinesiology, and Jeanne Langan, Physical Medicine and Rehabilitation Department.
Supervising Professor: Alan Wineman
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INTRODUCTION

Strokes affect more than 700,000 individuals in the United States each year; this is approximately one person every 45 seconds. Stroke patients often suffer from loss of motor control in both their upper and lower limbs. Research has indicated that upper limb rehabilitation is much slower than the lower limb, due to the immediate need to walk following a stroke. Practicing moving and squeezing objects has been shown to improve upper limb motor control and a device which helps patients do this could allow for quicker rehabilitation.

Dr. Susan Brown, professor at the University of Michigan's School of Kinesiology, has created a telerehabilitation program. This program, named Upper Limb Training and Assessment (ULTrA) is an intensive motor training program aimed at the functional recovery of upper limbs. Her research has indicated that upper limb movement has a slower rate of recovery compared to lower limbs for cerebral palsy and stroke patients. This research has led to the creation of the ULTrA program. Specifically this program's objective is to incorporate arm reaching movements, hand manipulation, and tactile discrimination tasks. A unique feature of this program is that it is designed for home use with a feedback system to the doctor via an internet connection. No program like this presently exists. Currently, Dr. Brown's program only addresses arm reaching movements. She, along with Dr. Jeanne Langan, Research Fellow at the University of Michigan's Physical Medicine and Rehabilitation, worked together to begin the creation of the hand manipulation portion of this program. This team's project was to create the device and program that will eventually become a part of the ULTrA program. Drs. Langan and Brown needed a hand manipulation program to assist patients with their ability to grasp (hold things with their entire hand) and pinch (hold things with thumb and a finger). The student team created a device and accompanying program that allows patients to practice and test their ability to grasp and pinch in their homes.

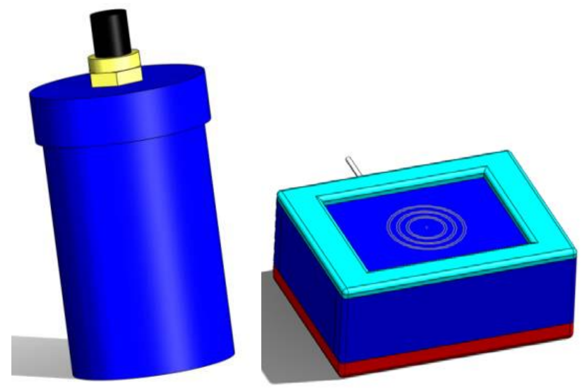

Fig.18.1. Grasping and pinching devices for telerehabilitation.

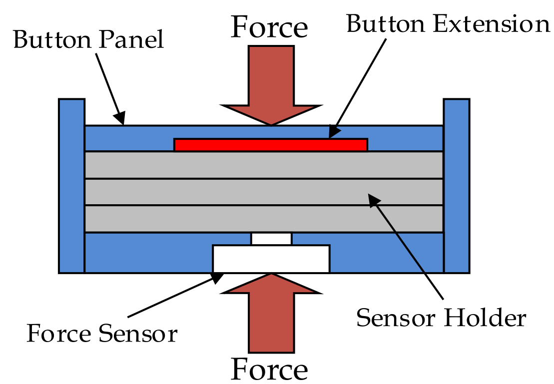

Fig.18.2. Cross section view of pinch sensing device.

SUMMARY OF IMPACT

This system will be incorporated with the ULTrA to expand the program. Initial research has indicated that no program exists that is exactly like the one that will be created. Existing programs only incorporate arm movement and not grasping or pinching force, which are essential to the patient's rehabilitation.

TECHNICAL DESCRIPTION

The grasping device resembles a water bottle but with internal sensors. The main advantage to using the water bottle design is its ability to measure the applied force regardless of where the patient applies force. The patient's applied force causes a change in pressure in the bottle and a pressure sensor reports the change to the computer. The grasping device has three main parts: the bottle, the manufactured fiberglass piece, and the pressure sensor. The manufactured fiberglass piece is a circular piece used to reinforce the top of the water bottle. This piece provides extra strength to the top of the bottle and prevents possible rupture. The pinching device is a rectangular box similar to a garage door opener remote. There are ten different fiberglass pieces that compose the pinching device. Four outer wall pieces make up the pinching device's housing. The button panel piece is where the patient applies the pinching force to the force sensor. The force sensor and the button panel are separated by a rubber plug. Two more pieces of fiberglass are used to hold the force sensor in place. These pieces also provide extra support for the outer walls and a place to insert the bolts. A square top lip piece ensures that the button panel stays inside the pinching device. The last two fiberglass pieces are the two bottom pieces. The bottom consists of two pieces to resist the button push force and to hold the device together. A section view of the pinching device (Figure 18.2) is provided to further detail the assembly. An amplifier circuit was constructed to amplify the voltage signal supplied from the sensors to the data acquisition system (DAQ). LabView was used to interpret the voltage signals and provide the user interface. The LabView user interface allows for four different modules which use the pinching and grasping sensors to rehabilitate the patient. Figure 18.3 shows a screen shot of one of the modules running in the LabView code.

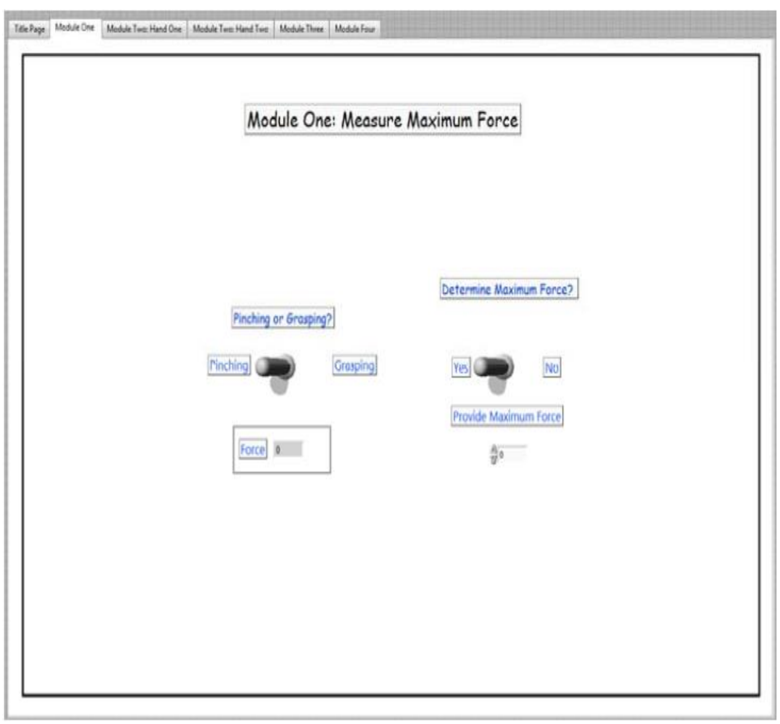

Fig.18.3. Example LabView module for maximum force measurement.

HAND TELEREHABILITATION DEVICE FOR RECOVERING STROKE PATIENTS

Designers: Coburn Bland, Claudio A. Hernandez, Justin Hresko, Sean McLain
Client Coordinator: Susan Brown, Associate Professor, School of Kinesiology, and Jeanne Langan, Physical Medicine and Rehabilitation Department.
Supervising Professor: Albert Shih
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INTRODUCTION

This project is a continuation of the Telerehabilitation Device for Recovering Stroke Patients project described previously. The sponsors wanted the telerehabilitation device to be more portable, to combine the pinching and gripping tests into one device, and to improve the aesthetics and functionality of the LabView program and user interface. The system developed is shown in Figure 18.4 as a package with sensors and cables for communication with the computer.

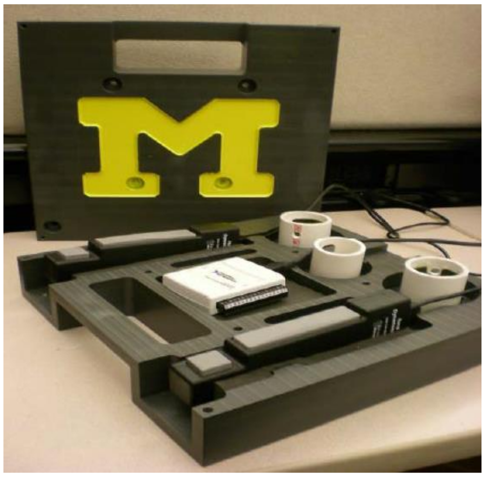

Fig.18.4. Hand Telerehabilitation Device for patients recovering from stroke.

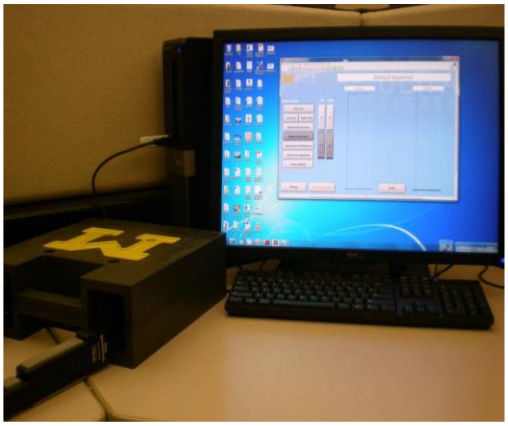

Fig.18.5. Hand Telerehab Device and Accompanying LabView program.

SUMMARY OF IMPACT

Making the telerehabilitation device more portable allows the user to practice in the comfort of their own home. This is important because the recovery period can be decreased since the user will be able to interact with the program more often if they can use it at home. Increasing the aesthetics and functionality of the LabView program helps the user stay dedicated to the program. A pleasing display and better functionality helps keep the interest of the user, making it more likely that they will complete the rehab.

TECHNICAL DESCRIPTION

The final design consists of three main components: Vernier Hand Dynamometer, LabView user interface, and a hard Transport Case with retractable force measurement devices. The Vernier Hand Dynamometer sensor ranges from 0 – 600 N and has a resolution 12 bit, or 0.2 N when used within LabView. An NI-USB-6008 DAQ from National Instruments was selected to interface the dynamometers with the LabView program. The user interface, shown in Figure 18.5, is a simplistic, centralized, and aesthetically pleasing display, which guides the user through six different modules to help with the patient's rehabilitation. The Transport Case is a high-density polyethylene case with wire retractors to retract the Hand Dynamometers and a USB cable to connect to the computer. The case body is separated into two halves; a top and bottom. Each is two inches thick with outer dimensions of one foot by one foot. The case is bolted closed during all stages of patient interaction, preventing the wiring from accidental disconnection or tampering. Users access the USB cable and Hand Dynamometers by pulling them out of the slots in the case. After use, springs retract the USB cable and Hand Dynamometers to protect them from damage. An exploded view of the protective case is shown in Figure 18.7. The wire retractors (1) are assembled in tandem with the lower half of the Transport Case. The wire retractors fit into the channels in both the top and bottom sections of the Case to fix the axis of rotation. The power spring is fixed through the slit in the stud (3) on the bottom section of the Case, and is held in place by the cap (4). Cable is passed through the hole in the wire retractor and out the top into the cable channel. All cables run through these channels and are wired into the DAQ (7). The two sections of the Case are fixed together with bolts through six fixture holes (8). The wire clips (9) are be screwed into the bottom of the Case. The cost of parts/material was about $230.

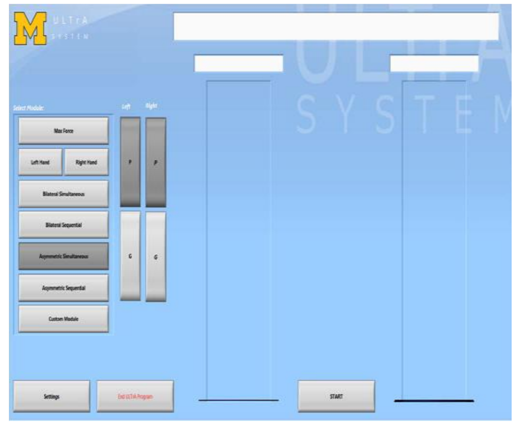

Fig.18.6. LabView user interface.

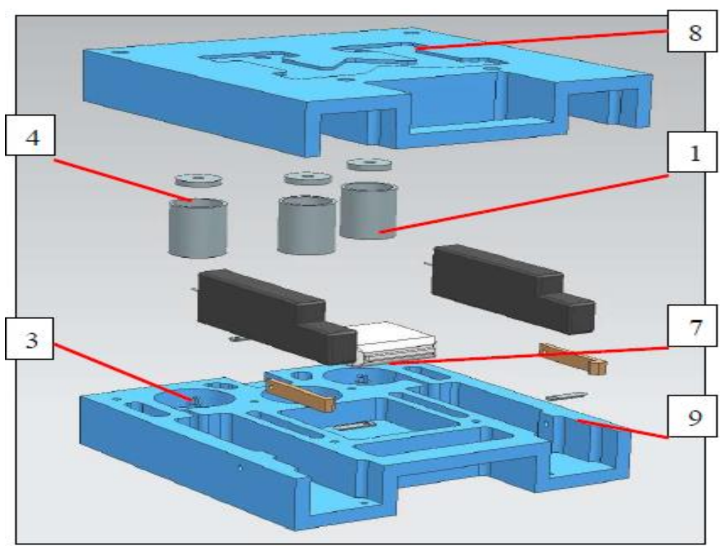

Fig. 18.7. Exploded view of protective case.

SHOWER CURTAIN FOR BATH ASSISTIVE TRANSFER BENCH USERS

Designers: Yung Leong Lee, Brandon Nichols, Adam Singletery
Client Coordinator: Naomi Gilbert, Occupational Therapist, and Susan Murphy, Assistant Professor, Physical Medicine and Rehabilitation Department, University of Michigan
Supervising Professor: Dr. Albert Shih
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INTRODUCTION

Assistive transfer devices for the bath tub help geriatric patients safely bathe while maintaining privacy, allowing them to live a more independent life. Working with Naomi Gilbert, an Occupational Therapist at the University of Michigan Med Rehab, and Dr. Susan Murphy, an Assistant professor for Physical Medicine and Rehabilitation Department at the University of Michigan, this student team improved current assistive bath transfer benches by designing a new shower curtain that closes around existing transfer benches, keeping water from spilling outside the tub while the patient is using the transfer bench. The curtain fits most bathtubs and major models of transfer benches.

SUMMARY OF IMPACT

The student team researched the weaknesses of the transfer benches in the market through online product reviews by customers. They found that efforts were made to include cuts in the transfer bench seats to allow the shower curtains to close. However, despite the efforts, the shower curtains were difficult to adjust and could not close fully; water still flowed out of the tub. The new assistive shower bench curtain contains all the shower water and allows for adjustments.

TECHNICAL DESCRIPTION

The final design of the assistive transfer bench shower curtain is an extra-long shower curtain with a "tent" cut in the middle. The final dimensions of the curtain are 107" long by 72" tall and the material used is ethylene vinyl acetate. User surveys suggested that most people prefer putting the transfer bench about 60% of the curtain away from the shower head. The team used an extra-long curtain and cut the tent in the middle to allow the user to select their ideal position, rather than just picking 60%. The tent structure was

Fig.18.8. Shower curtain designed for assistive transfer bench users.

designed to fit most major transfer benches, plus, an additional 2" of material on each side to allow room for adjustability. The final dimensions of the tent are 23" wide, 12" tall, and 5.75" long. At the end of the tent are weighted pouches. The pouches are thin PEVA pouches filled with plastic and copper pellets, sealed in the shower curtain and are approximately one pound. The curtain also has a cover flap over the tent structure to prevent water spill while the transfer bench is not in use. The cover flap has a length of 30" and a height of 26"and is attached 6" above the tent structure.

We also have a new idea after the end of the project to use two shower curtains and two shower rods to close the transfer bench. This concept was also proven feasible and a web-site will be established to demonstrate the use.

The cost of parts/material was about $120.

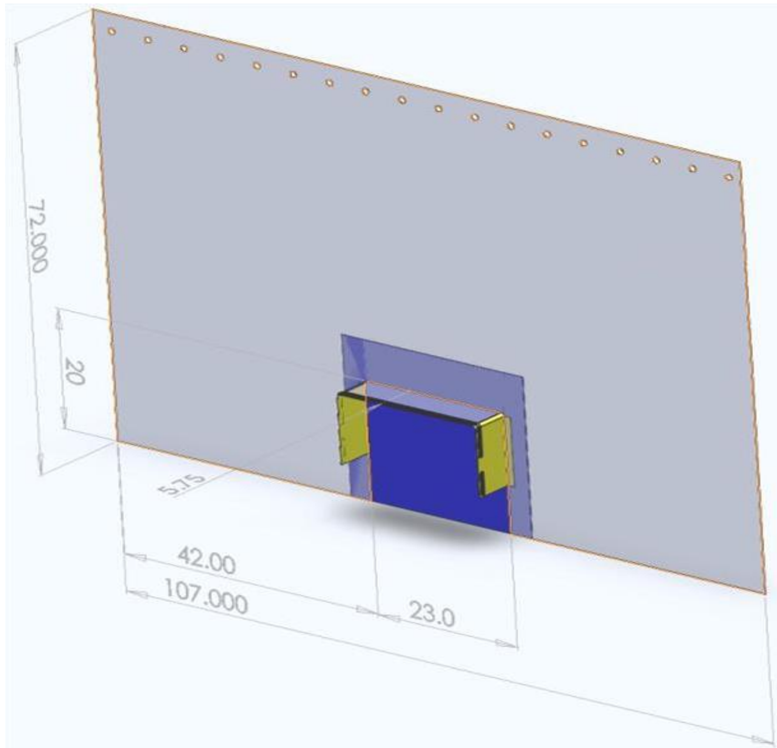

Fig.18.9. CAD picture of assistive transfer bench curtain with dimensions.

EDEMA SWELLING MEASUREMENT DEVICE

Designers: Marty Lueck, Chris Spangler, Kyle Schilling, Eric Zwart
Client Coordinator: Geeta Peethambaran Physical Therapist and Clinical Specialist, Department of Physical Medicine and Rehabilitation, University of Michigan
Supervising Professor: Dr. Albert Shih
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INTRODUCTION

Edema is swelling caused by excess fluid trapped in the body's tissues, most noticeably in the feet, ankles, hands, and face. Clinically, there is a great need to accurately measure the level of swelling to justify treatment methods to patients as well as the hospital and insurance companies. This student team worked with Geeta Peethambaran, a physical therapist at the University of Michigan Hospital, to design a new measuring device specifically for body measurements. The devices currently used are relatively low-tech, including standard, fabric tape measures. The device needs to have flexible tape to allow for accurate measurements of curves and be easy to use to allow patients to chart their progress from home.

SUMMARY OF IMPACT

The device, as shown in Figure 18.10, is a first attempt at producing a precise, easy to use, and cheap measuring device for use by physical therapists and patients. Measuring tape is an important tool for physical therapists because it allows them to chart the patient's progress, to justify the therapy methods or medication being used to treat the problem.

TECHNICAL DESCRIPTION

The exterior of the Edema swelling measurement device consists of a hard plastic case, an LCD screen, a locking button, and laminated vinyl tape with a clip on the end for measuring arms and legs. Inside the device are two wheels sitting on top of a spindle mount. One wheel functions as the locking mechanism while the other acts as the spool that the tape wraps around. The rotary encoder is connected to the bottom half of the case below the spindle mount. A steel shaft connects the rotary encoder to the main spool. The rotary encoder counts revolutions of the main spool and converts the count into a distance. The interior components can be seen in the section view in Figure 18.11. The microprocessor sits next to the spindle mount assembly and the LCD screen is recessed into the side of the plastic case.

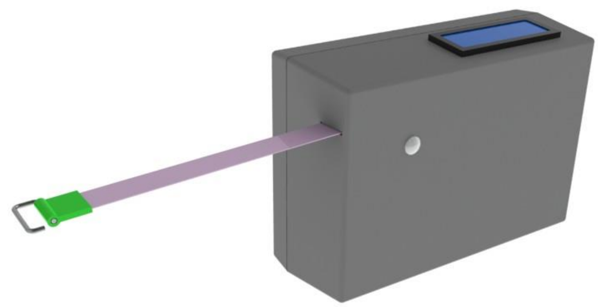

Fig.18.10. Edema Swelling Measurement CAD model.

The cost of parts/material was about $160. We have provided the drawing, design and prototype to a Taiwan digital tape manufacturer for potential commercialization. They did not respond to our request.

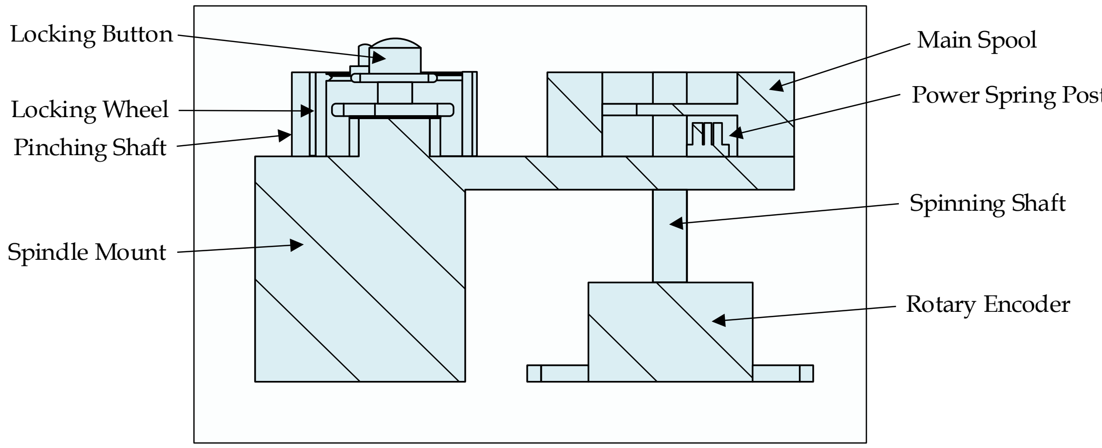

Fig.18.11. Section view showing interior components of Edema swelling measurement device.

SURGICAL LIFT WITH A SEAT FOR A NEUROSURGEON WITH SPINA BIFIDA

Designers: Aditya Chabria, Dmytro Dmytrenko, Lokesh Janarthanam, Kah Wee Liew
Client Coordinator: Dr. Karin M. Muraszko, Chair of the University of Michigan Neurosurgery Department
Supervising Professor: Dr. Albert Shih
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INTRODUCTION

This student team was tasked with redesigning a lift for Dr. Karin M. Muraszko, Chair and pediatric neurosurgeon of the Neurosurgery Department at the University of Michigan, to use during surgery. Dr. Muraszko has a mild form of Spina Bifida which hinders her mobility, requiring her to use a lift during surgery. Her father built her a lift 20 years ago but she needs a new one now. A new lift assembly was manufactured by Protomatic who supervised two previous student teams working on this project, but Dr. Muraszko demanded more change with the lift, particularly to add a seat for her during a long surgery.

SUMMARY OF IMPACT

Dr. Muraszko requires a stable seat (see Figure 18.12) because of the delicate nature of neurosurgery. There is no room for error when she is performing surgery, so the lift must minimize or eliminate bending and deflection. A stable and comfortable lift will greatly help Dr. Muraszko continue to treat her patients.

TECHNICAL DESCRIPTION

The seat design consists of a support block which attaches to the current lift, a main shaft that goes through the support block, two sleeve bearings which allow the seat to swivel around the main shaft, a locking mechanism to stop the swivel motion when the seat is in the correct position, a truss structure to support the weight of the user, and the seat. The support block is a 3 in. x 3 in. x 10 in. block placed under the platform of the lift so that it is hidden from view and lowers the center of gravity. Holding the support block in place are 6 bolts which are 0.5 in. in diameter that carry all the shear and tensile forces. The main shaft is a precision, 17 in. long and 1.5 in. diameter shaft press fitted through the precision hole bored in the support block. This shaft will remain stationary and locked while the truss structure will

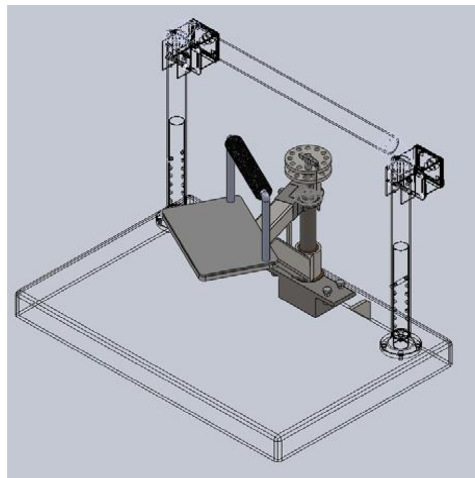

Fig.18.12. CAD drawing of the seat assembly attached to the original lift and Dr. Muraszko with the lift in operating room at University of Michigan Mott Children Hospital.

swivel around this shaft on the two sleeve bearings. The locking mechanism consists of two disks with holes drilled in them, located at the top of the shaft. The lower disk is welded to the upper part of the truss and the upper disk is bolted and fixed to the main shaft. A locking pin is placed through a hole in the top disk and a hole in the bottom disk, preventing the truss from swinging. The truss structure is made of square steel tubing to provide strength while not being too heavy. The truss structure is a common 45-45-90 right triangle. The seat attaches to the truss structure through a bearing press fit into the end of the truss, allowing the user to swivel the seat independently from the rest of the mechanism. A detailed view of the truss structure design and the locking mechanism for seat is shown in Figure 18.13.

This lift was used by Dr. Muraszko in surgery at the University of Michigan's Mott Children Hospital.

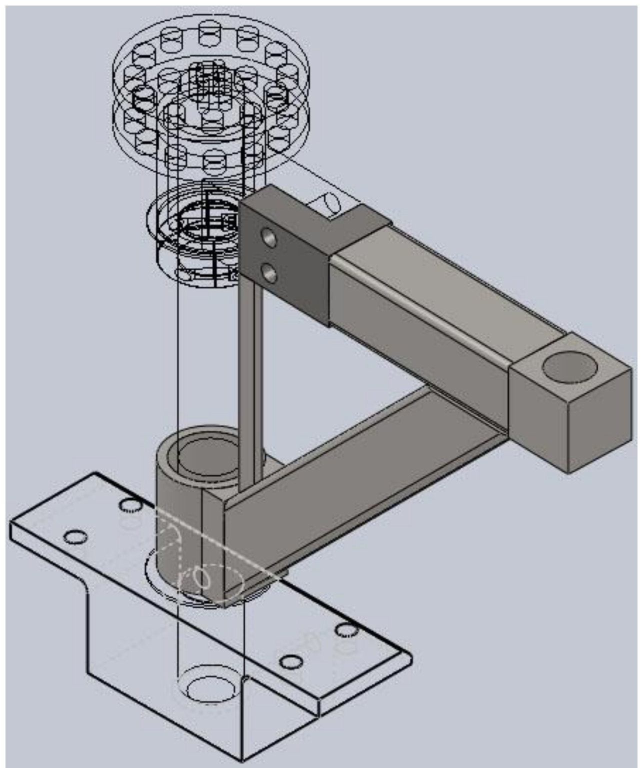

Fig.18.13. Main truss structure which allows the user to swivel.

BATHTUB SHOWER ASSISTIVE TRANSFER CHAIR

Designers: Yangbing Lou, Mitchell Polavin, Wu Xiao, Linxiang Wang
Client Coordinator: Naomi Gilbert, Occupational Therapist, Susan Murphy, Assistant Professor, Physical Medicine and Rehabilitation Department, University of Michigan, Albert Shih, Professor of Mechanincal Engineering and Biomedical Engineering
Supervising Professor: Dr. Alan Wineman, Mechanical Engineering
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INTRODUCTION

The bathroom is an inconvenient place for people with disabilities. It can get even more dangerous when water is involved. Getting into and out of the bathtub is a particularly difficult task for the elderly and disabled. There are several shower chairs available, but none of them allow the user to sit down on the chair outside of the bathtub and allow transfer to the inside with the curtain resting inside the bathtub. This is necessary because it keeps the water from running down the shower curtain and collecting on the floor. Water makes the floor slippery and the bathroom becomes an even greater hazard for the elderly and disabled.

SUMMARY OF IMPACT

Showering in a bathtub is a key barrier for the rapidly growing geriatric generation. This team took previous teams' ideas and expanded upon them to advance the shower chair towards commercial use. The new shower chair keeps elderly people safe and independent when bathing. It also folds up in the shower to allow others to use the shower. The device will help geriatric patients safely bathe while maintaining privacy and stability.

TECHNICAL DESCRIPTION

The assistive transfer chair device, as shown in Figure 18.14, consists of four main parts: the swivel seat, the sliding beam, supporting beams and folding mechanism. The swivel seat was purchased from Eagle Health Care Company. It is made of plastic and has dimensions of 17.5″ by 13.5″ with a back height of 12.5″. The swivel seat enables users to turn in 90° intervals and has a secure locking mechanism ensuring stability for patients entering and exiting the shower. The sliding beam allows the user to extend the seat out to the edge of the tub where they can easily sit down on it and to retract to the middle of the tub when using the shower. This device allows clearance between the inside edge of the bathtub and the mechanism so that the curtain can be closed. Heavy duty drawer sliders were used for the sliding beams and 6063 aluminum rectangular tubes were used for the supporting beams. The supporting legs were taken from Drive Medical Design and Manufacturing's folding chair. The chair legs are aluminum and are adjustable from 16″ to 18″. A pair of torsion springs help users fold the seat up and down safely. The force of the springs helps the user fold the mechanism and slows down the chair while unfolding.

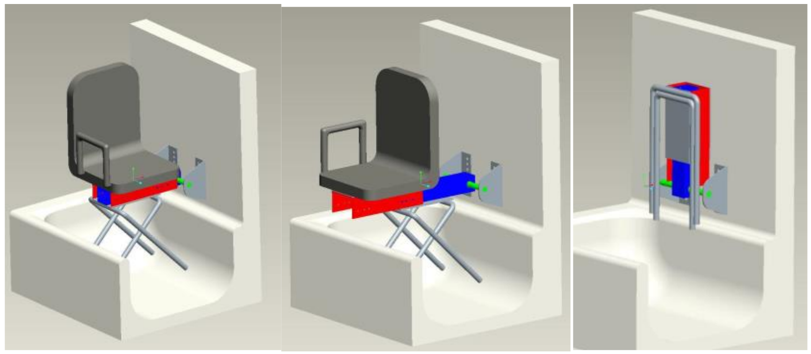

Fig.18.14. Bathtub shower assistive transfer chair for geriatric patients. Left to right: shower in use position, enter and exit position, and stored position

VEHICLE INGRESS/EGRESS ASSISTANCE DEVICE

Designers: Michael Merritt, Lisa Romelhardt, Ben Sutton, Pete Ward
Client Coordinator: Johnston Controls, Inc.
Supervising Professor: Dr. Albert Shih
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INTRODUCTION

The aim of this project, sponsored by Johnson Controls, Inc. (JCI), was to provide a device which can be installed in a vehicle to assist elderly people with ingress and egress. Many baby boomers are turning 65 every day, fueling a new market niche for devices aimed at assisting seniors with everyday life.

SUMMARY OF IMPACT

Creating a device to help elderly people get in and out of their vehicles will allow them to maintain independence; by having the ability to choose what to do and when to do it, they will also maintain a higher quality of life. The device has to be non-obvious, easy-to-use, and effective.

TECHNICAL DESCRIPTION

The student team's prototype consists of an extending handle between the door and the dash, and a mechanism allowing the door to be locked. The extension of the bar is accomplished using a telescoping steel tube, two inches in diameter. The two ends are on fixed pivots, located on the corner of the dash and the end of the door. The locking mechanism consists of a geared DC motor, a rubber brake, and two compression washers. When the motor is engaged, it compresses the rubber brake on the inside of the tube, preventing motion. The telescoping extension bar is two pieces of steel tube stock, which utilize different diameters for telescoping. The largest diameter is 2", which is small enough to wrap a hand around, but large enough to be comfortable in arthritic hands. The 12-volt DC motor outputs 18.1 ft-lbs and turns at a maximum of 37 RPM. It is mounted within a machined aluminum sleeve to locate it within the smaller bar. This sleeve is allowed to translate but not rotate by the use of a keyed notch between the sleeve and bar. A set screw is used to mount a steel coupler to the motor shaft, which allows a threaded rod to be driven. The threaded rod is threaded through a steel cap, which

Fig.18.15. Vehicle Ingress/Egress Assistance Device.

is welded onto the end of the smaller bar. A cylinder of neoprene rubber, 1/8 inch steel washer and brass thrust bearing are then placed onto the rod, and two nuts are locked onto the end of the rod. As the threaded rod spins, the steel washer is pulled towards the cap, compressing the rubber. As the rubber compresses, it applies a normal force causing friction force between the rubber and large bar locking the mechanism in place. Two brackets are used to mount the handle in the car. Both brackets are made of 4130 steel square stock. For the door-side bracket, one of the walls was milled to make a U-shaped bracket. Two 0.3125" holes were drilled and reamed to hold a clevis pin for the handle to pivot on. Aluminum spacers are used to locate the bars vertically in the bracket. The dash bracket is the same material and for the prototype, is 14.75" in length. Once the door was mounted to the model car exterior, we were able to measure the exact length the dash would be based on the door panel. At the hinge end, the two vertical sides were milled out along 2" of the tube to allow for clearance for the handle. Two 0.3125" holes were drilled and reamed for a clevis pin, and aluminum spacers locate the bar in the center of the bracket opening.

INNOVATIVE DOOR DESIGN TO AID PEOPLE WITH DISABILITIES AT HOME

Designers: Zach Stoklosa, Seng Wui Lee, Aleksandar Siljanovski, Michael Locher
Client Coordinator: Dr. Mark Ziadeh MD, a rehabilitation and physical therapy doctor at the University of Michigan Hospital.
Supervising Professor: Dr. Albert Shih
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INTRODUCTION

The goal of this project is to design, build, and test an innovative door system that showcases several concepts that can make the simple act of opening and closing a door at home as effortless as possible for the aging populations of the world. The percentage of the world's population that is elderly is increasing every day, and the need for engineering solutions that increase their independence and quality of life is growing as well.

SUMMARY OF IMPACT

The goal of this project is to design a system, as shown in Figure 18.16, which would make opening and closing of doors in the home effortless and also create a space to maneuver in tight interior space at home. This system would allow elderly people to maintain their independence, increasing their quality of life.

Fig.18.16. Easy open home interior door design for wheelchair users.

TECHNICAL DESCRIPTION

The team chose to make their easy open door similar to a garage door style system. The door is constructed from Quiet Barrier MD, a sound dampening fabric, which is rolled up and down by a motor and spool system mounted above the doorway. By rolling up vertically, the full width of the open doorway is available to the user, which is very advantageous to those confined to wheelchairs or walkers. The door is guided by a T-track system mounted vertically on each side of the doorway from the floor to four inches below the motor. This track system not only guides the door, but also slightly encapsulates the door material on each side of the door, which prevents light from passing through the door as well as increasing the sound dampening abilities of the door. At the bottom of the door material is a guide that attaches to the bottom of the material and slides into the t-track, keeping the material in line. The entire system can be activated by a remote, a wall-switch, or a pressure sensor mounted in the floor, depending on user preference.

RETRACTABLE CAR CANOPY

Designers: Luis Munoz, Kuo Sun, Yilu Wang
Client Coordinator: Dick and Norma Sarns
Supervising Professor: Dr. Albert Shih
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INTRODUCTION

Entering and exiting a vehicle with inclement weather is a challenge for everyone. Often we are inclined to make a quick dash to an automobile to avoid rain and snow. However, persons with physical disabilities do not have that luxury. Interviews of patients with physical disabilities have revealed that there exists a great struggle to access the passenger seat. Patients with disabilities can spend as much as two minutes to comfortably enter and exit a vehicle and they are not able to carry an umbrella to shield them from rain, snow, and wind. Most patients utilize walkers and need to use both arms to support their body weight. Individuals that help disabled patients become victims of the weather as well because they must focus their attention to assist patients rather than protect themselves from the inclement weather. There exist a great need for a sheltering canopy that can efficiently shield patients and assistants from exposure to rain, snow, or wind.

SUMMARY OF IMPACT

We are working with Mr. and Mrs. Norma Sarns, to design and construct an umbrella-like canopy that can be easily utilized by a handicapped person to protect them from heavy weather when entering/exiting a car. For Mr. Dick Sarns, this is a more personal mission as his wife, Mrs. Norma Sarns, is currently dealing with Multiple Sclerosis. This product has the potential to help them out greatly. Our base prototype will be designed to suit Mr. Sarns Chrysler Town and Country minivan.

TECHNICAL DESCRIPTION

The car canopy (Figure 18.17) shields an area of 19.6 square feet. The total weight is about 6.3 lbs. The car canopy is comprised of 5 aluminum ribs that are attached at a pivot point. The pivot point is a shaft inserted into a drilled hole at the end of each rib. Each rib is separated from the next rib with three washers, two plastic and one steel. The shaft ends are threaded and locked into place with matching thread caps. The

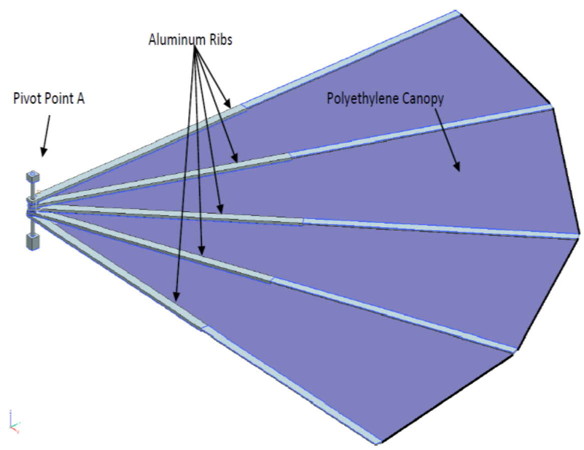

Fig.18.17. Retractable Car Canopy.

entire assembly is secured to a stainless steel drawer slide. The drawer slide is mounted atop the roof rack of the vehicle with a custom keyed fastener. The fixed rib attached to the drawer slide is 60″×1″×¼″ and is made of 6061 Aluminum. Each of the 4 6061 Aluminum rotating ribs are 60″ long and weigh 0.36 pounds. The total weight of each rotated bar is 1.1 lbs. The fixed rib will weigh 1.46 lbs. Both the fixed and rotating ribs have a 19/32″ (0.594″) hole drilled at the base. The distance from the center of the hole to the base edge is ½″, the distance from the sides of the rail is also ½″. Each rib will contain a plastic sleeve bearing that is press fit into the machined hole of each rib. The outside diameter of the sleeve bearing is 0.594 ± 0.005″ and the inside diameter is 0.5 ± 0.005″. The sleeve bearing will protect the pivoting machined surface of the aluminum bar from the outer surface of the steel shaft. The pivoting assembly is comprised of 8 polycarbonate plastic washers, 4 steel washers, 2 aluminum threaded caps and one steel threaded rod. The washer assembly can be seen in Figure 18.18. The threaded caps were machined from 1″ square 6061 aluminum bar stock. They are 1.5″ high and are drilled and taped to a thread fit of Class 2A. The purpose of the threaded caps is to secure the shaft from slipping out of the assembly. Additionally the threaded caps compress the assembly together to promote rigidity when the canopy is opened. The door clip is used to secure the canopy on top of the passenger door. It has two slotted spaces, one 1/8" thick and the other 1 ¾". The 1/8" slot clips into the top rib of the canopy and the lower 1¾" slot clips to the passenger side door.

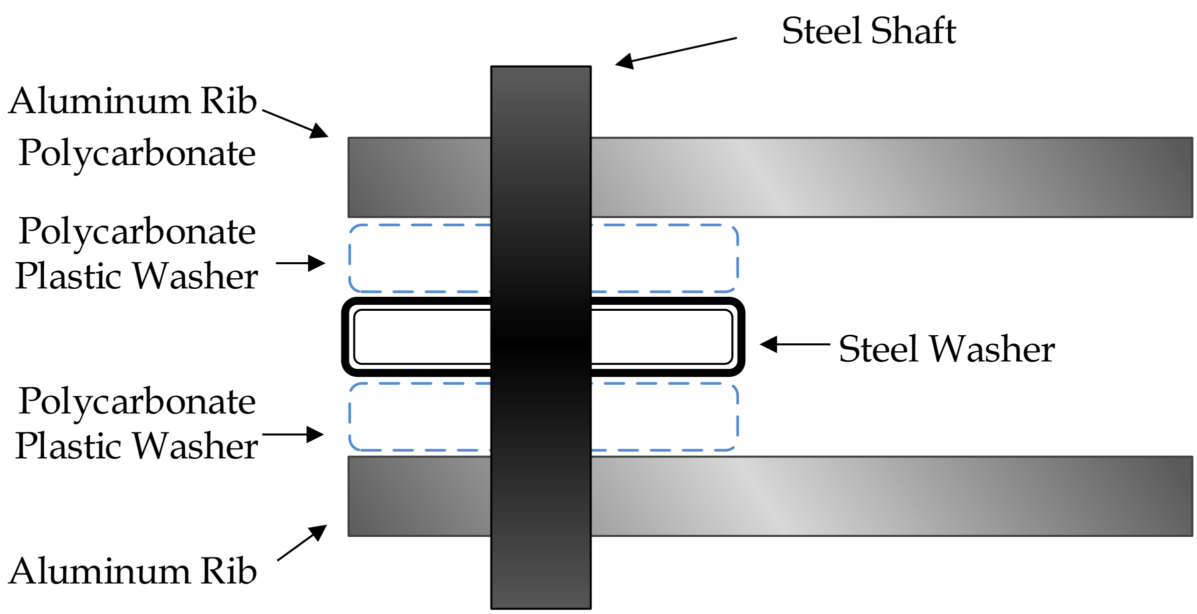

Fig.18.18. Cross section view of part of the pivot assembly.

POSITION ADJUSTMENT MECHANISM FOR A CROSS TRAINER

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Client Coordinator: Dr. Mark Ziadeh, Physical Medicine and Rehabilitation, and Matthew Weber, Engineer, NuStep Inc.
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INTRODUCTION

Ann Arbor based NuStep makes exercise equipment designed for people with physical disabilities. Since exercise for obese patients is very beneficial though challenging due to physical considerations, the T5XR Recumbent Cross-Trainer accommodates patients up to 600 lbs. T5XR users are typically assisted by therapists who manually adjust the machine to be ergonomic, ideally positioning the seat with the user in place. Due to the 7° angle of the rail the seat rides on, ideal seat adjustment is often difficult. This project aims to develop a method for therapists and users to easily adjust seat position in the forward and reverse directions.

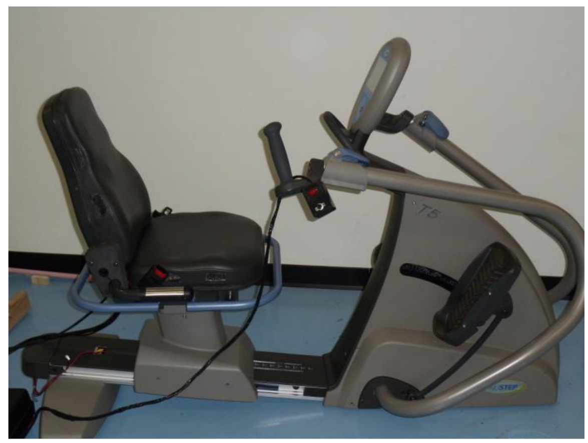

Fig.18.19. Position Adjustment Mechanism for NuStep Cross Trainer.

SUMMARY OF IMPACT

The NuStep T5XR Recumbent Cross Trainer is a full body exercise machine that accommodates a wide variety of users including the disabled, elderly, and obese for both clinical and home use. Many of these users have difficulty adjusting the seat forward and backward by themselves or with the help of a clinician due to physical inability (i.e. stroke, paraplegic, old age, weight). NuStep desires a more effective way for users and clinicians to adjust the T5 XR seat. Universal accessibility and convenience will allow patients to exercise in the comfort of their own homes, improving their health and quality of life.

TECHNICAL DESCRIPTION

The design achieves linear motion of the seat along the rail by utilizing a motorized lead screw system embedded within the supporting rail that the seat trolley rides on. The overview of the design is shown in Figure 18.20. A 12V DC motor with integrated worm-gear transmission is housed in the base frame at the rear of the rail and is mounted to the rail such that its output shaft is roughly centered within the rail and is parallel along the length of the rail. This motor shaft interfaces with a coupler via a Lovejoy spider coupler and is held in place by a dowel pin that aligns the through hole in the shaft. A setscrew covering the open hole in the coupler holds the pin in place. The coupler consists of two different shaft diameter hubs connected together with a rubber spider in the center to allow for misalignment between the shafts. The coupler end, opposite that of the motor, interfaces with the lead screw via a 3/16" x 3/16" hardened steel key. The threads of each end of the lead screw shaft are removed. These ends are each mounted inside a bearing housing assembly that is mounted to the rail at each end. Double-sealed needle roller bearings are pressed in bored holes in the bearing housings that face away from the lead screw. A hardened race fits between the machined shaft and each ball bearing within the bearing housing. Thrust needle bearings are sandwiched between thrust washers and sit along the machined lead screw shaft between the bearing housings and the lead screw. The washers facing the bearing housings are piloted in the bearing housing. A 0.005" gap is placed between the lead screw step and thrust washer on the motor side to allow for thermal expansion. These bearing housings are bolted to brackets and protrude from the bottom of the rail, where vertical and horizontal slotted holes are used for an adjustable, rigid attachment to the underside of the rail. A lead nut threads on the lead screw and rides between each bearing housing. This nut is connected to the seat trolley such that the trolley moves linearly with the nut as the lead screw spins. The off-the-shelf lead nut has an external thread, on which a custom-made bracket is threaded. This lower bracket stays upright inside the rail, and has two slip-fit dowel pin holes reamed in its top. The trolley has mounting holes and slots on its bottom plate that allow the upper bracket to mount from the inside, dropped via access window. The upper bracket is attached using two bolts and flanged threaded inserts that are inserted from underneath the bottom plate of the trolley. This upper bracket has two dowel pins pressed into its underside that mate with the two holes atop the lower bracket. Two parallel slots run the distance of travel on the top of the rail, which allow this upper bracket to connect to the lower bracket within the rail and slide along the direction of movement. These parallel slots are less than 0.39” to account for EN safety requirements. User interface controls will include a "Forward", "Backward", and emergency stop buttons. The remote with these controls will be center-mounted on the console, and wireless. The controls will ideally be integrated in the machine's computer in production, using position information from the trolley seat sensor to indicate when the seat has reached the limits of its forward and backward travel to indicate to disable motion in the appropriate direction. Signal to move the seat will only be sent while the selected button is depressed. In production, a safety feature will disable the motor if an obstruction (body part or otherwise) becomes pinned between the trolley and front body housing. This could be done by monitoring the current drawn by the motor and acting on a threshold, or using a sensor or bumper to identify an obstruction. This seat adjustment mechanism will be powered by plugging into a standard 120V AC wall outlet, which will be converted to 12V DC via a 102 W power supply.

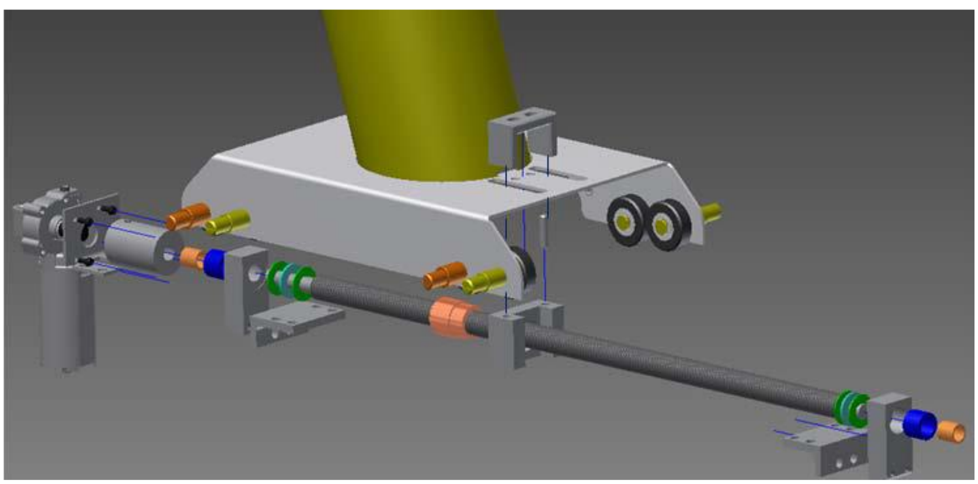

Fig.18.20. Exploded view of lead screw design.

COOLING SYSTEM FOR MULTIPLE SCLEROSIS PATIENTS IN A EXERCISE MACHINE

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INTRODUCTION

Multiple Sclerosis (MS) is a neurological disorder affecting about 2.5 million people globally. In the absence of a known cure for the condition, exercise has been found to be the most effective way of controlling MS in patients as it increases fitness levels, reduces fatigue, improves bowel and urinary control and reduces joint spasticity. Due to inadequate thermal regulation, a secondary effect of MS, patients face extreme discomfort and are often unable to continue exercising. The objective of this project is to develop and fabricate an integrated cooling system for the NuStep T5 Recumbent Cross Trainer to aid MS patients using it by providing adequate cooling while ensuring comfort.

SUMMARY OF IMPACT

Exercise has been found to be the most effective way of controlling Multiple Sclerosis. Patients who exercise regularly have increased fitness levels, reduced fatigue, improved bowel and urinary control and reduced joint spasticity. Patients with MS often suffer from elevated core body temperatures preventing them from continuing to exercise. A device which alleviated this secondary effect and allowed patients with MS to continue exercising would go a long way towards helping patients get in better shape and controlling the symptoms of MS.

TECHNICAL DESCRIPTION

The device uses five conductive metal plates as the conductive medium to remove heat as seen in Figure 18.21. These plates, with a cumulative area of 0.09 m^2, are cooled using individual Peltier modules which in turn cool the patient through conduction. The Peltier assembly consists of the Peltier module, an extruded fin array and a blower embedded within the seat foam. The cooling pads are flush with the upper surface of the seat foam, creating a uniform seating surface that, once covered with a vinyl material, should provide a cool and comfortable seating area for the patient. It was determined that numerous smaller pads were more comfortable in comparison to having a single large pad of the same cumulative area. Smaller pads allow the individual surfaces to conform to the patient's weight and shape, along with the seat foam material. The location of these cooling pads was also constrained by the existing structure of the T5. To minimize significant modification to the T5 seat, the pads must be placed in locations such that the entire cooling module does not come into contact with the seat frame structure. The seat bottom pads are split into three portions: one for the rear (12″ x 4″) and two smaller pieces for the thighs (3″ x 5″). The seat back utilizes two pieces, one mid-section piece (6.0″ x 4.5″) and one upper piece (6″x4.5″). In order to effectively package our module inside the seat, the inner foam structure of the seat had to be hollowed out in the areas above the Peltier modules. For both the seat bottom and back, 1/8″ hollow-outs corresponding to the areas of the cooling pads were made to allow the cooling pads to sit flush with the existing foam. Two holes for each module were drilled through the cooling and tapped using a metric m8x1.25 tap. All-thread m8x1.25 rods, with a length of 2.5 inches, were cut and inserted into the plate. The fin structure has two small 8mm tabs screwed onto each side so that it attaches to the plate using the all thread rods. The Peltier device is not permanently mounted to the copper plate, but rather sandwiched between the fin and copper structure using force provided by the all-thread rods and fasteners. To facilitate good conduction between the Peltier unit and the copper, as well as the fin structure, Arctic Silver thermal paste was used on the entire contact surface with an average thickness of 0.001 inches per manufacturer recommendation.

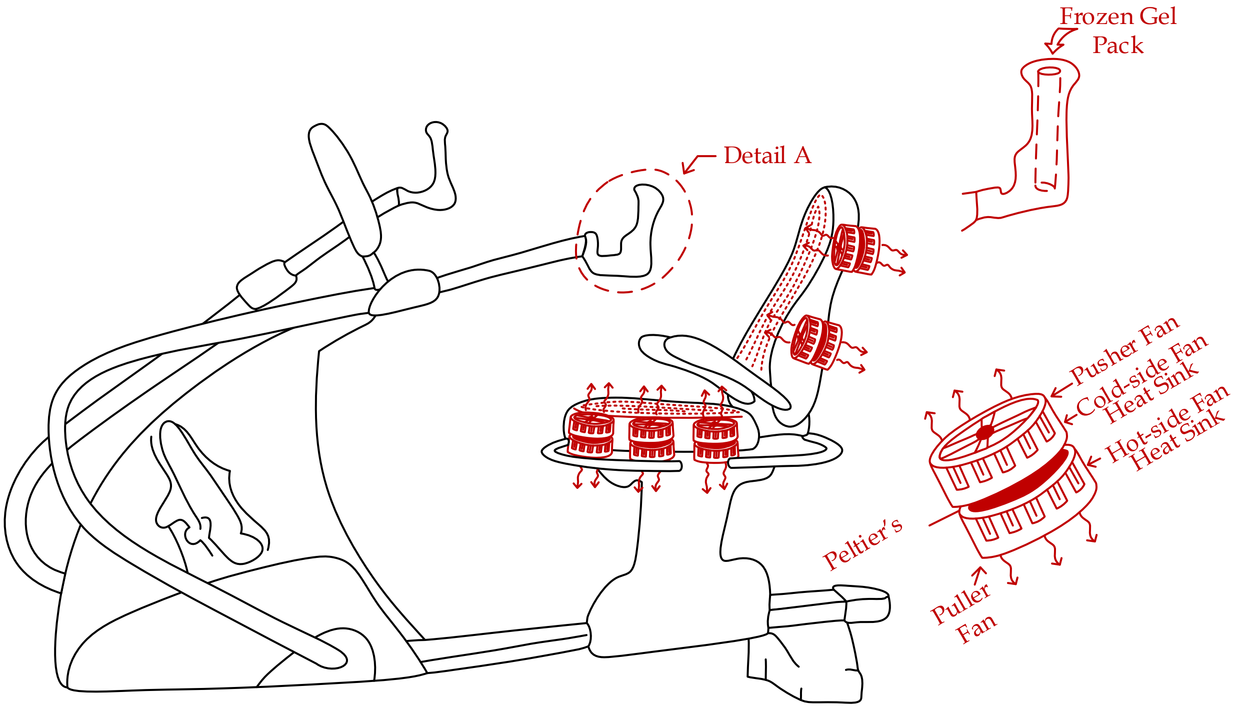

Fig.18.21. Cooling System for Multiple Sclerosis Patients using NuStep T5 cross trainer.