CHAPTER 8
NORTHERN ARIZONA UNIVERSITY

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Multi-Functional Rehabilitative Exercise System

Designers: Jonathan W. Furlong, Darren J. Stajduhar
Therapist: Marcia Lamkin, P.T.
Supervising Professor: Dr. David E. Hartman
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INTRODUCTION

An eighth grade Native American student suffers from juvenile rheumatoid arthritis. The disease primarily effects his lower body, causing inflammation in his joints and pain in his knees, ankles, and feet. Occasionally, the joints in his hands and wrists are also effected. Due to the pain and stiffness of the lower body, he has been confined to a wheelchair for several years causing muscle atrophy in his legs. It is therapeutically important that he move his joints and exercise his muscles to prevent loss of motion and regain strength in his lower body. His therapist believes that with the help of medication and physical therapy he will eventually be able to walk with the use of crutches or a walker. She indicated that a parallel bar exercise system would be an ideal rehabilitative device, however, she has not had success with those currently available on the market. Typical systems lack the compactness, portability and rigidity needed for the client.

The device needs to be compact so when not in use it can easily be stored against a wall or in a closet. It should be small enough to fit into a compact station wagon. The client is currently 60 inches tall and weighs 117 pounds. He has not yet reached his adult height and weight, so the design must allow for expected growth up to 74 inches and 200 pounds. The goal was to design and build a parallel bar system for the client that provides rigidity, portability, and adjustability.

SUMMARY OF IMPACT

The physical therapist states that the best way to fight the progression of the disease is to keep the client exercising, loosening joints and maintaining good muscle tone. A parallel bar exercise system is a critical element for the client to regain the muscle control needed to walk. The physical therapist was impressed by the rigidity, low weight, and portability of the system. After trying the parallel bars, the client was equally impressed by the rigidity and felt very comfortable using it. He plans to use the parallel bars for the remainder of the academic year and take them home to continue therapy during the summer.

TECHNICAL DESCRIPTION

After several meetings with the client, the physical therapist, and an extensive information search, a preliminary design was formulated. The parallel bars are designed with a 2-inch outer diameter to distribute the load across the palm of the hand and allow the client to fully wrap his fingers around the bars. For rigidity and availability, the wall thickness is chosen to be 0.125 inch. Based on stress analysis of each component of the system, the material that best meets the design criteria is aluminum. 6061-T6 aluminum is readily available and is chosen because of its high yield strength and light weight. The system was modeled as a simple beam with a point load in the middle for worst case loading.

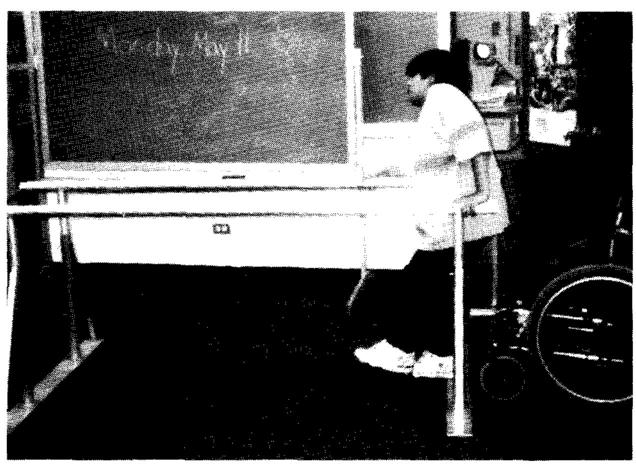

Figure 8.1. Photograph of the Parallel Bar System [Side View).

Adjustability is obtained through the use of telescoping tubes (Fig. 8.1). The outer member of the telescoping pair is welded to the base plate while the inner member is welded to the parallel bar. A single hole is drilled through the outer tube with several holes drilled through the inner tube. Height is adjusted by sliding cotterless hitch pins through the tubes. These pins are chosen because they are easy for the client to use with his limited hand strength, and they provide added security. Inner member dimensions of 1.75 inch O.D. by 0.125 inch

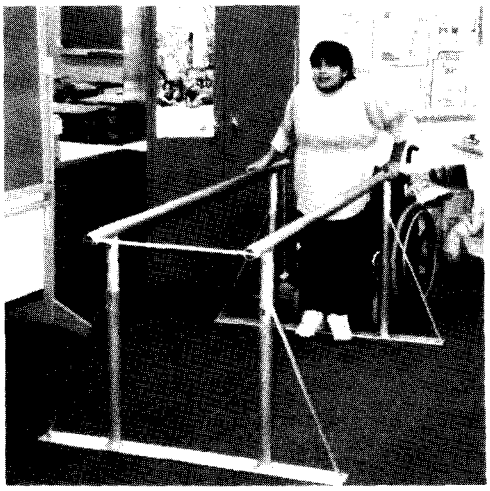

Figure 8.2. Photograph of the Parallel Bar System [Front View).

wall were chosen because of availability and to provide mating with the outer tubes. A clearance of 0.005 inches between the telescoping tubes provides good rigidity and easy adjustment. The bars are designed to be adjustable from 32 to 40 inches by using five holes drilled in the inner telescoping tube every 2 inches, and provide for the client's growth. Additional rigidity is supplied by supports that slide into the ends of the parallel bars, connecting them together (Fig. 8.2). Two end supports are provided but only one is required for stability during use.

For portability, the system separates into parts when not in use so that it fits into a compact station wagon for transport and allows for storage in a closet or against a wall. The fully assembled system requires 4 x 7 feet of floor space; disassembled only $\frac{1}{2}$ x 7 feet. Total weight of the system is 40 pounds, and its cost is $494. This compares favorably with currently available parallel bar systems that cost over $1000 and weigh about 100 pounds, with limited portability.

Laptop Computer Support System For A Wheelchair

Designers: Christine Henry and Nicholas Tetlow
Client: Alice Garcia
Client Coordinator: Tom Nolen, Hozhoni Foundation
Supervising Professor: Dr. David E. Hartman
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INTRODUCTION:

Alice has been with the Hozhoni Foundation for nearly ten years. She is multiply handicapped with cerebral palsy and has very limited communication. She recently received her own electric wheelchair with which she is able to be somewhat independent inside the facility. She appears to be very capable in various respects, however, because of her inability to speak she is limited in her functioning with others. Her present forms of communication consist of groans and limited finger spelling, through which she has shown a capability beyond what is expected. She needs a computerized augmentative speech communication system to enable her to increase her potential. In addition, a wheelchair tabletop is needed to accommodate the computer. Although there are many models of wheelchair tabletops available they will not function for Alice. Her jerky movements may knock a portable computer to the floor. Also, these tabletops are not adjustable to allow for comfortable positioning for her.

This project consisted of searching for and integrating an appropriate communication device to produce electronic speech for Alice, and then designing and building a safe, adjustable position tabletop to support the system. The Toshiba 1000XE portable computer was selected for the augmented speech system.

SUMMARY OF IMPACT

The overall impact of the design cannot be appraised until Alice has the complete system. The designers have assisted in locating local funding to purchase the computer and speech software, which costs about $3460 total. The tabletop computer support system is complete, and is attachable to Alice's wheelchair. The final design called for a deep purple color for the tabletop based on Alice's strongly stated preference, and she seems satisfied and comfortable with the tabletop. The position of the computer, once it is in hand, can be easily adjusted to adapt to her one-knuckle typing; thus, Alice should be able to more easily communicate. Her case worker thinks she may even be able to write some stories.

TECHNICAL DESCRIPTION

For the initial design it was proposed to build a swing arm table to house the computer. This would allow Alice to move it out of the way when not in use. However, after observing her mobility and talking with her case worker, it was determined that she might damage the computer because she has a tendency to run her wheelchair into things. It was then decided to build a removable tabletop.

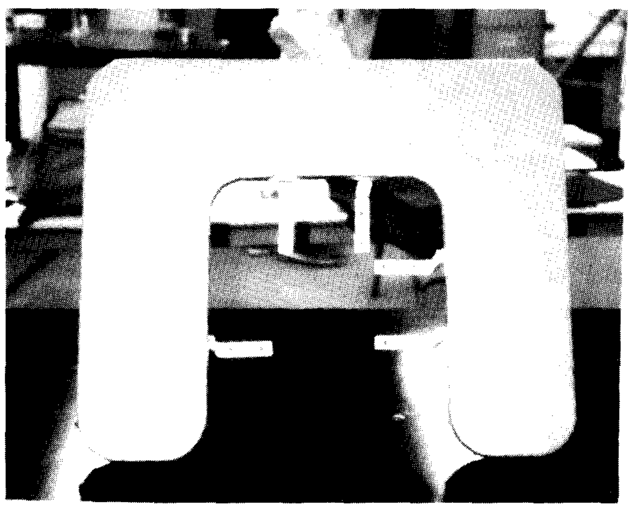

Figure 8.3. Photograph of the Finished Tabletop [Front View).

After many design iterations, including interaction with Alice to find the most convenient and yet comfortable position on her wheelchair (we switched her chair control location four times at her request be-

A Pressure Relief Trainer for a Client in a Wheel Chair

Designers: Stephen Whittemore, Scott Hansen, Charlotte Rekiere
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Hozhoni Foundation

INTRODUCTION

The goal of this project is to design a pressure relief trainer (PRT) device mountable to the client's wheel chair. The objective is to provide a means to remind the client to perform prescribed pressure relief lifts and to track the client's performance and status in the wheel chair. The PRT will ultimately reduce the clients risk of hospitalization due to pressure sores.

Figure 8.5. A Pressure Relief Trainer for a Client in a Wheel Chair.

SUMMARY OF IMPACT

The client in this case is a young adult who suffers from Fetal Alcohol Syndrome (FAS). Other complications cause her to be confined to a wheel chair and therefore suffers from ischial decubitus ulcer, or pressure sores. She has a history of hospitalization due to the severity of her sores. Her Physical Therapist has prescribed a routine for pressure relief training. A pressure lift is performed when the client lifts her body off the seat of the wheel chair with her arms as shown in Fig. 8.5.

To prevent pressure sores and to allow current sores to heal, our client is prescribed to perform a pressure lift once every ten minutes and hold for ten seconds. Due to FAS she does not have cause and effect memory and is not able to understand completely how performing the lifts will relieve her of her pressure sores, and therefore fails to stay with the prescribed routine. The PRT provides the client with the needed reminder to perform her pressure relief lifts, and provides her personal counselor with a count of the number of lifts performed each day to track performance and healing. With this combination our client will be able to greatly reduce her risk of hospitalization due to pressure sores.

TECHNICAL DESCRIPTION

The PRT module is a micro-controller based device mountable to the client's wheel chair. The M68HC11EVBU board was used for this application. The code is stored in the on board EEPROM with optional 8kx8 EPROM memory mapped in for future code changes or added features. The EEPROM was programmed through the serial port on a PC reference Fig. 8.6.

Each cycle duration for the ten minute wait, ten second lift, buzzer, and LCD is controlled by software. The overnight low power sleep mode is controlled by reading the real time clock chip. A force sensing fore she found a position she was comfortable with), we decided to construct the table top out of birch wood. This decision was based on rigidity and workability of the material. The case worker insisted on a $\frac{3}{4}$ inch thick platform so that it would "look sturdy," even though analysis showed that a thinner ply would suffice. The tabletop is attached to the wheelchair using aluminum tubing. Additionally, it is covered with purple vinyl because Alice insists that she would have no interest in any other color.

The tabletop is a platform of 20 x 24 inches. These dimensions were chosen to provide a full worktable space for Alice. A 12 x 14 inch section is cut out of the center to allow for placement of the computer. The computer is recessed 2-inches, and is fixed to the tabletop with angle brackets. The 2-inch recession allows for a hinged Plexiglas cover to be placed over the top of the closed computer so that Alice can use the table for eating and other activities without risking damage to the computer. The tabletop position is adjustable to allow for the different size seat cushions that Alice uses. The adjustment is made with specially designed clamps that attach the tabletop to any part of the vertical bars that are on the front of Alice's wheelchair. Also, these clamps allow attachment to other wheelchairs that have different size bars.

The total cost of the computer, voice synthesizer, attachments and tabletop is $3619. We have made intensive efforts to get assistance with funding from several local banks, social security, and other agencies. The total amount has not yet been reached, but is being approached. The actual tabletop cost $159.

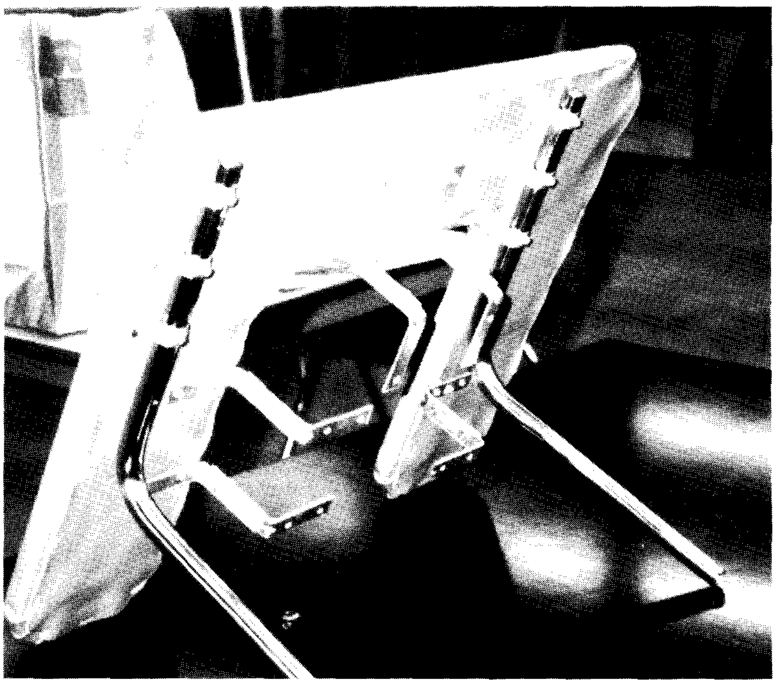

Figure 8.4. Photograph of the Finished Tabletop [Back View].

resistor (FSR) is used to track the state of the patient in the wheel chair (sitting or absent/lifted).

The FSR is used as a pull up resistor to 5v in a voltage divider circuit for the input port to the M68HC11EVBU. The voltage divider circuit contains a one MΩ potentiometer to adjust sensitivity of the FSR. As the pressure on the pad increases, the FSR resistance goes down from the MΩ range to the KΩ range. This causes the node to the input port to be a logic high. This signal is inverted before the input port to provide the logic level necessary to signal the software of the presence of the client in the wheel chair and to act as an interrupt to pull the controller out of sleep mode.

The final module is water resistant and durable to the environment. The client's wheel chair was modified minimally. The FSR pad is attached with Velcro strips for easy removal. The module is mounted underneath the wheel chair on a metal support rack drilled to the seat board for easy removal of the module. Styrene was used for the module housing with a sealed removable lid. All ports to the module use a waterproof connector socket for protection and are sealed with silicon sealant.

A 12-Volt lead acid rechargeable battery is the power source for the module. The battery is recharged while in the module via a plug in 2A commercial battery charger. The battery is calculated to last approximately three weeks between charges. A low battery indicator was designed into the system with a led that lights when the battery discharges to a value of 8 volts. The voltage to the micro-controller is regulated to 5 volts. All additional circuitry is wire wrapped to the M68HC11EVBU wire wrap area.

There are two distinctive buzzers used as reminders. The first occurs after the client has been in the wheel chair for ten minutes. It sounds similar to a digital watch announcing the hour. If this first reminder buzzer is ignored, then after a two minute duration, the second buzzer occurs, and continues to beep until the client performs their lift. The second buzzer is also used to call the client's caregivers to assist/encourage the client. At any point in the ten or two minute counting cycles, a lift can be performed. When the client is lifted out of the wheel chair a ten second count begins, upon completing the ten second count a single beep occurs to announce the lift is finished and the client may sit back down. At this point the LCD display is incremented. If the client does not complete the full ten seconds, the second reminder buzzer will occur to have the client try again.

The PRT is considered a training device to develop a consistent system for the client. The client's personal counselor may disable the system at any point in time by unplugging the seat pad from the module. A user's manual of written instructions was used to explain the cycles and duration of lifts, the code changes that could be made to modify cycles, and the use of the interfaces to the module including: FSR pad, battery charger, led low battery indicator and LCD. Also instruction on removing the module from the seat was given. The total cost incurred was approximately $450.

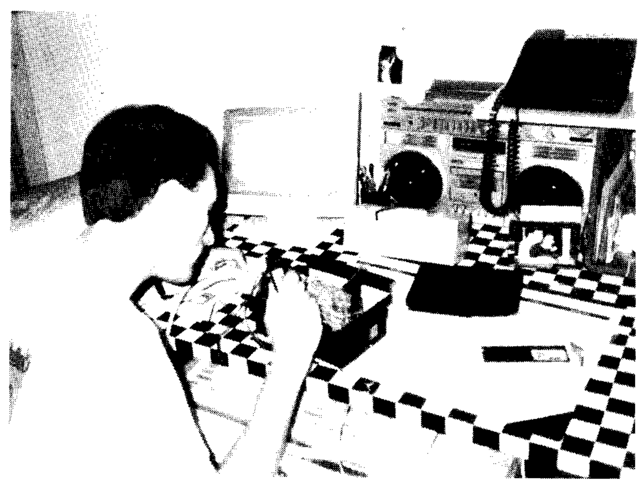

Figure 8.6. Micro-controller Pressure Relief Trainer for a Client in a Wheel Chair.