CHAPTER 6
MONTANA STATE UNIVERSITY

College of Engineering
Department of Mechanical Engineering
Bozeman, Montana 59717

Principal Investigator:

R. Jay Conant (406) 994-2203

Consultant:

Peter *Axelson*
Beneficial Designs, Inc.
5858 *Empire Grade*
Santa *Cruz,* California 95060

A Dry-land Mono-ski Trainer

Designers: Tory P. Brogan, Peter E. Southwick, James A. Day
Rehab Professionals: Lee Barkmann, Eagle Mount, Bozeman, MT
Peter Axelson, Beneficial Designs, Santa Cruz, CA
Supervising Professor: Dr. R. J. Conant
Department of Mechanical Engineering
Montana State University
Bozeman, MT 59717

INTRODUCTION

The dry-land mono-ski training device has been designed and constructed to simulate the motions associated with the sport of mono-skiing. The trainer adapts a mono-ski seating system to the Skier's Edge alpine ski training device and serves three purposes: the trainer will aid novice mono-skiers in learning the balance and muscle control needed to mono-ski; it will aid experienced mono-skiers in their quest for ideal conditioning to excel at the sport; the trainer can be used by non-skiers as a means of exercise. The design allows a user to independently enter, exit, and use the trainer, as well as to adjust the motion to the user's personal needs before utilizing the device. Since the device will be used by a variety of people, the seating system is fully adjustable.

SUMMARY OF IMPACT

Although the device has received only limited testing to date, this testing does indicate that the trainer performs its intended functions. Non-skiers who have used the device have been especially impressed with the physical workout they obtain by using the device. Experienced mono-skiers have indicated that the device provides a reasonable approximation to the balance and motion required in mono-skiing.

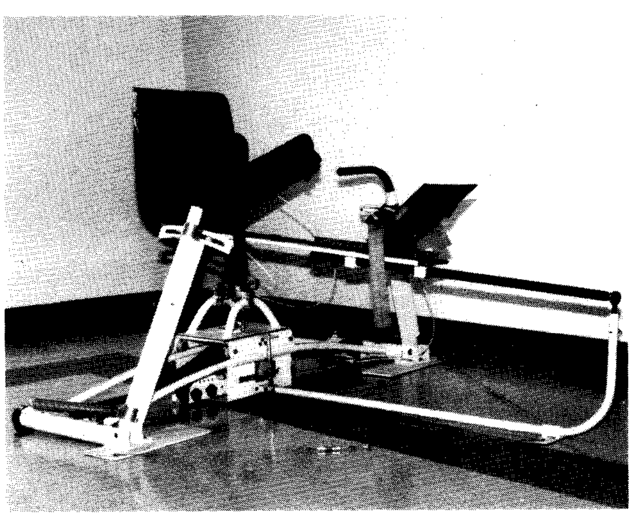

Figure 6.1. A Dry-land Mono-ski Trainer.

TECHNICAL DESCRIPTION

The design process began with a thorough investigation of the sport of mono-skiing. Throughout the design, input was gathered from mono-ski users and mono-ski instructors to find the most important aspects of the sport that could be incorporated into the design. Motion simulation was determined to be the focus of the design. Included in the motion simulation is sliding, pivoting and rotating. Sliding is necessary to simulate the side-to-side motion across the ski slope, pivoting to simulate leaning into a turn and rotating is associated with the turning of the ski in relation to the slope. In addition to motion simulation, the trainer needed to provide the user with a means to exercise in a way that would prepare themselves for actual mono-skiing. Three design alternatives were constructed as mockups and the merits of each were considered. The best alternative was selected, and a preliminary design was developed. A prototype of this design was tested to assess the various parameters involved with this particular design. Again, input was solicited from experts in the field. This prototype testing led to many conclusions including seat height, handle bar positioning and configuration along with various ergonomic considerations particular to people with disabilities.

The trainer is designed to function in two modes. One mode is used for technique training. In this mode the seat is lowered to the bottom position and the handle bars are unlocked at their base to allow rotation. Foam pads are inserted at the base of the trainer to limit the lean angle and provide resistance during leaning. While in this mode, the user is able to move the arms forward and back while leaning the seat. In this mode the base is locked which prevents sliding motion. The motion is a simulation of the mono-skier's action while skiing. The second mode is designed to allow the user to exercise the muscles used while mono-skiing. In the second mode the handle bars are locked to prevent rotation and to allow the user to push from side to side. The seating system then slides back and forth across the Skier's Edge and the user leans the seating system inward to simulate leaning into a turn. Another variation to the exercise mode is the seat height relative to the pivot point. The seat can be raised to its highest point to allow the user to simulate long slow turns or the seat can be lowered so the user can simulate fast, more aggressive skiing. The seat height is adjusted by pulling a T-handle located beneath the seat. The seat is then raised or lowered into position and the T-handle released, locking the seat in position. The T-handle is located for easy access by a person in a wheelchair.

Developing the handle bar system was the most difficult part of the design process. The handle bar system must perform three functions: provide a means of simulating the hand motion of mono-skiing; give support and security to the user throughout all stages of the simulation; and provide a solid base to allow the user to push themselves from side to side. Through testing it was discovered that the handle bar system could not perform all of these functions simultaneously. It is for this reason that the training system was designed to function in the technique and exercise modes as discussed above.

The seating system includes a seat and foot support. The seat for the mono-ski trainer was donated by a premier manufacturer of mono-skis. It allowed the designers to utilize existing technology that would benefit the user the most in terms of comfort and support. The foot support is adjustable to accommodate various size users and, in conjunction with the seat, allows the legs to be bent at an angle to prevent hyperextension.

The ease of entering and exiting the trainer was a prime consideration during the design process. The seat of the mono-ski trainer is designed to rotate 110 degrees from the use position to allow better access from a wheelchair. To stabilize the trainer while transferring, a braking system was incorporated which prevents the trainer from translating and rotating during the transfer. The levers for each brake are located within easy reach of the user.

The final design (Fig. 6.1) meets all of the design objectives and provides mono-skiers with a means to train and learn techniques in safe and user-friendly environment.

The cost of the Dry-land Mono-ski trainer is estimated to be $250, excluding the cost of the Skier's Edge.

Cycling Device for a Quadriplegic

Designers: Daniel Kanta, Kevin Larson, Daniel Sarnborsky
Supervising Professor: Dr. R. J.Conant
Department of Mechanical Engineering
Montana State University
Bozeman, MT. 59717

INTRODUCTION

This adaptive cycling device is a design that allows a quadriplegic to cycle for recreation and exercise. Current devices on the market are intended for paraplegics, are not directly compatible with quadriplegics and cost over $1000. Operation of these products involve accurate fingertip control and require much upper body and arm strength. These are areas where quadriplegics have limited abilities. This design takes current designs and modifies them so that a person with quadriplegia can operate the cycle and enjoy the freedom of cycling in the great outdoors of Montana.

SUMMARY OF IMPACT

Our client has indicated that this cycling device has created an activity that he can enjoy for hours while exercising outdoors. This activity will allow our client to enjoy cycling, alone or with his children. Throughout the design we were concerned whether our client had the power to operate a cycle. Testing indicated that our client could produce a maximum of about 5 watts of power with his arms. Estimates obtained from various sources indicated that 5 watts should be adequate to operate the cycle, but no definitive power requirement could be found. In practice, our client can start the cycle only on ground that is level or has a downward slope. Once the cycle is moving our client can maintain the motion on the roads in the immediate vicinity of his home, which are mostly level.

TECHNICAL DESCRIPTION

Our client imposed certain design constraints on the cycle concerning weight, stability and speed. The cycle was not to weigh more than the client's wheelchair, which could be easily lifted in and out of a van. The device weight limit was set at 45 pounds. The cycle had to be stable, for safety reasons, at rest or at the design speeds of 5 to 10 miles an hour. Also, the cycle must not alter the structural integrity of the wheelchair to which it is attached.

Before the design phase of the project was started, considerable research was performed to determine if there was an existing product on the market that would satisfy our client's needs. No product was found which could satisfy all the constraints. However, the search did find many cycling devices that were designed for paraplegics. Many design and safety considerations were located in this literature search. Many of the designs encountered in the literature search were incorporated into the final design.

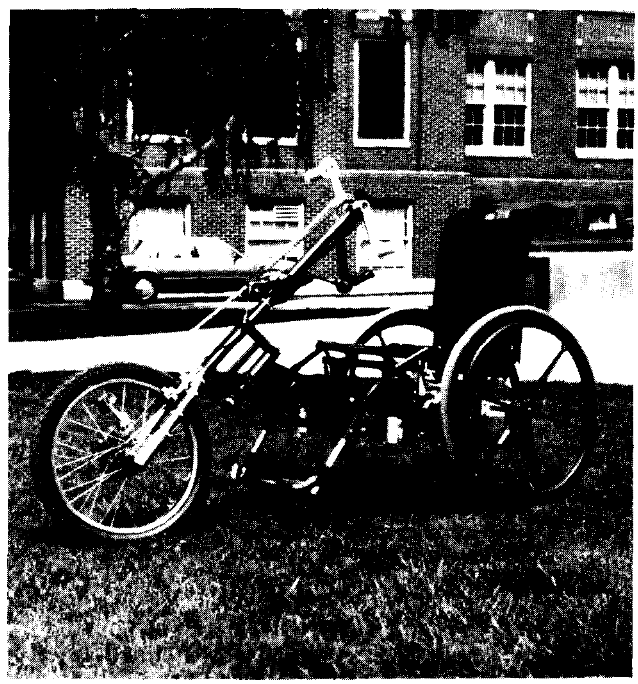

Figure 6.2. Cycling Device for a Quadriplegic

From the literature search and discussions with other experts, three design alternatives were created and full scale mock-ups were constructed. Construction of these mock-ups provided valuable information on design problems not considered until actual construction. Of these three designs, the best design was chosen. The two designs that were rejected involved a cart, which the wheelchair sat on, and a two-wheel rear drive design with each wheel operated by its own chain and pedal assembly. Each of these two designs addressed the design constraints, but had fundamental design flaws that resulted in their elimination. The chosen design was then analyzed concerning cost and construction. Three alternatives of cost and construction were studied and the lowest cost option was chosen.

The chosen design was a device that firmly attached to the structural frame of the user's wheelchair and positioned the controls in a comfortable position as shown in Fig. 6.2. The device consists of two structural frames joined together with a heavy duty bearing assembly. The upper frame contains the steering, braking and shifting mechanisms. The lower frame connects to the wheelchair and allows the top frame to rotate and steer.

The upper frame is constructed around a 1.25 inch outside diameter steel tube with a 0.140 wall thickness. This tube connects heavy duty wheel forks with the hand pedals. All of the other members on the cycle frame are either 1 X 1 or 0.75 X 0.75 square steel channel with wall thicknesses of 0.140 and 0.075 inches respectively. Although the design could be optimized for lower weight, the member sizes were chosen using a design safety factor of 2.5 concerning yielding. Attractiveness of the structure also was a major design consideration.

Braking of the cycle is performed by back pedaling of the arm cranks, which engages a separate free wheeling hub and pulls a cable that is attached to a standard caliper brake on the front wheel.

Shifting is done with a redesigned index shifter. Standard shifters involve a precise force applied to a small lever. The redesign uses oversize molded lever pads which allow a person with quadriplegia to shift accurately with the palm of their hand. Pedaling of the cycle with low input forces is achieved by using low gear ratios and a small, 20 inch diameter front wheel.

The completed design weighs 29 pounds and is constructed, wherever possible, with standard bicycle parts for reliability, cost and ease of replacement, should a failure occur.

The cost of the project was approximately $420 for materials. Welding and other machining costs were defrayed and labor was donated.

Adaptive Stroller for the User of a Wheelchair

Designers: Jason D. Beaudette, Darren L. Hitchcock and Michael J. Keenan
Supervising Professor: Dr. R. J. Conant
Department of Mechanical Engineering
Montana State University
Bozeman. MT 59717

INTRODUCTION

Our client is a mother who has paraplegia. She has no motor control of the muscles below her waist, and uses a manual wheelchair for mobility. She wanted a device to assist her in tending to her child while using her wheelchair. This device is needed to bring her child with her on longer wheelchair trips such as shopping.

Strollers available on the market today are not equipped for use with a wheelchair. Extensive research was performed in an attempt to locate such a stroller that could be used with a wheelchair, but with no success. Many adaptive strollers exist, but these are for children with a disability and not for a parent with a disability.

The need for an inexpensive child transport device is shared by a range of people with disabilities requiring the use of a wheelchair. To accommodate them, a commercial stroller must be modified and used in conjunction with a wheelchair.

SUMMARY OF IMPACT

The mother for whom this device was designed has used the device when travelling around town. She has found that the device works well. It has no difficulties when encountering curb cuts and sidewalks with a slight side slope. It is easily attached and detached to her wheelchair in about 30 seconds. She has encountered no difficulty in loading the device into her minivan, or in unloading it from the minivan.

TECHNICAL DESCRIPTION

The design of the adaptive stroller was based upon the wants and needs of our client. A design that was built solely for our client would be just that, just for our client. One goal was to design a device that would not only satisfy the wants and needs of our client but also those of other people in similar situations. To achieve this, many possible design solutions were conceived. Designs that would fill the required need but not be limited to one type of solution, such as a stroller, were evaluated. Other methods were investigated such as pouches, backpacks, and carseat type devices. Another goal was to have a design that was simple, economical and available for many people with disabilities. Thus, the design should be able to be used in conjunction with many wheelchairs makes and models. Also, the design should not be limited to people with a specific type of injury.

Our client desired a device that would allow her to independently travel with her child several blocks to other downtown businesses. Thus, the device should be capable of overcoming obstacles such as curb cuts, sidewalk inconsistencies, and other terrain normally encountered. She does not wish to have the device attached to her wheelchair while at home or in her place of business.

Figure 6.3. Adaptive Stroller for the User of a Wheelchair.

Many design alternatives were proposed, four of which are presented here, before a final selection was made. The first alternative was a stroller that would connect to the front of the wheelchair but the rear stroller wheels would fold in to bring the stroller closer to the wheelchair. This method was not chosen due to complexity. The second alternative would mount a carseat type device equipped with carrying straps to the front of the wheelchair. This alternative was eliminated from consideration by our client. The third alternative also mounts a stroller to the front of the wheelchair. While attached, the stroller is tilted back onto its rear wheels to aid in child access and in overcoming obstacles. This option was eliminated due to possible safety hazards.

The chosen alternative (Fig. 6.3) provides a design that meets all the design specifications as well as our client's approval. The stroller is the most important part of the design. The stroller is a regular production unit as found in most department stores such as Sears or J.C. Penney. Yet for use in the design it must have certain features for proper operation. First, it must have all four wheels that caster or swivel independently. This is a requirement because the stroller keeps all four of its wheels on the ground and must allow the wheelchair to turn from side to side when it is attached. Second, the stroller must have a multi-position seat. This seat must have a position that allows the back to fold flat. Children under a few months of age have little or no back support. Therefore, they must lay down on their backs as in a carriage and not a seat. It is necessary to have the seat fold up when the child gets older. And lastly, the stroller must have large diameter tires. This will allow the stroller-wheelchair combination to overcome irregularities in the sidewalk and turn easier.

EZ-Link is the package that allows a stroller to be used in conjunction with a wheelchair. It consists of the following: stroller blocks, connector links, and chair blocks. The stroller is attached to the wheelchair through the use of connector links. These links are fastened to the mounting blocks on the stroller, called stroller blocks. Here, the connector links are allowed to rotate about the connection. The links are fastened to the mounting blocks on the wheelchair, called chair blocks, through the use of quick-release pins. This enables our client to quickly and easily connect or disconnect the stroller from the wheelchair. Here, the connector links are also allowed to rotate about the pins. This system allows the stroller to be elevated as well as tilted relative to the wheelchair.

The linkage is made of rectangular tubing similar to that used on the stroller. A linkage of this type was selected to offer an aesthetically pleasing appearance while retaining the required strength. The stroller and chair blocks are constructed of Tivar-100, an ultra high molecular weight polyethylene. This material was chosen for its desirable properties.

The total cost for this project, including the stroller but not labor, is less than $140.

Transportable Bathing Support Device

Designers: John H. Melvin, John J. Bernhardt, Bill P. Hanser
Supervising Professor: Dr. R. J. Conant
Department of Mechanical Engineering
Montana State University
Bozeman, MT 59717

INTRODUCTION

A bathing support device was required for our client and people in general with athetoid cerebral palsy. A specific geometry was needed for the bathing support device to reduce and constrain the strong, involuntary muscle contractions of our client. Our design also reduces the degree of lifting involved in transferring the bather in and out of the device by eliminating extended lifting over the edge of the bathtub. Also, since our client cannot walk, we felt it would be convenient if the device itself were mobile, thus providing transport to and from the bathing area, and eliminating the inconvenience of an additional transport device.

SUMMARY OF IMPACT

This device has been successful in providing an improved bathing situation for the family. It enables the child to be conveniently moved from the bedroom to the bathroom shower area, and the specific shape of the support device reduces spasticity during bathing.

TECHNICAL DESCRIPTION

There are three distinct parts to our final design: the bathing support itself; a mobile cart used to transfer the support device; and a removable, folding rail structure mounted in the bathtub. The bathing support and mobile cart are shown together in Fig. 1. During bathing, the one piece rail system is removed from a storage area and mounted in the bathtub via two locking clamps attaching to the bathtub walls, and four suction cups attaching to the tub floor. The attendant then loads the bather on the support device from a convenient location in the house. The support is transported into the bathroom using the mobile cart. The mobile cart and the bath rail system are locked together for safety, and the support device is slid from the cart onto the rail support in the bathtub. After bathing the procedure is reversed.

The frame of the bathing support is made of 1.5 inch, schedule 80 PVC pipe. For the device to be effective, the hip angle (the angle between the user's abdomen and knees) must be reduced to less than 90 degrees while the user remains in a comfortable, seated position. This was accomplished during the design of the device by using differently angled PVC couplers at the joints of the support. The support material is pipher text, a vinyl coated nylon mesh, that is high in strength, non-abrasive to the skin, and unaffected by the bathtub environment. We also felt there was a need for support belts and pads. The neck pad holds the head in place, preventing injury, while also providing a comfortable position. The hip and ankle belts provide the constraint necessary to prevent the bather from falling from the support, and to minimize uncontrolled muscle reflexes.

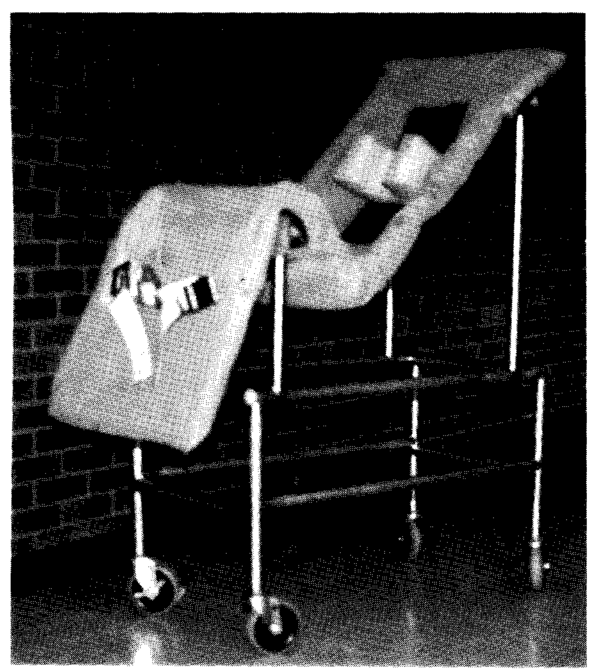

Figure 6.4. Transportable Bathing Support Device

The transfer cart is constructed from one inch diameter, 0.083 inch wall thickness, stainless steel pipe. A set of four, one inch wide and six inch diameter castors provides easy maneuverability on all household flooring surfaces.

The bathtub rail system is constructed of water sealant coated, lightweight metal. It is a one-piece design, hinged in three places with two sets of locks to rigidly hold the device while in use. The rail system easily collapses into a five-inch wide unit requiring a minimum of storage space. The male end of the rail system, on both the transfer cart and in the bathtub, is stainless steel, while the female end connected to the bath chair itself is PVC. This design allows the device to be easily slid over the stainless steel surface during transfer. The universal approach of this rail system is intended for a more general use if commercial production is carried out.

Finally, the design is adaptable to a walk-in shower. The cart is designed to withstand the moisture of the shower, and the rail system is simply no longer used.

A conservative loading scheme for the device while in use was developed and modeled on a three dimensional structure's program developed at Montana State University. This program was used to design all member sizes, with a minimum factor of safety of 5 with respect to minimum yield strengths of materials. The large factor of safety was used to take into account the large amount of dynamic loading that occurs during use of the device.

During the design and construction of this project the safety of the bather and the attendant was of premiere importance. Considerations included the stability of the cart. The transport cart, with the loaded support device attached, had to meet the rigorous wheelchair specifications for stability. Also, the entire system was subjected to a rigorous testing procedure including static, dynamic and impact testing. The system also contains a number of locking and restraint mechanisms to prevent injury. The design and its operation were made as straight-forward as possible, for the purpose of eliminating user error, or misuse.

The total estimated cost, not including labor, is $700.

Dynamic Linkage for a Cross-country Sit-ski

Designers: Rob Martin, Mark Slovak & Tom Wilson
Rehab Professional: Lee Barkmann, Eagle Mount, Bozeman, MT
Peter Axelson, Beneficial Designs, Santa Cruz, CA
Supervising Professor: Dr. R.J. Conant
Mechanical Engineering Department
Montana State University
Bozeman, MT 59717

INTRODUCTION

Traditionally, cross-country ski equipment for people with disabilities consists of a seat mounted rigidly atop runners or skis. Sit-skiing allows the user to strengthen their large muscle groups as well as experience the freedom to explore the outdoors with little or no assistance. Unfortunately, most of the sit-skis currently available, are heavy, cumbersome and usually suited to a specific user with individual needs or abilities. Due to the rigid system, poling can be quite exhausting because the seating device does not move relative to the skis. Recognizing this, the goal of our design project was to create and develop a dynamic linkage for a cross country sit-ski to eliminate the inherent problems associated with the sport.

SUMMARY OF IMPACT

Skiers have indicated that this design allows them to use a longer poling motion, thereby increasing glide and reducing the effort necessary to propel a sit-ski. With this reduced effort, longer ski tours are possible.

TECHNICAL DESCRIPTION

Having established the need and problem definition, it was necessary to consider designs that would fulfill our requirements. Our goal was to develop three alternative designs, evaluating each to determine which would best fit our needs. A brainstorming process generated attributes and qualities considered important in the design of a dynamic linkage. In addition to the ideation process, a field study was also conducted with input from current users of sit-skis. In November 1991, our design group attended a training seminar for the U.S. Nordic Disabled Ski Team in West Yellowstone, Montana. This opportunity to interview leading competitive sit-skiers provided insight and aided

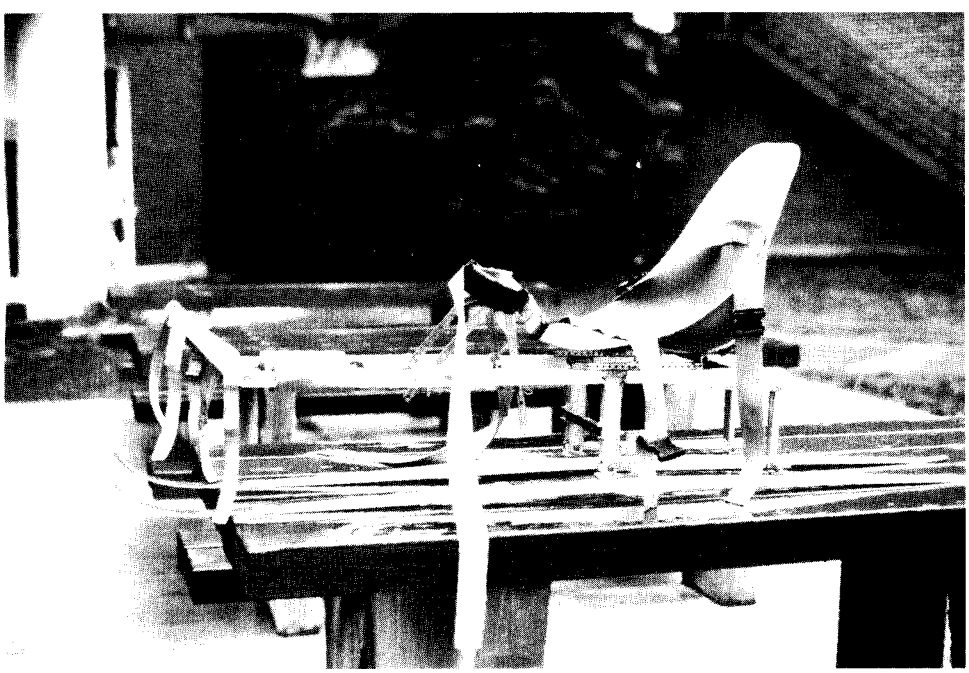

Figure 6.5. Dynamic Linkage for a Cross-country Sit-ski

our group in assessing needs and identifying problems relevant to our design. For example, two of the top-ranked sit-skiers recommended emphasizing stability and light-weight construction. The alternative that our group decided to pursue incorporates the use of a coil-spring linkage. This design was selected due to the simplicity and manufacturability. Next, the system was modelled mathematically for spring and pivot placement. The final step of the design process was to determine the construction materials and the dimensions of the device. This was performed through stress calculations to ensure adequate factors of safety for material failure and device safety. To begin construction, mechanical drawings were composed and checked for manufacturability by a resident machinist. Upon approval, the components of the sit-ski were machined and assembled.

The beneficiary of our sit-ski device is Eagle Ski, a local disabled ski program. Eagle Ski is an 8 week program that enables people of all abilities to experience alpine and nordic skiing. Lee Barkmann, co-coordinator of the volunteer ski organization, actively recruits volunteers for the winter ski season. This program provided our design group with numerous opportunities to test our working model and gather feedback from actual sit-skiers.

Our current task has been distributing our questionnaire to the sit-skiers, whose responses provide us with the specific information necessary to refine our design. After evaluating the questionnaires, we have used the information to modify our prototype and, as a result, better fulfill the needs of our user group. To date, preliminary testing has confirmed our design concept. Cross-country trials conducted on a 30 meter course have improved average times by a 5 second margin over contemporary designs. In addition, the user questionnaire and simple observation has indicated a more fluid, and significantly longer glide.

The cross-country skis and poles were donated by Eagle Mount, with an estimated value of $200.00.

Cost for the sit-ski, shown in Fig. 6.5, is approximately $200, excluding labor and machining.

User Adjustable Chair for a Person With Cerebral Palsy

Designers: Ray Schwehr, Marcia Dyrud, Ezra Szöke
Supervising Professor: Dr. Michael K. Wells
Montana State University
Bozeman, MT 59717

INTRODUCTION

The user adjustable chair is designed to allow a girl with cerebral palsy to seat herself at a table, piano, or desk of arbitrary height without assistance. Current devices on the market do not fully address the problems associated with the client independently seating herself. This chair will relieve her parents of the task of lifting her onto a chair at mealtime or for any other activity requiring her to sit. It also gives the client more independence, which she desires.

SUMMARY OF IMPACT

Our client's parents have indicated that this device has relieved them of lifting their daughter into and out of a chair at mealtime, and given their child an added measure of independence. She is able to transfer from her walker to the chair, attach the seatbelt, raise the chair to the correct height, rotate and slide the chair into position at the table, and lock the chair in that position, all without assistance. She can also independently reverse these actions to get back into her walker. Use of the footrests pose somewhat of a problem for her.

TECHNICAL DESCRIPTION

After several interviews with the client, followed by group discussions of the client's capabilities, a definition of the problem and design specifications were developed. The primary concern of the client was to be able to transfer safely from her walker to a seated position unassisted. This requires the chair to be stable during the transfer. After being seated, the client must move closer to the table, in order to use it, and elevate herself to the desired height. A lift range of 8 to 10 inches is needed.

Family members are required to move the chair to the location where the client wishes to use it. Therefore, the chair must be mobile and fit easily through doorways within the house.

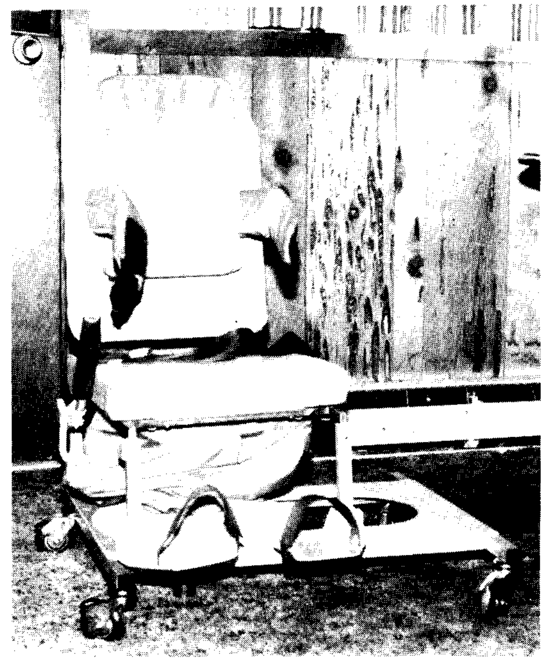

Figure 6.6. User Adjustable Chair for a Person With Cerebral Palsy in lowered position.

A thorough search of existing technologies provided many ideas that helped in developing a solution to the problem. Ideas were constrained to solutions that require the use of the client's arms. Her upper body strength and control are comparatively better than that of her legs.

Brainstorming sessions lead to three design alternatives of which models were made to determine their feasibility for a final design. All three alternatives employed a rotating and elevating seat that is accessible to the client when in the lowered position (about 16” from the floor). Rotation is provided for by swivel bearings interfaced between the seat and base. Possible lifting mechanisms for elevating the seat utilize a linear actuator, a ratchet type car jack, or a hydraulic cylinder with piston. All can be powered electrically or manually except for the car jack that is manual only. Lateral motion of the seat to and from a table, desk, or piano is achieved by the implementation of a sliding rail system or base mounted casters such as used on office chairs. The rail system would allow the seat to glide horizontally relative to the fixed base while casters would permit the chair as a unit to roll over the floor.

The final design, shown in Fig. 6.6 in the lowered position and in Fig. 6.7 in the raised position, combines some aspects of all three alternatives. The expense of the linear actuator precluded further consideration of it as a viable lifting mechanism and the ratchet type car jack could not be used in its available form without major modification. Therefore, both were abandoned in favor of the hydraulic system that was purchased outright and required little alteration.

Manual power provided by the client is preferred over electric power because of the nuisance of recharging batteries or running a power cord to a wall outlet was deemed undesirable by the client and her family. Manual operation also has some therapeutic value to the client.

In an effort to reduce the machining and construction time, large casters for moving the chair to and from the table proved to be the simpler choice over the rail system. Testing of the device showed that this method was too difficult for the client when on the deep pile carpeting in the eating area. Therefore the chair was rebuilt with the rail system, which works very well.

As in the three alternatives, the final design incorporates a swivel to allow the client to face the table after seating herself. A footrest, scoli pads, seat and chest belts, and a brake system were added for stability and safety. The chair can also be adjusted to allow for growth of the client.

The cost of materials needed to build this chair plus outside labor costs amounted to about $650.

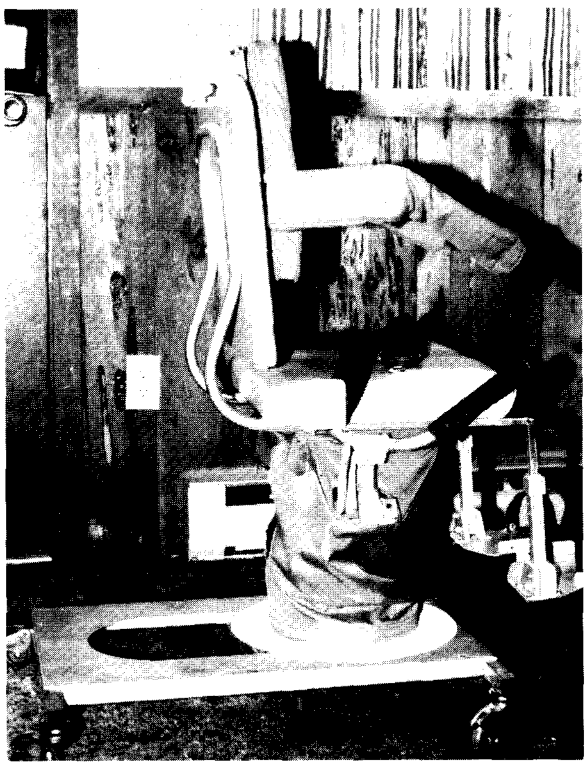

Figure 6.7. User Adjustable Chair for a Person With Cerebral Palsy in raised position.

Adjustable Computer Work Station

Designers: Randy Hansen, James Konynenbelt, Lance Fred
Client: Ms. Annalee Allen
Supervisor: Dr. R. J. Conant
Department of Mechanical Engineering
Montana State University
Bozeman. MT 59717

INTRODUCTION

A speech therapist working at the Montana Center for Handicapped Children in Billings, Montana, needs an adjustable computer work station. Many of her clients use specialized wheelchairs that require different heights for the key board and various positions for the monitor. Because the clients range in size from small children to adults, adjustments in the station must often be made before it is suitable for the next user. For example, individuals who are oriented in their chairs in a manner that directs their vision towards the ceiling require a monitor position that is 18 inches higher than the keyboard position. Others, who have a dominant eye, require the monitor to be adjustable from side to side.

A state-of-the-art analysis revealed that office furniture and rehabilitative equipment is not readily available to meet the need of our client. Prices for the desks range from $600 to $4900, depending on options and ease of adjustability, which places them out of reach for many consumers.

SUMMARY OF IMPACT

Our client has indicated that she is pleased with the accessibility and adjustability of the new work station. In comparison to the standard commercial computer desk used previously, she cites the following advantages: the new desk is readily accessible to every wheelchair that has been tried; the height of the work surface is easily adjustable to accommodate various users; the height and position of the monitor is readily adjustable; the work surface of the desk provides adequate room to support adaptions such as the Power Pad or the Unicorn expanded keyboard; the storage unit keeps all the modifications in proximity to the work area. She indicates that the new work station significantly enhances her ability to provide services in adapted computer access to individuals with disabilities.

TECHNICAL DESCRIPTION

The design criteria were created by analyzing the needs of our client and the intended use of the desk. After meeting the client, a wish/required list was created which included the range of adjustability for the keyboard and monitor, and the ease and speed at which this could be accomplished. The intended use of the desk was used to determine its strength and stability characteristics. Although under normal use, the desk is to hold only a computer, printer, and monitor, the design requirements made allotments for people sitting or leaning on the desk, and overloading with books or other heavy items. In this manner, the desk was designed for a realistic worst case scenario.

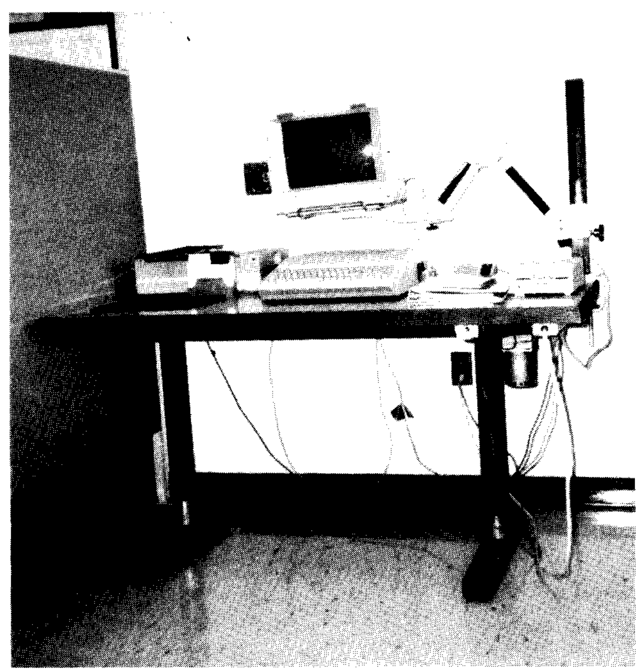

Figure 6.8. Adjustable Computer Work Station

Three alternative designs were considered before a final design was chosen. The first alternative, a scissors lift table that included a torsion bar, was considered because it could be adjusted with one power source, thus eliminating the need for a self leveling mechanism. This design was eliminated because it is geometrically weak, which required large structural members and made the desk too heavy. The second alternative used two linear actuators, which were placed inside two telescoping legs located at the sides of the desk. This design was lightweight and easy to manufacture, but the actuators were too expensive. The third alternative used a master-slave hydraulic system to raise and lower the desk top. The possibility of spills, plus the high cost of an electric pump made this design less attractive.

Since the only disadvantage of the second design was the price of the linear actuators, the final design was modeled after it. A power jack, similar to the one conceived in the first alternative, was substituted for the linear actuators. The final design, therefore, had both the structural and weight advantages of the second design, and the price of the first.

The final design of the work station, shown in Fig. 6.8, features an aluminum U-shaped base that allows for easy frontal access by wheelchair users. The circular telescoping legs, also made of aluminum to minimize weight, have a small clearance with respect to each other to minimize binding. The power jack is composed of two vertical threaded rods, one in each leg, which are connected by a chain and powered by a 115 volt reversible motor. Initially a 12 volt motor was desired for safety reasons, but the increased cost of the motor, plus the additional cost of a rectifier and battery made this option very unattractive. Furthermore, the complexity of a 12 volt system in comparison to a 115 volt system may in fact make the system more dangerous.

A modified, commercially available CRT arm was used for the monitor adjustability because it was cheaper than building one from scratch. Several designs for monitor adjustments were studied in the state-of-the-art analysis, but very few had 3-D adjustment capabilities. A 2-D CRT arm was modified by welding a post to its mounting clamp, allowing a jacket attached to the existing arm to slide up and down the length of the post.

The $1\frac{15}{16}$" thick desk top is made of $\frac{3}{4}$" plywood, $\frac{3}{4}$" particle board, and $\frac{1}{16}$" Formica. The Formica is scratch resistant that increases the life of the desk top. Initially, the top was only made from $\frac{3}{4}$" particle board, but the plywood was added for additional strength and stiffness after initial testing was completed.

The cost of the desk, excluding labor, is about $580.