CHAPTER 4

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Trunk Support for a Horseback Rider With a Disability

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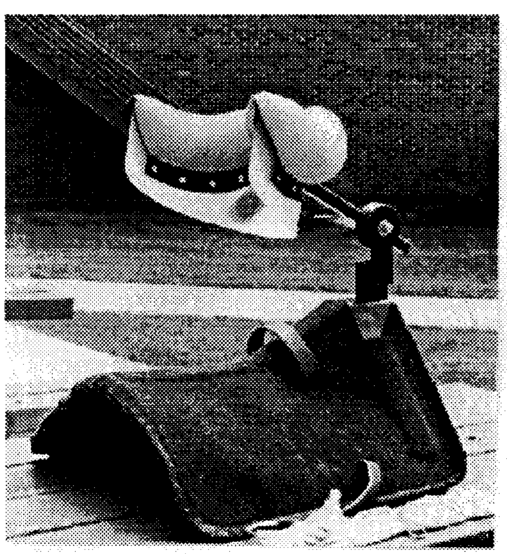
INTRODUCTION

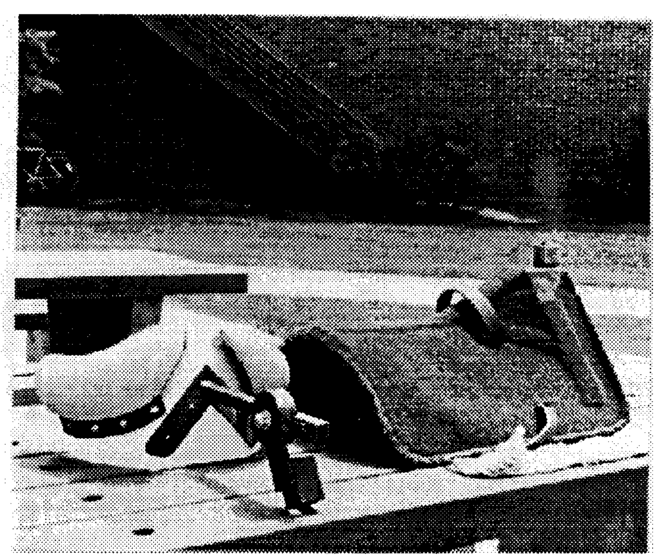
Horseback riding is known to provide excellent therapy for people with disabilities because it stimulates and strengthens muscles, and improves balance. For people with cerebral palsy, whose muscle tone tends to be abnormally high, horseback riding has the very desirable effect of causing muscles to relax, thereby reducing muscle tone.

Often, in order for a person with a disability to ride a horse a volunteer, called a back-rider, is needed to sit behind the rider and support their trunk. This is tiring for the volunteer and reduces the sense of independence that goes with riding a horse.

The goal of this project is to develop an assistive device for supporting the trunk of a teenage boy with cerebral palsy so that he can safely and comfortably enjoy the sense of independence that comes with horseback riding without a back-rider.

The final design features a device that mounts in front of the rider and lends support under the rider's arms. The support wraps partially around the sides of the rider, extending up and under the rider's arms and thereby providing the required trunk support. This trunk support system is lightweight and does not hinder the rider's control over the horse. It meets the requirement of the North American Riding for the Handicapped Association (NARHA) that the rider not be tied to the horse or saddle in any way. Preliminary testing of the design indicated that the design provides adequate trunk and balance support for the rider while still allowing for an emergency dismount. The device also places the individual in the correct riding position. A ROHO saddle cushion is utilized to insure further comfort and minimize the possibility of pressure sores.





SUMMARY OF IMPACT

Cindy Dabney, director of Eagle Mount's therapeutic riding program, offers the following comments: "This device that has been designed and built for a specific individual can benefit many other riders with multiple disabilities. With assistance from this device a participant in a therapeutic riding program who previously needed a back-rider for support can now ride a horse semi-independently. It can be very difficult and tiring to support a person with multiple disabilities in the riding position necessary to control a horse. It is hoped that this device can free a person who has limited or no upper body use to become semi-independent in their riding abilities. This device could be used in many therapeutic riding programs throughout the country."

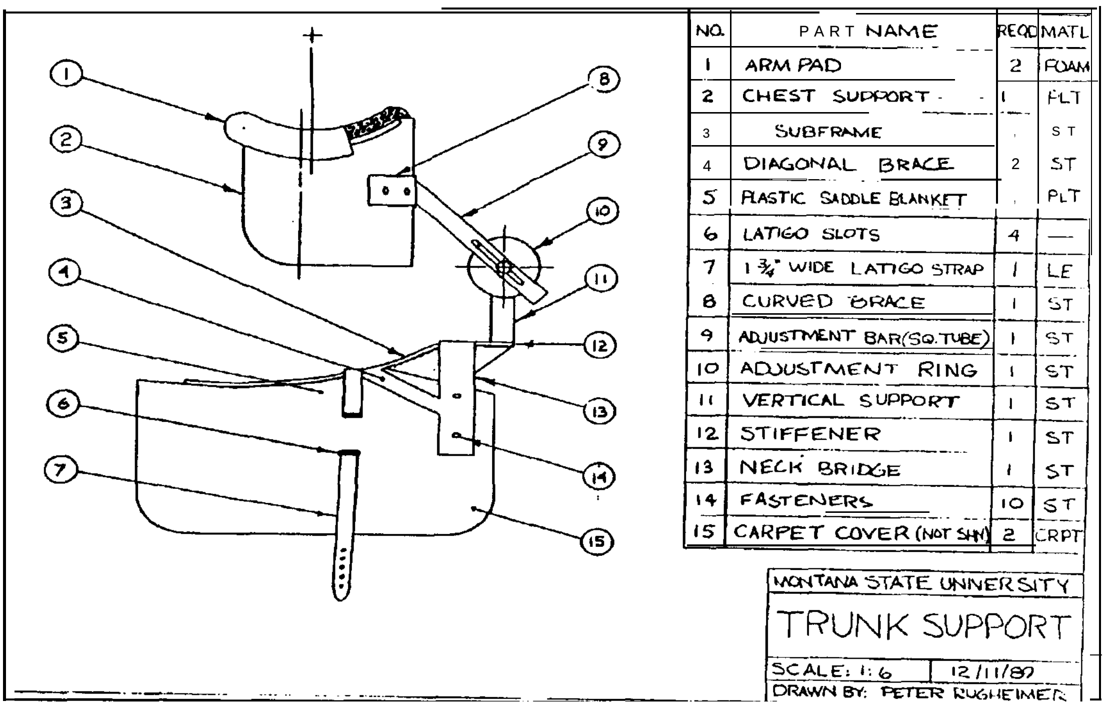
TECHNICAL DESCRIPTION

DESIGN PROCESS

Research in the horseback riding field for people with disabilities was carried out to see if any existing designs would solve the problem. Several devices used to support the trunk were found, but all tied the rider to the horse. For safety, the main concern was not to tie the rider to the horse in any way. With no current devices meeting the design requirements, several riding and brainstorming sessions were held. Design specifications were established and several design alternatives that met the specifications were developed. The final design was chosen from these alternatives because it was felt that it could be designed and fabricated with the skills available to the designers and would meet the time and cost constraints of the project.

The final design features a device that mounts in front of the rider and lends support under the rider's arm. The trunk support system allows the rider to escape in a rearward direction in the event of a run-away horse. The chest support component wraps partially around the sides of the rider, extending up and under the rider's arms and thereby providing the required trunk support.

The trunk support system is composed of two major components. The first component is a polyethylene plastic saddle blanket mounted to a steel sub-frame. The covered plastic saddle blanket is placed between the normal saddle blanket and the saddle. For stability, the plastic saddle blanket is held onto the horse by the weight of the saddle and rider, the saddle's cinching system, and its own cinching



system. The second component consists of an adjustable linkage and the chest support. The adjustable linkage allows adjustment to fit a range of rider sizes. The chest support, which is made of polypropylene plastic, is attached to the adjustable linkage. For comfort it has covered foam padding under the arm area. Once the device has been adjusted to the individual, the chest support can be easily and quickly detached from the plastic saddle blanket, allowing for easy mounting and dismounting.

ANALYSIS OVERVIEW

In the specifications, based on the anticipated rider weight, the trunk support was to support a load of 100 lb. A safety factor of three was applied to this load for a design load of 300 lb. The following is an overview of the analysis of the trunk support from the top down.

The applied load from the weight of the rider's trunk contacts the foam arm pad. The load is carried through the foam arm pads and distributed along the curved arm slots of the plastic chest support. The geometry of the chest support prevents it from being analyzed with classical methods. A different tool was needed to perform the analysis. The tool used was a finite element computer program called ALGOR which divides the structure up into hundreds of little elements (hence the name finite element) and performs a stress analysis on each element. The output from ALGOR is a visual display representing areas of differing stress as shades of color. To complement the color distribution, there is a legend on the screen that indicates the amount of stress that each color represents. The point of maximum stress occurred at the point where the plastic chest support attaches to the adjustable linkage. The maximum stress calculated by ALGOR was 2200 psi, well under the allowable stress of 4300 psi for the plastic.

The load is then transferred to the curved brace that attaches the adjustable linkage to the chest support. The stress in the curved brace is a combination of bending and torsion caused by the loads on the plastic chest support. The torsional stress formula for rectangular members [1],

$$\tau_{xy} = \frac{T}{wt^2}\left(3+1.8\frac{t}{w}\right),$$

where T is the torque, t is the thickness of the cross-section and w is its width, was utilized to determine the torsional shear stress in the brace. The bending stresses were determined from the flexure formula. The principal stresses were then found from Mohr's circle and compared to the allowable endurance strength. The member size, 2" x 3/16" AISI 1018 HR steel, was then determined by the above analysis.

The load passes through the weld that attaches the curved brace to the slotted square tube. Weld analysis indicated minimal stress in the weld.

The load is then carried to the adjustment bar. The maximum point of stress is at the slotted end where the tube enters the adjustment mechanism. The adjustment bar is a long slender beam and was therefore analyzed using beam theory. The member, 1-1/4" x 1/8" AISI 1018 HR square steel tube, was sized by fatigue considerations.

The load is then applied to the adjustment mechanism. Here, two adjustments are combined First, the angular position of the square tube is infinitely adjustable. Second, the square tube can be linearly positioned by sliding the square tube under the head of the carriage bolt and then by tightening the bolt. The frictional force produced by the preload on the central carriage bolt resists the torsional load induced by the 300 lb loading. To overcome the applied torsional force, the frictional force must be exerted at a large distance from the axis about which it acts. A formula can be derived that gives the maximum torque, T,
that can be resisted with a given coefficient of friction, μ, and bolt preload, F_{pre}, as

$$T = \frac{1}{2}\mu F_{pre} L$$

where L is the outer radius at which friction acts. The analysis determined the diameter of the frictional adjustment plate needed to minimize the carriage bolt preload while still producing sufficient frictional force. The frictional force is highly dependent on the material that is clamped together. Rubber was chosen as a buffer between the two metal pieces because of it's high coefficient of friction. Analysis of the stress in the preloaded carriage bolt determined the size needed. The analysis indicated an UNF 3/16" Grade 8 carriage bolt would be of adequate strength, but it was decided to use an UNC 1/2" Grade 8 carriage bolt for safety in other considerations. One was that not as much wrench force was needed to tighten sufficiently the 1/2" bolt.

After the load is transmitted through the adjustment mechanism, it reaches the vertical support. The support was specified larger than necessary with respect to stress. It was sized large to minimize the inherent inaccuracy that occurs when the support is fitted over the upright post. The upright post allows the whole upper half of the trunk support to be removed from the plastic saddle blanket. This allows for removal when a rider mounts the horse or when an individual wants to ride without the chest support component in place.

The load is then transferred to the metal sub-frame that extends under the plastic saddle blanket. The function of the steel sub-frame is to distribute the 300 lb. load to prevent pressure concentration on the horse. Analysis for stress and deflection of the steel subframe was performed. From the above analysis, the sub-frame stress was determined to exceed the allowable fatigue stress of 10 Kpsi. This was acceptable because the stress is distributed to the plastic. The metal must deflect somewhat to conform to the different horse shapes, but not so much that permanent set prevents the even distribution of pressure.

Finally, the load is distributed over the plastic saddle blanket producing small pressure areas on the horse's back. The analysis performed determined if the plastic had sufficient strength to prevent puncture due to forces exerted by the metal pieces, which was the limiting factor of the plastic. The calculated stress was under the limiting value of 2500 psi needed for a safety value of three for the plastic.

CONSTRUCTION OF DESIGN

Using an actual horse, positive and negative plaster molds were constructed from the horse's back. Utilizing the molds, the plastic saddle blanket was formed using polyethylene plastic softened in a radiant heat oven. Polyethylene plastic was chosen for it's characteristics of strength, flexibility, and moldability. The chest support was also formed using the radiant heat oven to soften the polypropylene plastic and then form it around a tubular mold. The steel sub-frame was hand-formed and welded to fit the shape of the horse's back. The plastic saddle blanket was padded, painted, and covered with a water resistant carpet. A surcingle cinch system was then attached.

The adjustable linkage was machined and welded using various machining equipment. Special knurling methods were utilized on the friction surfaces of the adjustable rings to prevent slippage. A hand formed steel frame was constructed to attach the chest support plastic to the adjustable linkage. Covered arm pads were sewn and attached to the plastic chest support.

TESTING CONCLUSIONS

The design and testing process was an iterative process, and during all phases of testing improvements to the support were identified and made.

During testing, an open cell three inch foam pad was used underneath the arms. A few test riders indicated more padding was needed. It was decided that it would not be advantageous to use more than three inches of foam as the pad may begin to hold the rider's arms out too far, which could cause the rider to slip out of the device prematurely.

One area of testing that has not been carried out is fatigue testing. One cycle of loading and unloading occurs each time the horse takes one walking stride. Analysis has shown that the steel parts that make up the support will have sufficient fatigue strength, but this should be verified through testing.

Testing has shown that this device should be used for people who have normal trunk lengths and are between 4' 6" and 6' tall. A different size chest support would have to be built for riders with longer or shorter trunks.

For reasons of safety, the support should only be used by individuals with an injury level similar to a C-7 or lower who have use of their arms. The reason is that if a person falls off the horse during an emergency dismount, they can break their fall with their arms. Individuals with higher injuries would have a diminished ability to break their fall with their arms.

COST BREAKDOWN

The following cost breakdown is for the materials that went into the trunk support. Not included is the cost of labor.

MATERIAL	COST($)
Steel	20.00
Plastic	60.00
Fasteners	25.00
Cinch/Latigo	24.00
Carpet	10.00
Lycra	3.00
Plaster	20.00
Contact Cement	14.00
Misc.	20.00
Molding Labor	25.00
Roho Cushion	300.00
Plaster Cloth	40.00
Plywood Sheet	10.00
Steel Components	25.00
Total Cost	$596.00

Note that half the cost is for the Roho cushion. We were fortunate enough to have this donated.

FINAL REMARKS

During this rehabilitation design project all phases of the engineering design process were covered, starting with in depth research of the horseback riding field for people with disabilities. It was determined that no "safe" trunk support devices currently exist. Through riding and brainstorming sessions, several alternate designs were developed that would give adequate support to the rider. After reviewing the alternatives, a final design was chosen that satisfied the design specifications. A prototype of the chosen design was built and tested. From test sessions, it was concluded that the design safely provides adequate trunk support. Throughout the engineering design process, safety has always been the number one concern.

It must be remembered that horseback riding is a high risk sport and the participating individual must realize the risk involved. The designers strongly suggest the person using this device ride only under close supervision of experienced personnel and in a controlled environment, such as an indoor arena, so that unpredictable events that may spook the horse can be minimized.

REFERENCES

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An Adaptive Bicycle Adaptations to a Commercial Bicycle for Children with Mobility Impairments

Designers: Jeff Errett, Brent Johnson and Dennis Coffey
Rehabilitation Professional: Arlene McKinnon, RPT,
Bozeman Physical Therapy Center, Bozeman, MT 59715
Supervising Professor: Dr. R. J. Conant
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INTRODUCTION

Children with certain mobility impairments such as cerebral palsy are unable to ride a standard bicycle because they lack the required balance and coordination. In cases where these limitations are not too severe, these children can ride a bicycle that has been modified to accommodate their special needs.

The goal of this project was to design a bicycle that could be used by a child with cerebral palsy. The resulting design converts a commercial bicycle to a three-wheeled configuration and provides the necessary modifications to the brakes, handlebars and seat. The modifications are easy to carry out and result in a three-wheeled cycle that is functional, lightweight and inexpensive.

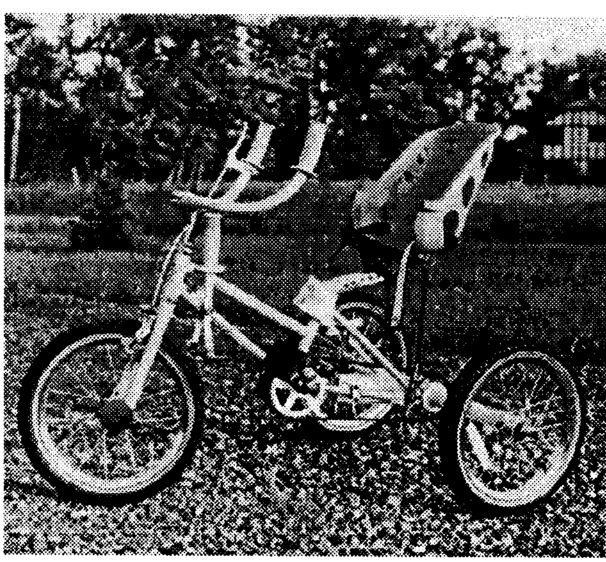
SUMMARY OF IMPACT

All kids love bicycles, and having one enables a child to go places and to things with friends. The three-wheeled cycle will strengthen this child's reciprocating leg motion and will provide the child with an additional source of independence.

Current three-wheeled cycles are expensive, heavy, and are not available in this small size. This design is inexpensive, lightweight, and easy to build. It should benefit a number of children whose mobility is limited.

TECHNICAL DESCRIPTION

The young child for whom this design was developed is ambulatory with the use of a walker. Because the child's particular walker has upright handgrips it was decided that the bicycle also should use upright handgrips. This required modification of the handlebars. To provide the trunk support needed by the child the standard bicycle seat was replaced with one that has a backrest with lateral supports. A Velcro waist strap is used to secure the child in the seat.



To facilitate getting the child on and off the bike, a parking brake was added to the front wheel. This brake is actuated by a simple lever, similar to a wheelchair brake.

Toe straps were required to keep the child's feet on the pedals. However, these make the pedals top-heavy and the they have a tendency to rotate so that the toe straps are underneath the pedals. Because of the child's lack of fine motor control this was considered a problem. A solution is to use self-righting pedals often found on exercise bikes. For this project, Schwinn Aerodyne pedals were used. These are selfrighting and include an adjustable velcro strap to restrain the foot.

It was felt that dynamic braking could most easily be accomplished by this child with a hand operated brake. Therefore a caliper brake, attached to an existing hole in the front fork, was chosen over the coaster brakes typically found on small bicycles. The caliper brake is actuated by a brake lever from a child's BMX-style bicycle attached to the right side of the handlebar. A three-wheeled design was chosen over other alternatives considered because it proved to be a lightweight and stable way of providing the stability needed by this child. It also seemed the most effective means of accommodating the uneven surface of the gravel road on which the cycle will be used.

A conventional tricycle was ruled out because it was felt important for this child to have a design that was similar to what her peers were riding. Also, with a tricycle, the pedals are attached to the front wheel, so that the legs must twist to compensate for the rotation of the front wheel for steering purposes. This complication is eliminated with a pedal arrangement that drives the rear wheel or wheels.

It was decided that, to maintain simplicity, the bicycle hub should not be modified unless absolutely necessary. To avoid the need for a differential arrangement, and to simplify power transmission, only one rear wheel is powered. Bicycle hubs are designed so that the rear sprocket is to the right of the driven wheel. To use the hub on the right wheel of a three-wheeled configuration, its orientation would have to be reversed so that the sprocket was on the left side of that wheel, in which case the operation of the free-wheeling mechanism would be reversed. To alter this would mean extensive reworking of the hub. Thus the left wheel must be the driven wheel. To simplify the design, a stationary axle was used through the frame. This dictated that all rotating components, including the rear sprocket, be located to the left of the frame. To avoid having the chain pass through the frame it then became necessary to reverse the crank arm so that the front sprocket was also on the left side of the frame.

The drive assembly consists of a 1 in. by 2 in. rectangular tube that slips between the rear frame members, and extends three inches to the rear of the frame. The front of this tube has holes drilled in it so that an U-bolt can clamp it to the frame members. A round steel bar passes through holes in the rectangular tube and is welded to the tube. This bar fits between the dropout slots in the bicycle frame, and provides primary support for ' the drive assembly. Holes drilled in the ends of the steel bar enable bolts to hold the drive assembly in the dropout slots. The stationary axle passes through holes in the portion of the rectangular tube that extends beyond the bicycle frame. Thus the rear axle is moved rearward a few inches. Drilled and tapped holes in the ends of this stationary axle accept one end of a standard bicycle axle. An extra front wheel is used as the right rear wheel. The bicycle's rear wheel is used as the left rear wheel in the threewheel configuration. The sprocket is removed from the hub and a sleeve is threaded on in its place. This sleeve slips over the left side of the stationary axle and the frame end of the sleeve is supported by a bearing mounted on the stationary axle. The sprocket is welded to the frame end of the sleeve, placing the sprocket to the left of the frame, as desired. The sleeve is slipped over the stationary axle and the one end of the hub axle treads into the stationary axle. The sleeve transmits torque from the rear sprocket to the left wheel.

Total cost for this project, excluding labor, is $190 of which $100 is for the purchase of a 16 in. bicycle.

Alpine Ski Walker
A Device for Therapeutic Recreation

Designers: Wes Mikes, Steven Henderson and W. Karl Martin
Rehabilitation Professional: Lee Barkmann Eagle Mount, Bozeman, Montana
Supervising Professor: Dr. R. J. Conant
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INTRODUCTION

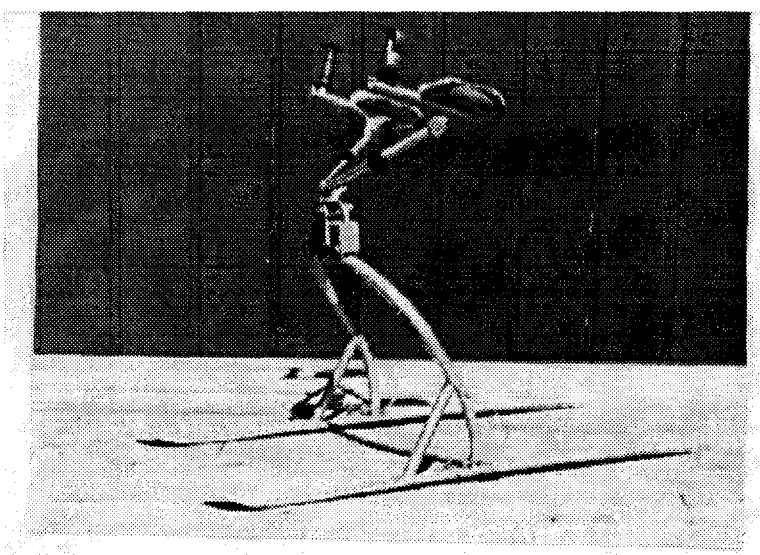
Therapeutic recreational activities such as alpine skiing offer a feeling of independence to people who suffer from various types of physical disabilities. This is a very important factor in rehabilitation. However, the current device being used by persons with disabilities such as cerebral palsy and post polio disability for support while skiing is inadequate in design and severely limits the skier's ability to make turns. The current device, called a ski walker, is simply a conventional walker device mounted on a pair of alpine skis. The skier uses conventional alpine ski gear. To prevent the ski tips from crossing, the tips of their skis are connected to those of the walker. Two volunteers are required to ski on either side of the walker to aid in turning and to prevent tipping on side slopes. A third volunteer skis behind the walker with a set of reins that are attached to the skier. This volunteer controls both speed and turning. The current walker is very rigid and stiff with little or no adjustment for height and width. In addition, the ski walker is difficult to turn and tends to tip while being turned on steep inclines.

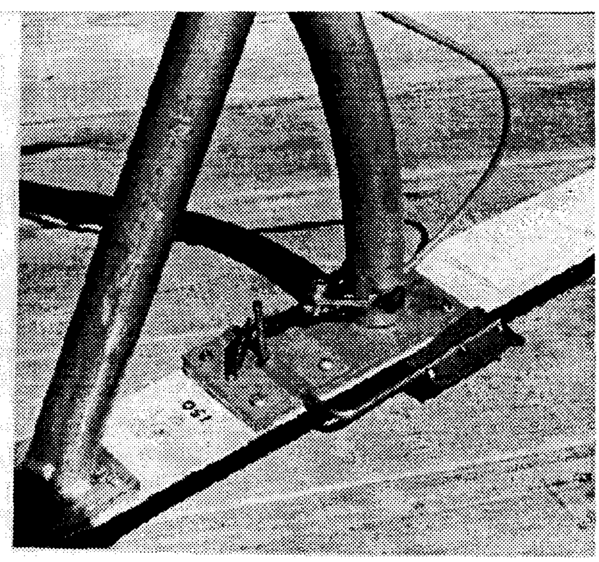
A new ski walker has been developed that has improved turning capabilities, flexibility and stability, and has maximized adjustment while retaining a light weight. With this new device, a skier with a disability becomes a more active participant in the sport of alpine skiing.

SUMMARY OF IMPACT

We now have one full winter of experience with the ski walker. There were some annoying failures of welds due either to improper design or fabrication, but the basic concept is sound.

Lee Barkmann made the following comments regarding the ski walker: "The intent of the design is to provide the skier with more control and independence in steering through turns. Skiers





using this new design are able to take a much more active role in skiing. Due to the design of the walker, they are learning the concept of weight transfer which facilitates the initiation of turns and thus gives them more speed control. The use of this walker has provided more flexibility for skiers in our program and a greater opportunity for them to learn more skills in skiing."

The walker, as built, is intended for adults. We hope to be able to build a child's version as well. We think the walker could potentially benefit other therapeutic skiing programs and hope to have the walker tested in a few other programs to get more feedback on the design.

TECHNICAL DESCRIPTION

The new ski walker (Fig. 1) is fabricated of aluminum alloys. These alloys have good strength to weight ratios allowing the ski walker to be light weight. A light weight ski walker is essential because someone has to carry it up the ski slopes via ski lifts! The newly designed ski walker uses a single piece of (1.25" OD) continuous round tubing for the legs. It has large radius bends and is wider than the current ski walker. This improves the stability of the ski walker when turning on and traversing steep inclines.

The handlebar assembly contains upright and crossbar members. The upright members are made of two pieces of telescoping round tubing (1.125" OD female, 1.00" OD male) with locking collars. The crossbar is also telescoping round tubing (0.75" OD female, 0.625" OD male) with a locking collar. Telescoping tubing and locking collars allow height and width adjustments of the new ski walker. Forearm rests made from PVC tubing and standard ski pole grips are mounted to the top of the handlebars.

Each forearm and grip assembly is mounted to the handlebars by locking couplings. This allows the assemblies to be adjustable relative to horizontal. Each grip is also mounted using these couplings so the grips can be rotated relative to vertical and locked at any rotational angle. The handlebar assembly attaches to a center hinge joint that is bolted to the mid point of the leg piece. This joint adds flexibility by allowing the handlebars to tip left or right when the disabled skier leans to initiate a turn. A spring mechanism returns the handlebars to center. The center hinge joint activates turning mechanisms located on each walker ski (see Fig. 2) via shielded cables. To initiate a turn, the skier rotates the handlebar assembly in the direction of the turn . For instance, if a left turn is desired, the skier rotates the handlebar assembly to the left by leaning on the left forearm rest thus activating the turning mechanism located on that side of the ski walker through cable pull. This causes the paddle on the left turning mechanism to drop below the walker ski into the snow. The created drag slows that side of the walker and results in a turn to the left. There are some disabilities where an individual has very little muscle control. In these cases, the center hinge joint can be locked to prevent handlebar assembly rotation.

The prototype ski walker was field tested for three months at a local ski area. Several things were learned from this testing. Control was improved and skiers felt more comfortable with the reins attached to the ski walker rather than the skier. In shallow turns the paddles don't dip low enough to contact the snow. However, the skier's turning skills are still improved because rotating the handlebar assembly allows the skier to lean into the turn. For sharper turns, the paddles dip into the snow creating a "rooster tail" of snow and causing the walker to respond with graceful turns. On shallow slopes the skier has full control of their actions, with the volunteers acting only as backup. On steeper slopes as well as on side slopes the volunteers still play an active role in controlling speed, assisting in sharp turns and preventing tipping. Comments from volunteers indicate that the new walker allows much more active participation in skiing by the disabled skier. They also indicate that the addition of hand grips on the legs would help in getting on and off the lift with the walker, and would give them something to grab when their help is needed to aid in turning or stability. Because the disabled skier now plays a more active role in skiing, the amount of work done by the volunteers in controlling turns with the reins or by physically turning the walker is reduced. The new ski walker also may be adjusted to fit the disabled skier and adds stability and flexibility while retaining a light weight. This all adds to the sense of independence felt by the disabled skier and enhances their enjoyment of alpine skiing.

The new generation ski walker cost three hundred dollars ($300) to build, excluding labor costs.

Hand-Powered Scooter
A Mobility Device for a Down's Syndrome Child with Severe Mobility Impairments

Designers: Koy Brooks, Larry Kaylor, Edward Kelly, Rob Dixon and Dan Chamberlain
Rehabilitation Professional: Arlene McKinnon, RPT, Bozeman Physical Therapy Center
Supervising Professor: Dr. R. J. Conant
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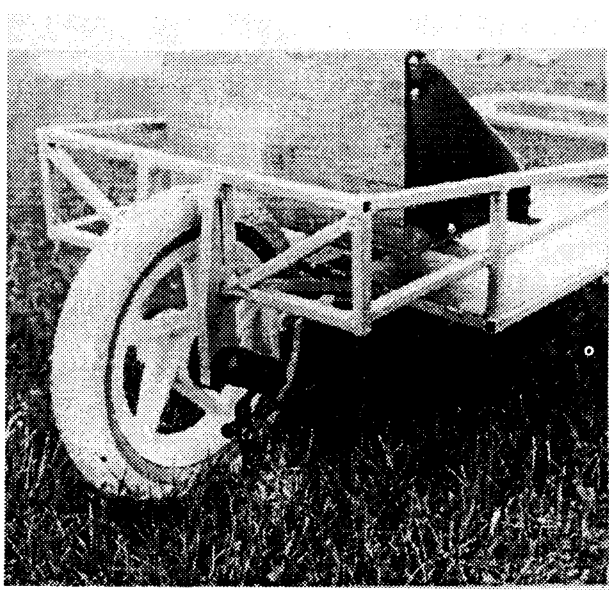
INTRODUCTION

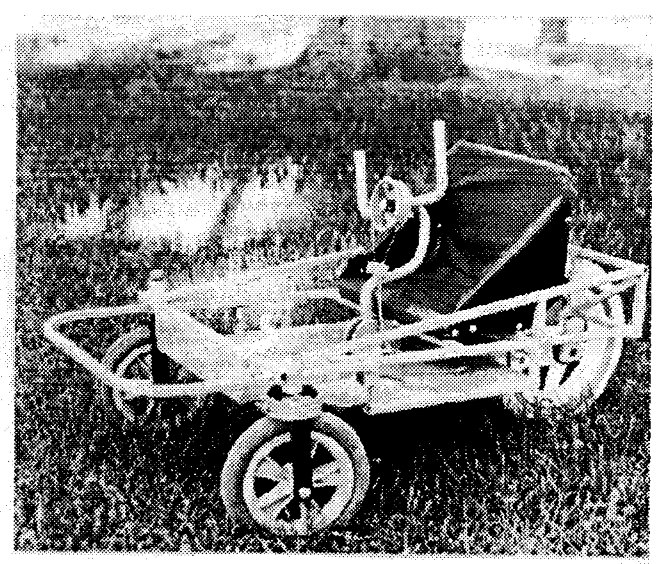
The hand-powered scooter is designed to provide mobility to a young Down's Syndrome child with severe mobility impairments. The scooter is intended to be used in the home and classroom, with some outdoor use possible.

The scooter can negotiate the tight corners encountered in an indoor setting. It is easily propelled, maneuverable and light weight. The back and forth arm motion needed to power the scooter is converted to rotary motion at the rear wheel by a screwdriver ratchet, a readily available device used by mechanics.

SUMMARY OF IMPACT

This scooter was designed by the first three students listed above. The remaining two students fabricated the device. Fabrication took about an academic year to complete, during which time the fabricators made design changes to accommodate various manufacturing considerations. Because of the time required for this project our client, a preschooler, grew considerably and outgrew the device after about 6 months of use. He has recently started to walk. The scooter worked very well for our client, giving him increased mobility both in the home and in the classroom. He enjoyed using the scooter and had no trouble learning to propel it or using the brake. The ratchet mechanism used to propel the scooter works very smoothly so very little force is required to propel the scooter. Since our client is mentally retarded, he had difficulty mastering the steering, and was never entirely successful at it. Now that our client has outgrown the scooter, we are looking for another child who may benefit from it.





TECHNICAL DESCRIPTION

The goals of this project were to design a mobility device for our client that is lightweight, highly maneuverable, and easily propelled. This child can use a wheelchair, but is not motivated to do so. He also can use a small stool with wheels, but motivation is again a problem. Thus, an overriding goal of this project is to design a device that the child would enjoy using.

The device is intended to be used in the child's home and in his school. The vehicle needs to be very maneuverable because of obstacles that will be encountered in these situations, so the mobility device must have a tight turning radius. The vehicle also will be made reversible to that obstacles that even a small turning radius cannot avoid can be overcome. As a safety feature, a braking system is incorporated into the controls of the vehicle. After discussions with the child's physical therapist, it was decided that the braking would be actuated by the child's legs.

To keep the reversing mechanism simple and to avoid the need for a differential it was decided to use a tricycle configuration with two wheels in the front and a single powered rear wheel. Stability with this configuration was a concern. This led to positioning the seat just ahead of the rear wheel, so that it could be located as low as possible.

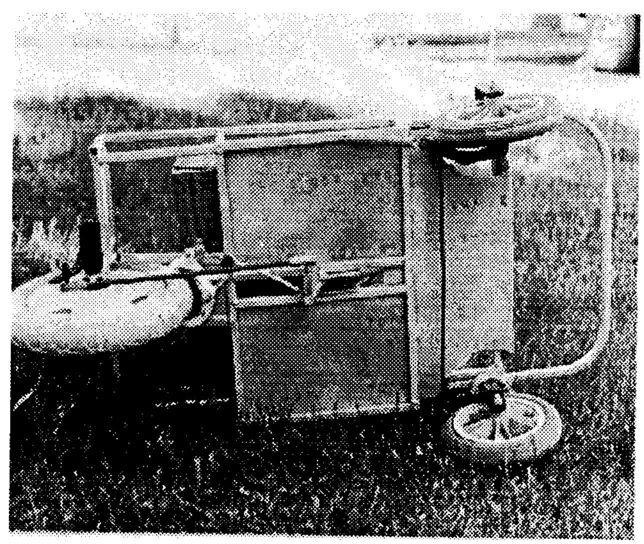
Input power is provided by the child's arms, which are used to move the input lever back-and-forth. This motion is transmitted to the rear wheel by a linkage that is attached to a screwdriver ratchet whose output shaft acts as the rear axle. Since the ratchet is reversible, the vehicle is reversed by pushing a lever that is connected to the ratchet reversing mechanism by a cable. The screwdriver ratchet is a common device used by mechanics and is therefore readily available. A Snap-On ratchet was chosen because it operates very smoothly.

The shaft of the ratchet drives a 12.5 in. diameter plastic wheel with a nonmarking pneumatic tire. The non-marking tire prevents skid marks from being left on floors. The tire is used on a Schwinn scooter and can be purchased from Schwinn dealers. The wheel is attached to the ratchet shaft by a specially made hub that is pressed onto the shaft and attaches to the wheel hub with bolts.

Steering is accomplished by turning the front wheels. A steering wheel is mounted on the input lever and the steering action is transferred to the front wheels by cables. These are bicycle brake cables. These cables run from a disk mounted on the front of the steering wheel down the input lever to the frame, along the frame to the steering linkage that is part of the front wheel assembly. The front wheels and their forks are taken from a wheelchair. These wheels have high quality bearings both in the wheels and the casters that allow for minimal rolling resistance and minimal steering resistance.

The brake used on the mobility device is a caliper brake similar to that used on bicycles. It is attached to the frame, and brakes the rear wheel. It is actuated by a foot pedal (adapted. from a bicycle brake lever), which is connected to the brake by a cable.

The frame was designed to be rigid, lightweight, and to provide good appearance. No external body was incorporated because the physical therapist and the parents wanted a "tricycle" appearance. The frame is welded 6061-T6 aluminum square tubing. The tubing is 1/2 inch square with .058 in. wall thickness. The scooter weighs about 20 pounds and cost about $340 to build, excluding the cost of labor.



Kayak Simulator
A Sports Therapy/Recreation Device for People with Disabilities

Designers: Mike Eystad, Eric Peterson, H. Frederick Woods, Bob McCann and Jim Kriskovich
Rehabilitation Professional: Paul Hengel, Summit Independent Living Center, *Missoula, Montana*
Supervising Professor: Dr. R. J. Conant
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INTRODUCTION

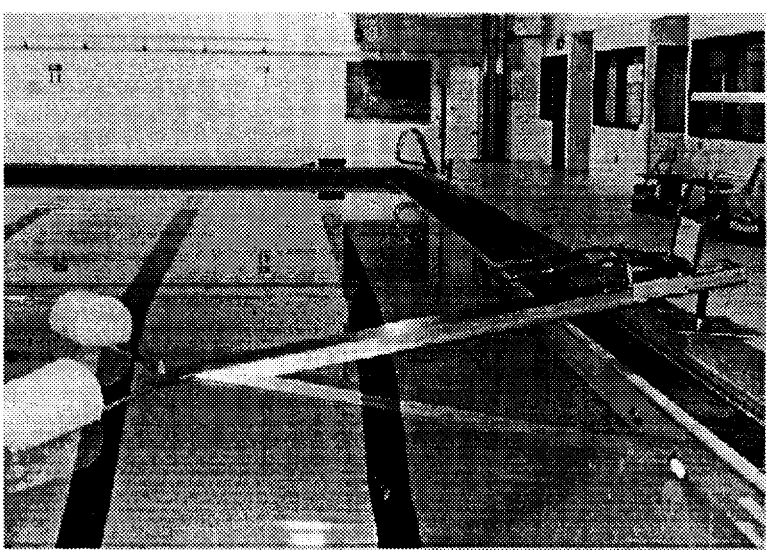
The Kayak Simulator is a swimming pool device that will integrate the sport of kayaking with therapy programs available for people with disabilities. The Simulator consists of a sling-style chair mounted on a slider mechanism. The slider mechanism travels up and down a rail. The rail is connected to the pool deck via a mounting platform and a ball joint. From the deck, the rail angles down to the pool water where it is supported by two polyethylene drums.

The device can be used for recreation or therapy. As a recreation tool the Simulator will be used as a training device for persons desiring to pursue the sport of kayaking. As a therapeutic device, a physical therapist can use the Simulator for improving the motor skills and endurance of people with a variety of disabilities.

SUMMARY OF IMPACT

As more and more people with disabilities enter sports and recreation, the limited range of activities they once engaged in is becoming limitless. The Kayak Simulator was designed as a training tool for those people who are interested in learning the basic techniques of kayaking. With the practice and training gained from use of the Simulator, a person can more easily make the transition to an actual kayak. Additionally, the Kayak Simulator will be used as an indoor training device for year round use.

An alternate use for this device is physical rehabilitation. People with disabilities in need of therapy are faced with a narrow scope of activities in which they can participate. The Simulator will provide an alternative to some exercises now performed. It can provide many of the same benefits as swimming and in addition, it can be used to custom tailor a therapy program designed to improve upper-body strength and muscular coordination.



TECHNICAL DESCRIPTION

The Kayak Simulator consists of several main components: a chair, a rail, a slider mechanism, a float, and a deck mounting platform.

The frame chair with nylon seat and back is modeled after a conventional wheelchair. The frame is made of 3/4 in. aluminum alloy tubing that was bent to the desired shape. The seat and back are made of 400 denier nylon. The seat is equipped with Velcro fasteners to allow a person in a wheelchair to attach customized padding. Footrests are provided at the foot of the chair.

The rail assembly (6061-T6 aluminum) is approximately 12.5 ft. long and is made of two 4 in. C-channels. The channels are arranged parallel to each other with the flanges facing outward. A skin 12 in. wide and 12.5 ft. long is fastened to the top flange of the channels, and T-channel cross-members are fastened to the bottom flanges to provide the correct spacing. The skin provides rigidity and prevents injury that could result from getting an arm or leg caught between the C-channels. The chair is mounted to a slider mechanism that travels up and down the rail. The slider mechanism is 16.5 in. long by 14 in. wide by 4 in. high. It is C-shaped, with two nylon wheels mounted inside each flange. The wheels ride on the bottom flange of the rail C-channel. Mounted on the slider mechanism, beneath the seat, is a hand operated winch that is used to move the chair along the rail. The winch cable is attached to the deck end of the rail.

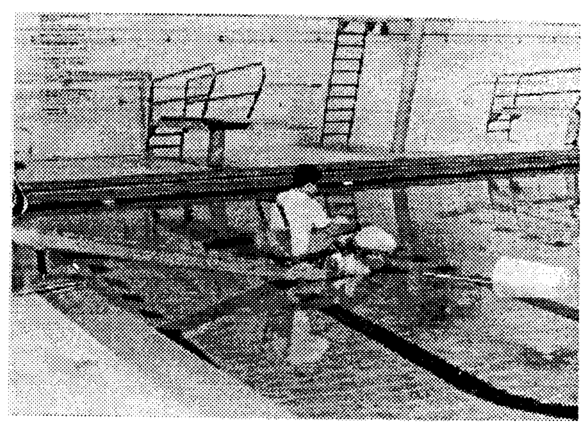
Support at the pool end of the rail is provided by two polyethylene drums that provide buoyancy and give the Simulator a realistic feel. The spacing of the drums is adjustable so that the stability of the Simulator can be varied. The drums also can be partially filled with water to position the seat closer to the water. At the deck end, the Simulator is attached to a mounting platform via a ball and socket connection. The method by which the mounting platform attaches to the pool deck is customized to individual pool deck specifications. The design makes use of a standard 1.875 in. trailer ball mounted to the platform, and a trailer hitch connected to the deck end of the rail.

The basic requirement for the mounting platform is stability, given the varying kayak simulator loading situations. To simulate a conventional kayak one should incorporate its stability characteristics into the design. The ball and socket joint at the platform connection was chosen for this reason. The pitch of the Simulator is not constrained, thus allowing it to adjust to the user's weight or the water level of the pool. Lateral motion can be fixed by inserting a pin through the ball and socket joint. Fixed lateral motion will allow the user to concentrate on exercising one side of their upper body or the other, while free lateral motion will give the user the opportunity to work on coordination skills and to develop equalized body strength. Roll is constrained to plus or minus 5 degrees by the fit tolerances at the pinned connection between the ball and hitch.

A conventional kayak paddle with reduced blade area will be used with the Kayak Simulator. Since the Simulator doesn't move through the water, a smaller blade area is required to simulate the paddling resistance experienced in a moving kayak.

The Kayak Simulator cost approximately seven hundred and fifty dollars ($750) to build, excluding labor. The cost will vary depending on the design of the pool deck mounting platform.

The versatility of the Kayak Simulator will allow it to be a useful tool for recreation or therapy programs. The Kayak Simulator will provide an innovative way for users to have fun while simultaneously gaining therapeutic benefits.



Kayak Seating System
A Kayak Seating and Support System to Aid Paraplegics

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Rehabilitation Professional: Paul Hengel, Summit Independent Living Center, Missoula, MT
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INTRODUCTION

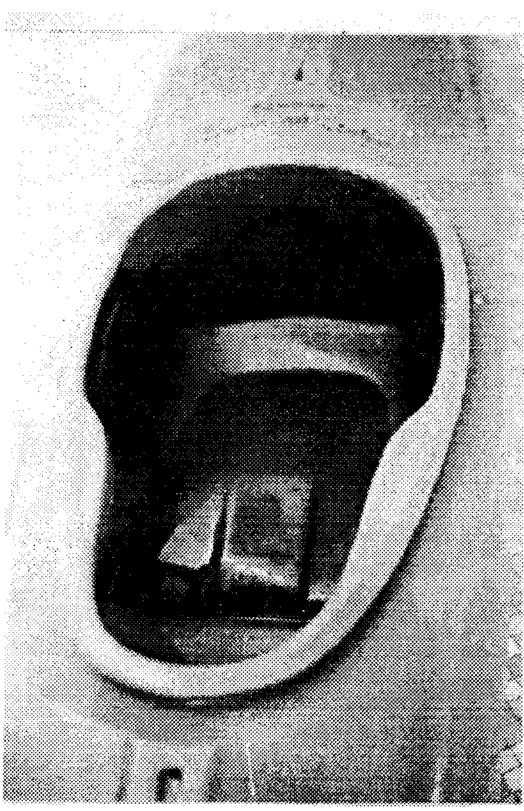
The Kayak Seating System is a two-piece device that provides the additional support that is needed for people with spinal cord injuries to kayak. The first piece consists of a backrest to provide additional front-to-rear support, while the second is a support belt. The support belt fits around the user and attaches to the kayak itself to increase both lateral support and to help hold the user into the kayak in the event of a rollover.

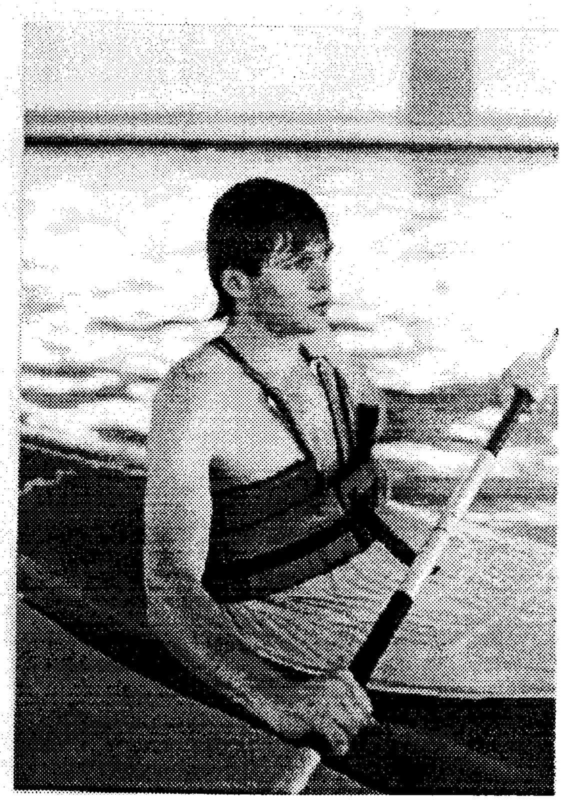
The device is designed so that it will work for different levels of spinal cord injury, as well as allowing the kayak to be quickly converted for use by a non-disabled person.

SUMMARY OF IMPACT

A two-piece kayak seating support system was developed to accommodate paraplegics with lesions as high as the upper thoracic vertebrae. A person with this type of disability has no use of the legs, very limited use of the abdominal muscles, and the possibility of reduced use of the hands and arms. With reduced muscle control such as this, kayaking can be difficult, if not impossible.

With the support system, the kayakers have found it much easier to control the kayak with the support provided by the belt as well as the backrest.





TECHNICAL DESCRIPTION

The device consists of a backrest and a restraining and support belt. The belt attaches around the user's torso and the sprayskirt, which is a nylon cover that fits around the user and attaches to the combing that forms the perimeter of the kayak cockpit. The sprayskirt belt arrangement rests on the backrest when the kayaker is in the sitting position. The backrest is attached inside the kayak from the rear by two mounting bolts.

The belt consists of two layers of 1/4" closed-cell hard foam, a layer of 1/8" one-sided neoprene, and a 1/16" piece of polyethylene. The foam is then covered with a breathable nylon shell that is sewn together to contain the foam and provide stiffness. Attached to the belt are support straps which run from the belt to the edge of the sprayskirt (combing attachment point). The belt is designed in two pieces. One piece consists of the main belt to which all support straps and the velcro front holding closure are attached. The second piece is a thin piece consisting of the foam and nylon shell with velcro along one longitudinal edge. This velcro can then be mated to the matching velcro on the main support belt to increase the overall height of the belt and provide increased support and versatility.

The backrest is constructed of 1/4" ultra-high density polyethylene. Polyethylene was chosen for its toughness, water impenetrability, and stable chemical composition. The general shape for the backrest was determined by comparing the shape of the human back with the shape of the kayak cockpit. By measuring and making templates, a mold was constructed using layers of particle-board sheeting. As each layer was cut, they were stacked until a final shape was obtained. The mold was then sanded to provide a smooth molding surface. With the mold complete, the polyethylene sheet was cut in the approximate shape (note: both the mold and seat shape will vary with each kayak) of the final seat. Utilizing an oven set at 275 F, the sheet, placed on top of the mold, was heated for approximately 1.5 hours until it was transparent. As the polymer was heated, it conformed to the general mold shape. However, due to the nature of polyethylene, further reshaping and pressing was needed. The mold was removed from the oven and placed on a support stand. A wet towel and holding straps were placed on the mold to hold the plastic in its final shape until complete cooling could take place. Final adjustments to the seat were made with a heat gun.

The entire kayak seating system cost $120 to build. Half the cost was the purchase of the sprayskirt, which most kayakers would already own.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