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Portions of Clinical Supplement No. 1 first appeared in somewhat different form in the following:

- *Atlas of Limb Prosthetics/Surgical and Prosthetic Principles, American Academy of Orthopaedic Surgeons* The C.V. Mosby Company, St. Louis, MO, 1981. (Snow Skiing, pp 42-44)
- *Boating for the Handicapped/ Guidelines for the Physically Disabled: "Sailboats," "Canoes"* by Eugene Hedley, Ph.D., Research and Utilization Institute, National Center on the Employment of the Handicapped at Human Resources Center, Albertson, NY, 1979. (Boating, pp 8, 9, 11, 12)
- *The Fragment*, published by War Amputations of Canada, "Swivel Golf Shoe" by Cliff Chadderton, et al., Vol. 126, Ottawa, Canada, Spring 1980. (Golf, pp 20, 21)
- *Inter-Clinic Information Bulletin*, "Horsemanship for the Physically Handicapped" by Carolyn Larkins, Vol. 9, No. 7, April 1970. (Horseback Riding, pp 23-26)
- *Sports 'N Spokes*:

  "Saltwater Kayaking for the Marine Enthusiast" by Syd Jacobs, Jan./Feb. 1984, Vol. 9, No. 5. (Boating, pp 10, 11)

  "Sit Skiing" by Peter Axelson, edited by D.K. Slagle, Jan./ Feb. 1984, Vol. 9, No.5. (Snow Skiing, pp 50-54)

  "Nifty New Stuff", Jan./Feb. 1984, Vol. 9, No. 5. (Wheelchair Unicurl, p 87)

  "People in Sports" by Phil Taylor, March/April 1983, Vol. 8, No. 6. (Snow Skiing, pp 53, 54)

  "The Challenger Challenge" by Felix Wedgewood-Oppenheim, March/April 1983, Vol. 8, No. 6. (Boating, pp 11, 12)

- University of Illinois Rehabilitation-Education Center (c/o Brad Hedrick) Champaign, IL (literature to members). (Wheelchair Football, p 83)

Special thanks are due to the publishers, writers and editors of the foregoing books, magazines, and consumer literature.

On the Front Cover:

(Right) A bilateral above-knee amputee using Mauch Swing "N" Stance knees developed through VA sponsorship. (Photo courtesy of Mauch Laboratories, Inc.)

(Left) A bilateral above-knee amputee prepares his wheelchair for competition. (Photo by Bernice Kegel)

On the Back Cover:

(From left to right)

Wheelchair archery. (Photo by Bernice Kegel)

A unilateral above-knee amputee who is a skilled water skier. (Photo by Bernice Kegel)

A bilateral above-knee amputee using his helmut as a mountain climbing aid. (Photo courtesy of Everest & Jennings)

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Page 2. A sit skier with tetherer. (Photo courtesy of *Nationals Magazine*)

Page 3. A unilateral above-knee amputee playing tennis without wearing a prosthesis. (Photo courtesy of the National Organization on Disability)

Page 67. Competitive basketball. (Photo courtesy of *Ability Magazine*, Majestic Press, copyright 1983)

Page 71. A hand-driven unicycle designed for attachment to a wheelchair. (Photo courtesy of Unicycle (1982) Inc.)

Page 88. Competitive wheelchair marathon racing. (Photo by Bernice Kegel)

Preface

During the rehabilitation process, a person with an amputation must once again learn how to stand, sit, walk, ascend and descend stairs, and perform other necessary functions for daily living. In Clinical Supplement No. 1, the author, Bernice Kegel, R.P.T., focuses beyond these basic day-to-day functional skills. The text is written to facilitate the clinician's role in helping people with lower limb amputation and other limb impairments discover new levels of physical and emotional well-being through recreational and competitive participation in sports.

In preparation for her publication, Kegel, in association with Dr. Ernest Burgess and the Veterans Administration's Prosthetics Research Study (Seattle, WA), undertook a survey of 100 people with lower limb amputations to learn the extent, if any, of their interest in sports.

Of those surveyed, some 60 percent routinely participated in at least one activity. The survey further revealed that more than one-half of these individuals chose to wear a prosthesis during vigorous activity.

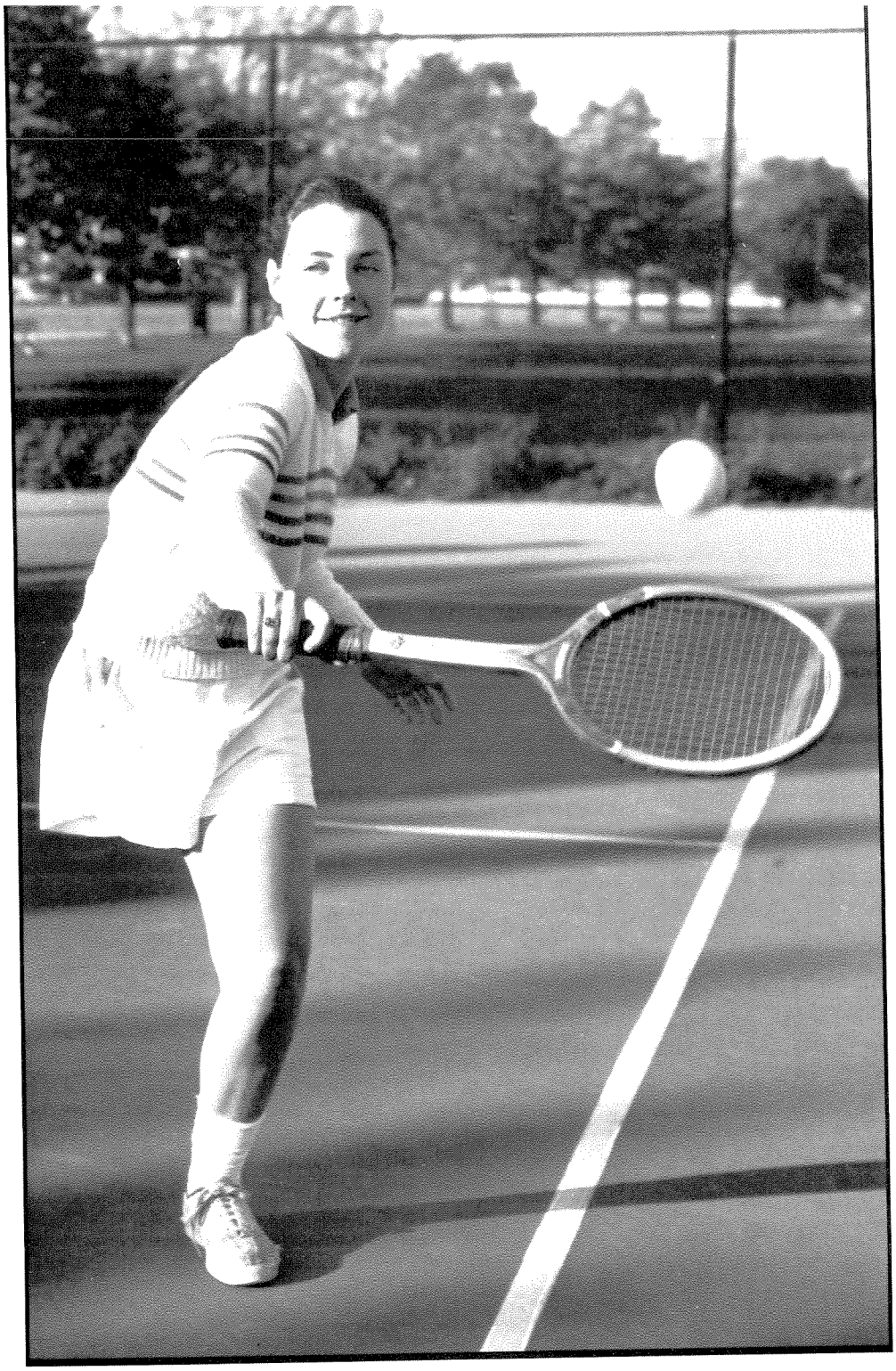
Water sports were found to be the most popular. Jogging, racquetball, soccer, and handball were least popular, though increasing awareness among people with amputation of their ability to participate in these sports may generate new enthusiasm in the activities. Hunting and jogging caused participants the most discomfort, while swimming and fishing caused little or no problem. Running and jumping were by far the most difficult to master.

In Clinical Supplement No. 1, Kegel discusses some 48 sporting activities in which those with lower limb amputation and other disabilities can, and do, effectively participate. Prosthetic systems and assistive techniques designed for the sports enthusiast with disability are described throughout the text. In addition to substantive narrative, over 100 captioned photographs and extensive lists of related literature and sports organizations are included.

The information in Clinical Supplement No. 1 is generally based on firsthand experiences of individuals having undergone amputation and on research. While some of the adaptive procedures and equipment described are widely applicable, others are not. Therefore, every procedure addressed will not necessarily be appropriate for every user, nor does the material presented represent the only, or necessarily the best, approach for the person with lower limb disability who wants to participate in sports. In all cases, monitoring by the clinician of both the beginner and advanced sports enthusiast alike, including an overall physical fitness program, is suggested.

Although portions of the material presented in this publication appear in somewhat different form in several published books and magazines, few works offer the clinician and patient a single source of information on sports modified for the individual with lower limb amputation. This single-format feature makes Clinical Supplement No. 1 unique. Future supplements as well will provide the clinician with a one-stop resource of research findings that can be of immediate benefit to a wide spectrum of patients.

A comparison of what was known in science and medicine as recently as five years ago with the knowledge of today elicits amazement. The application of this abundant knowledge has not begun to catch up in day-to-day clinical practice. This series will assist in bridging that gap and answer questions concerning the common, and even some of the uncommon, symptomatology that the patient with disability presents in everyday clinical practice.



Sports for Those with Lower Limb Amputation or Impairment

Baseball

Many individuals with amputation play baseball. Some have played successfully on the same teams with able-bodied players. Two notable examples are the famous Bert Sheppard who following a below-knee amputation went on to successfully pitch for the Washington Senators, and Monte Stratton who pitched for the Chicago White Sox after an above-knee amputation.

While those people with below-knee amputation who are interested in baseball might be able to play any of the positions on the team, they generally achieve the greatest mastery playing pitcher or first baseman since these positions require somewhat less agility than the other positions. A thigh corset/side joints prosthesis is best suited for this activity, and then the sports enthusiast can return to the PTB (patellar tendon-bearing) socket for ordinary use.

The person with above-knee amputation faces an even greater challenge and thus is usually better off playing infield. Catcher, for example, is a particularly difficult position to play since the catcher must be able to get down on his haunches with his artificial limb extended out to the side. Then, he or she must be able to get up quickly to throw the ball. As for batting strategy, the sound leg should be positioned behind to facilitate a good push toward first base. After reaching first base, some select a substitute runner to continue the rest of the way, while many others proceed to home plate independent of any assistance **(Fig. 1)**.

For additional information on baseball, contact:

- Am. Special Recreation Assn.
  c/o John Nesbitt, Ed.D.
  Recreational Educ. Program
  University of Iowa
  Iowa City, IA 52240
  (319) 353-2131
- Nat'l. Handicapped Sports and Recreation Association
  c/o Jack Benedick
  P.O. Box 18664
  Capitol Hill Station
  Denver, CO 80218
  (303) 232-4575

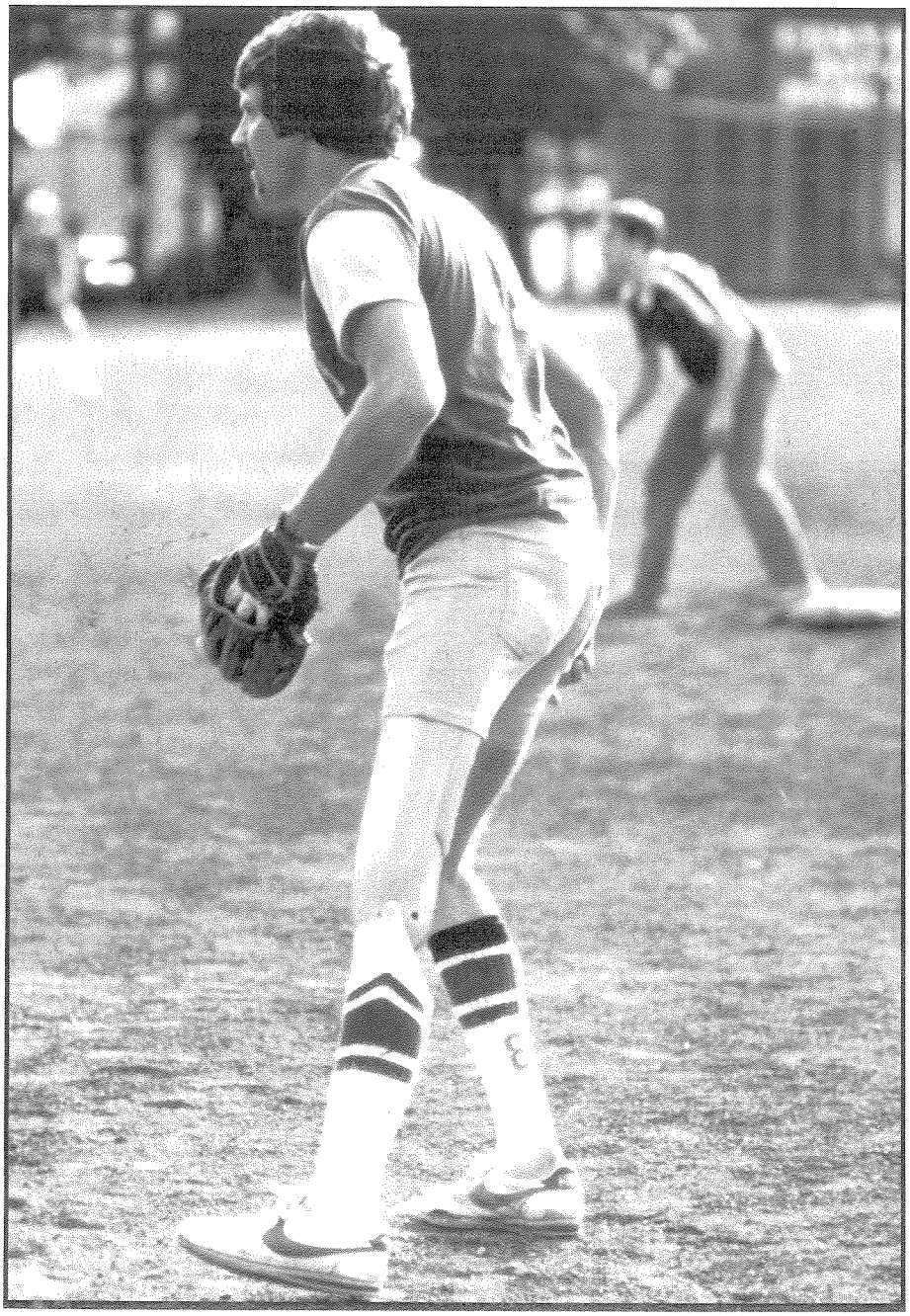


Fig. 1. A baseball player with unilateral above-knee amputation. (Photo by Bernice Kegel)

Bicycling

Bicycling is an exhilarating experience. Many people favor it as a form of exercise because of its grace, speed, and utility. By bicycling, one can keep in shape, commute, run errands, walk the dog, avoid the need for a second car, and save money. The individual with an amputation who is interested in bicycling can start on either a three-wheeler or a tandem bike.

The cyclist with below-knee amputation should not encounter any difficulties while riding with a prosthesis. A prosthesis with a thigh corset will help protect the thigh from abrasions **(Fig 2)**.

Some people with amputation prefer to put the prosthetic heel rather than the toe on the pedal as this generally provides a more effective push, while others like to use a toe clip on the prosthetic side. Toe clips are sold in most sporting goods stores. The device serves to prevent the prosthesis from sliding off the pedal and allows more effective pushing and pulling on the pedal. Still others choose to use a toe clip on the sound foot only for fear that its use on the prosthetic side might "trap" the foot.

The individual with above-knee amputation needs to decide whether to use a prosthesis at all while riding. Some say that a prosthetic leg limits power output, while others choose to wear one anyway because of the more natural look that it gives. Others choose to wear a prosthesis, yet avoid its use directly on the pedals. The prosthetic leg is used as a "landing strut." Above-knee prostheses without hip joints and pelvic bands allow the cyclist to straddle the bicycle in comfort. Those with an above-knee amputation who wear, for example, a Mauch Swing N' Stance (S-N-S-) hydraulic knee unit generally find it effective for bicycling. To achieve ease of motion, the prosthetic knee should be set in a free swinging mode. (The Mauch S-N-S knee, developed under VA sponsorship, is manufactured by Mauch Laboratories, Inc., Dayton, Ohio.) If one wants to use bicycling as a strengthening exercise, he or she need only adjust the stance control mechanism to offer desired resistance. For those individuals who choose to wear a foam-covered prosthesis, care must be taken to protect the foam from dam-

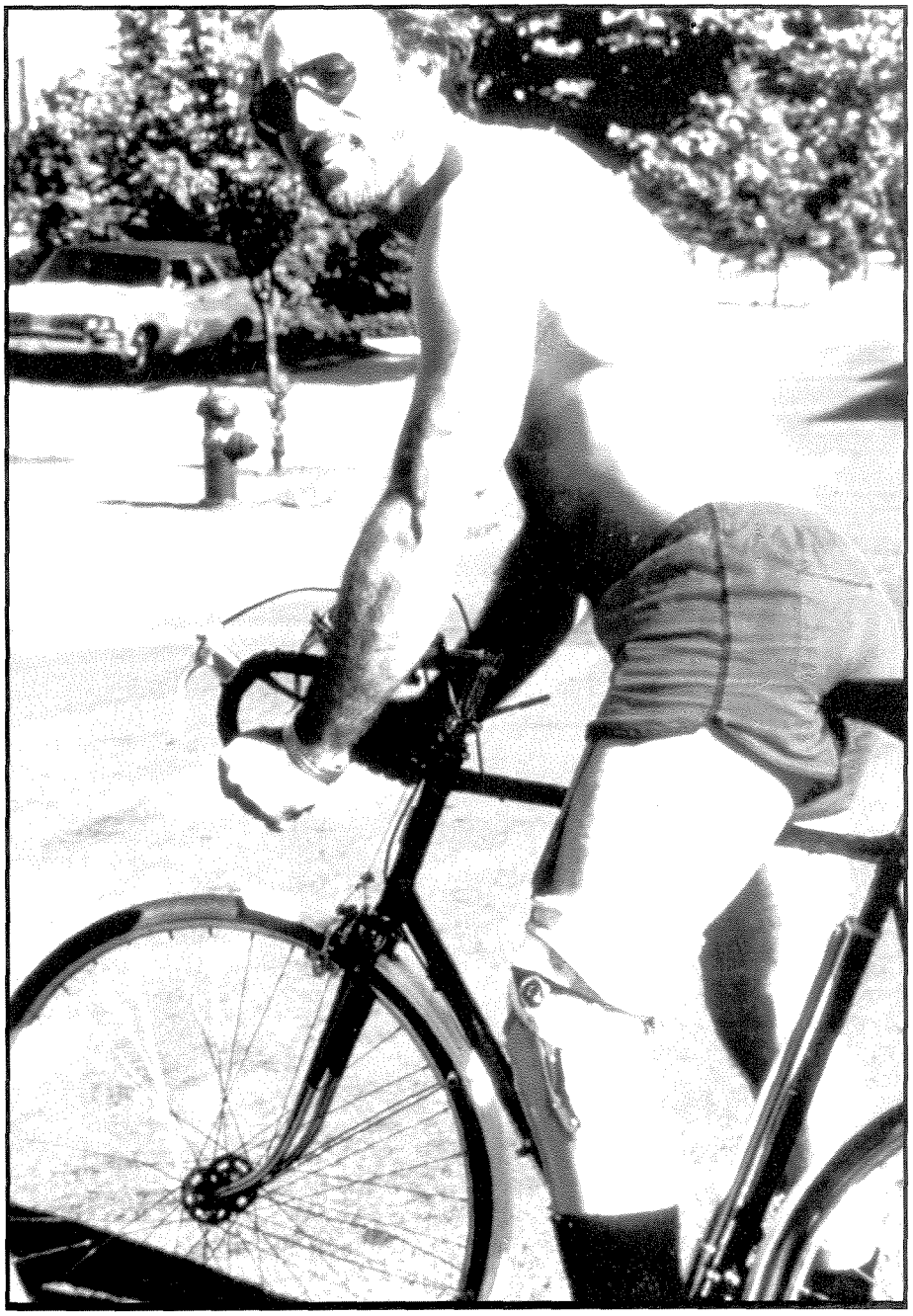


Fig. 2. A cyclist with unilateral below-knee amputation rides with a prosthesis and thigh corset. (Photo courtesy of Prosthetics Research Study)

age caused by friction from the pedals.

There is one essential rule for the cyclist with lower limb amputation to remember—he or she must keep both hands on the handlebars whenever exerting leg power. When coasting, the hands can be removed from the handlebars without any problem. The gear-shift lever should be positioned so that one can grip the handlebar with his or her palm and outer two fingers, while the other three fingers work the levers. The individual with disability will want to obtain the best touring 10-speed gear system possible. Even two-legged bike riders need all 10 gears to adapt to hilly terrain, so a one-legged biker most certainly needs optimal equipment.

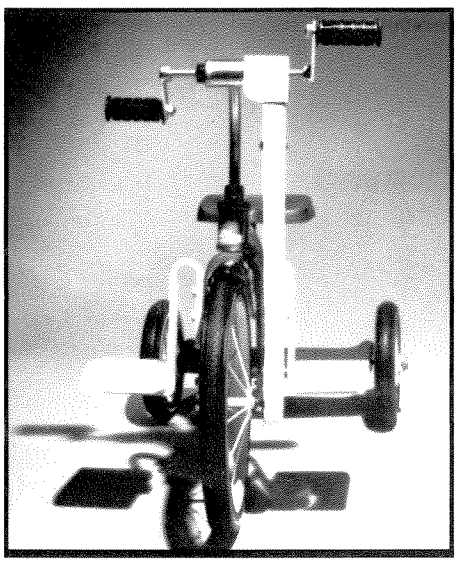
For racing, conventional positioning of the handlebars can be uncomfortable because cyclists with one leg operate in a push/pull mode, requiring energetic arm use and pounding up and down on the seat. Some people prefer to sit in a more upright position with their torsos at approximately 60 degrees to the horizontal rather than in the classic bike-racing position of 30 degrees. Others prefer to turn the racing handlebars upside down. Standard nonracing handlebars are adequate too.

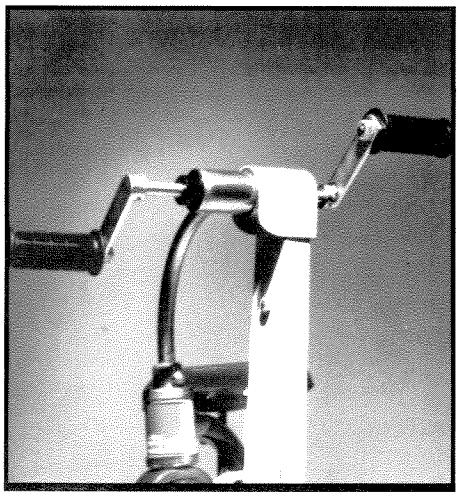
Optional modifications also include removing the unused pedal and/or crank, turning the seat slightly away from the good leg, and padding the seat. Extra padding is especially helpful because one-legged bikers pull hard with their uninvolved leg, and thus sit hard upon the seat.

For competitive and distance riding, friction between the residual limb and the socket can be a problem. Some people with amputation choose to put a sheet of Spenco 2nd Skin onto the residual limb with a sock on top to hold it in place. Available at athletic supply stores and consisting of a breathable hydrogel, with 96 percent water and 4 percent polyethylene oxide, Spenco Skin serves to recycle friction between two moving surfaces. For more information on Spenco Skin, write to Howard (Bud) Beloin, President, Spenco Medical Corporation, P.O. Box 2501, Waco, TX 76710, or call Mr. Beloin at (817) 772-6000 or (800) 433-3334.

Amputees with hip disarticulation amputation may choose to ride by placing their stomach on the saddle, their sound leg on one pedal, and the opposite hand on the other pedal. Although this sounds precarious, the rider can control both the handlebars and brakes with the hand on their sound side. Special bicycling shoes are helpful, as they provide extra leverage on the upward portion of the bicycling stroke. This allows the amputee to ride by both pushing and pulling with the sound leg, rather than just pushing as in normal bicycling.

For the child with an amputation who does not wear prostheses at all, a hand-propelled tricycle may be the solution **(Figs. 3a-3d)**.





Figs. 3a, 3b, 3c, and 3d. Four views of a hand-powered, hand-controlled tricycle modified from a regular tricycle. (Photos courtesy of R.J. Reynolds Tobacco Co.)

Fig. 3e. A commercially bought, hand-operated bicycle. (Photo by Bernice Kegel)

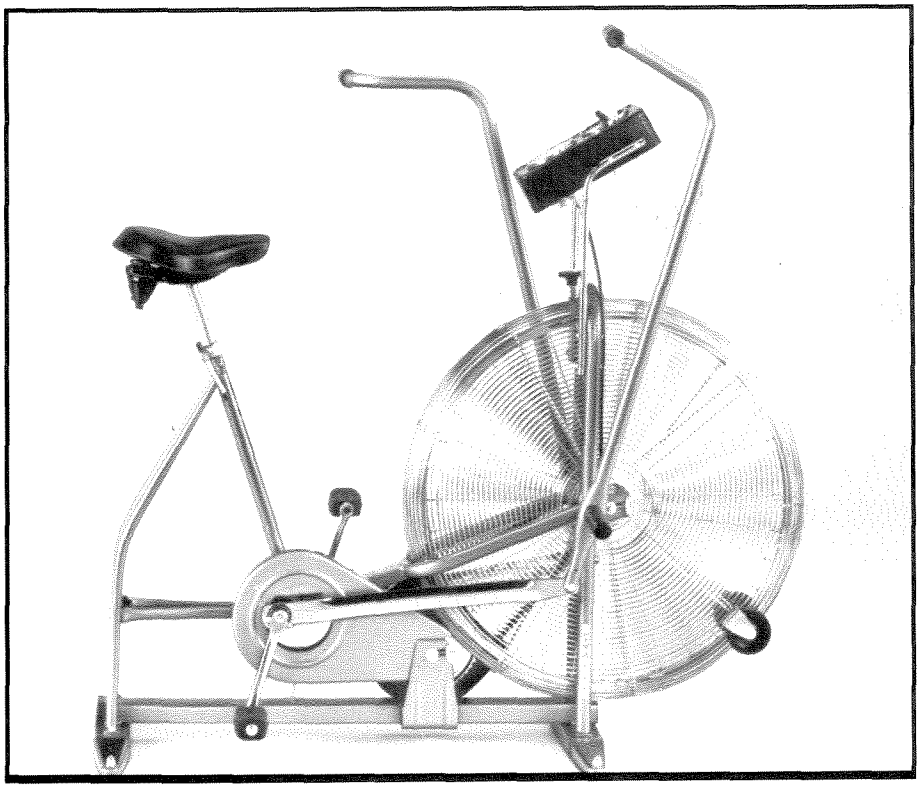


Fig. 4 The Air-Dyne stationary bicycle exerciser. (Photo courtesy of Schwinn, Excelsior Fitness Equipment Co.)

These and the tricycle for adults **(Fig. 3e)** are available commercially. For information on how to construct a tricycle, contact:

- Mary Ann Bush, O.T.R. and
  Associate Professor
  Western Michigan U.
  West Michigan
  Kalamazoo, MI 49008
  (616) 383-1765

- Kenneth Kozole, O.T.R.
  Director of Rehabilitation
  Engineering Services
  Sharp Memorial Hospital
  7901 Frost Street
  San Diego, CA 92134
  (619) 292-2048

- R.J. Reynolds Tobacco Co.
  Public Relations
  c/o Betsy Annese
  Winston-Salem, NC 27102
  (919) 775-7693

Schwinn has developed a stationary bicycle exerciser for indoor use by disabled individuals. This ergometric exerciser (Air-Dyne) operates on an air displacement principle and provides a range of variable, but measured, working loads combined with desirable cooling effects from its own wind vane system **(Fig. 4)**.

Another feature which makes the Air-Dyne attractive is that its arm levers and pedals work in concert to allow simultaneous workout of the upper and lower limbs. When preferred, however, the upper and lower limbs can be exercised as separate activities.

For additional information on the Air-Dyne, contact:

- Schwinn Bicycle Company
  1856 N. Kostner Avenue
  Chicago, IL 60639
  (312) 292-2900

Of additional interest to the cyclist with amputation, is David

Bicycling

Kiefer's "Ride Across America." This 28-year-old with a hip disarticulation established a handicapped world's record in cross-country cycling at 17 days, 5 hours, and 7 minutes. Kiefer's achievement is particularly noteworthy since he exceeded his goal to come in at two times the able-bodied record set in 1983 by Lon Haldeman at 9 days, 20 hours, and 2 minutes. Kiefer rode without a prosthesis on a team of six cyclists and at an average speed of 20 miles per hour, or an average of 160 miles per day. He spent from 10 to 18 hours each day on the road. He departed from the Santa Monica Pier on June 2, 1984 and culminated his trip at the Empire State Building on June 19, 1984 **(Fig. 5)**.

For more information, contact:

- David Kiefer
  P.O. Box 582
  Smithville, OH 44677
  (216) 669-3717

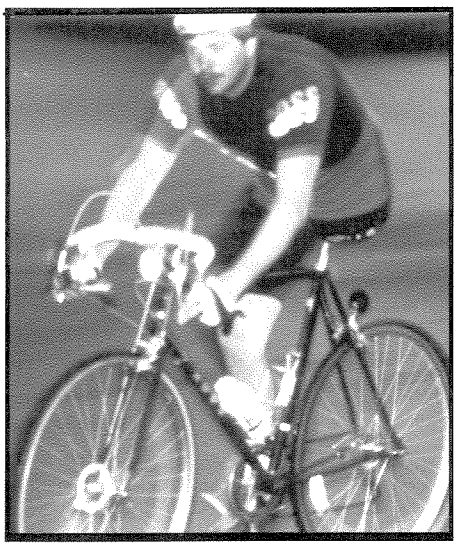


Fig. 5. David Kiefer, the hip disarticulation amputee who bicycled across America in June 1984. (Photo by Bernice Kegel)

Boating

Boating offers the individual with disability an opportunity to experience a sense of mastery and control, and to express a healthy need for competition.

The adaptations and modifications made by the boater with disability are wide-ranging, although many such people require no significant alterations to their craft but may need additional handholds and rails. The person with amputation who is interested in boating must master certain skills, like transporting himself, his equipment, and his boat to the launching area **(Figs. 6a and 6b)**. Also, one must learn the technique of self-rescue in the event of a capsize. Most people prefer to wear a prosthesis for walking to the boat, particularly over steep, slippery, or rocky banks which demand maximum dexterity. Moreover, hopping without a prosthesis for even a short distance can be exhausting, especially if carrying boating gear.

Recreational Canoeing

Recreational canoeing is an ideal way to relax and fully enjoy nature. If an individual with disability wants to learn to canoe, there is ample opportunity to do so. Preferred methods of transferring into a canoe differ according to the nature of one's disability. The person with a lower limb amputation, for example, generally finds it easier to board the craft from a seated position rather than merely stepping into the boat. The legs should be placed in the canoe first, as close to the center as possible, and, after that, the remainder of the body is positioned into the craft.

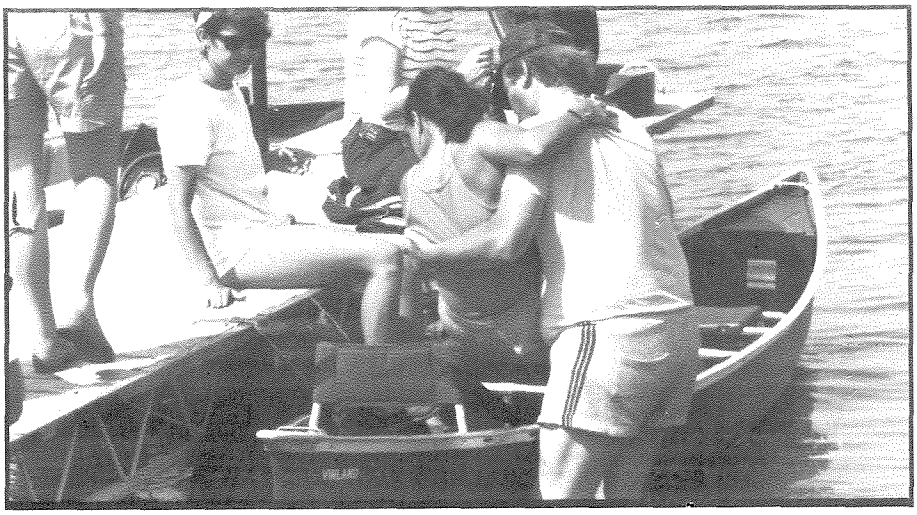
Some modifications to the seat of the canoe may be helpful. Lowering the seat height slightly may help to lower the center of gravity, thus improving balance. For extra back support, attaching the top portion of a plastic stacking chair to the canoe seat may be useful. For wheelchair users planning overnight trips, it is important to assure that the wheelchair fits into the canoe being used, that the user is able to transfer the chair into and out of the canoe, and that the wheelchair is secure should the craft capsize.

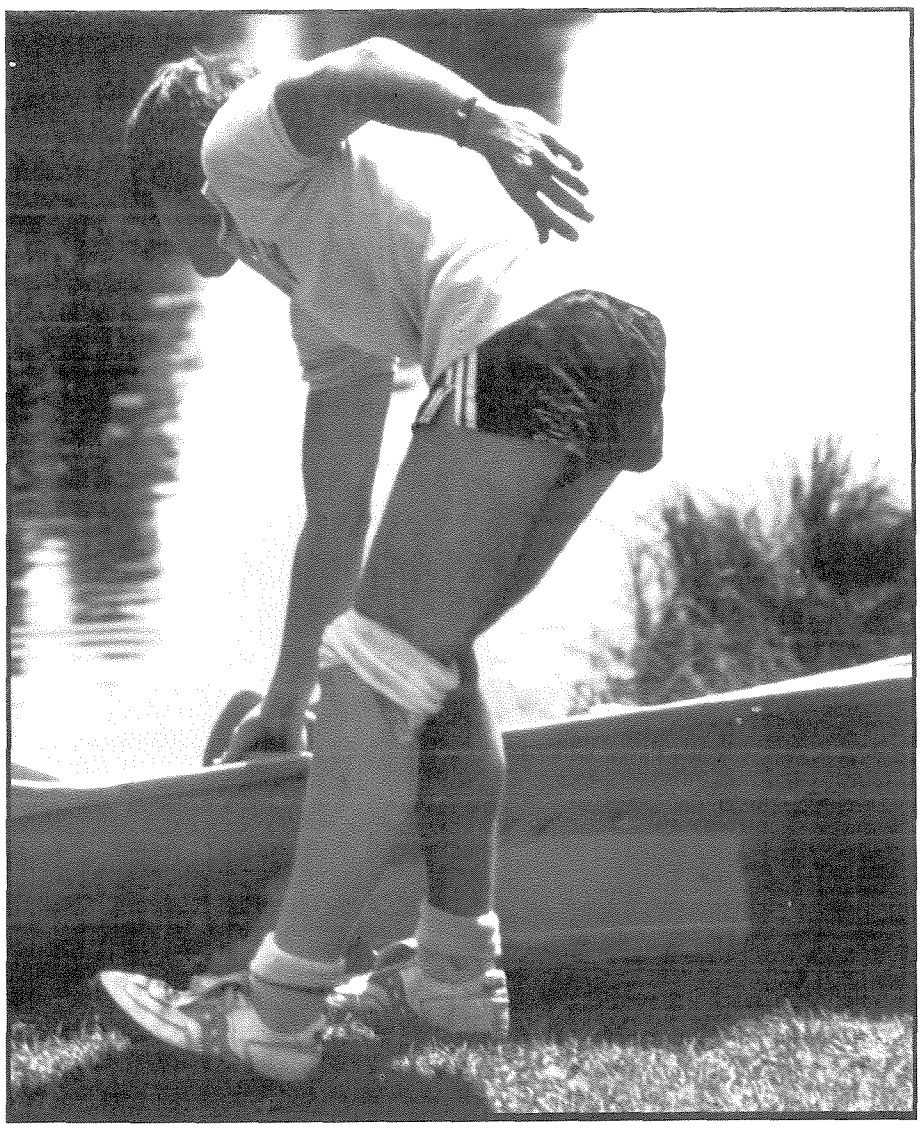
Although canoes are usually powered manually by paddling, they can be equipped with small, low horse-powered motors on a side or stern mount for easy accessibility. Another advantage to canoes is that most are easily transported, although a large one would obviously be more difficult to take out of, or put into, the water.

Many canoes are fabricated of either aluminum or fiberglass because of their light weight. For example, a 17 to 18 foot canoe generally weighs no more than about 75 pounds. Thus, one person can unload such a craft from the car, and two can carry it to the water. Moreover, because of the canoe's light weight, even a person confined to a wheelchair can support one end of the craft to help transport it to the water

Canoe Racing

Canoe racing is a sport that depends largely on upper body strength and stamina. Other than contributing to balance, the legs are not used at all. Arm, chest, and back strength determine the champions in this sport, one in which those with and without disability can compete equally. A person with unilateral leg amputation may not require any boat modifications at all, whereas a person with a double leg amputation will need some bracing to keep from





Figs. 6a and 6b. The amputee's major difficulties while boating will be at the launching area. (Photos by Bernice Kegel)

sliding forward on the seat.

Canoe racing is divided into three categories, with the competitors in each ideally having different physical characteristics, paddling styles, and equipment.

The first category is short distance slalom racing, which demands strength, speed, and precise timing. Boats used in slalom racing are compact and highly maneuverable. Long, straight paddles are used to facilitate control.

The second category is composed of races that are a minimum of 20.92 kilometers (13 miles) long. These races require strength and enormous stamina, and are called the marathons of canoeing.

The third category of canoe racing is the downriver, or wildcat, classification. These races are generally between 8.04 to 20.92 kilometers (5 to 13 miles) long and are often held in choppy waters. Downriver paddlers ideally combine the strength, speed, precise timing, and stamina of the slalom and marathon paddlers.

Of interest to racers in all three categories, are the simple and lightweight exercise machines now commercially available for use in the home. These machines, if properly used, can help to improve the canoeing stroke, stimulate cardiovascular/respiratory function, and strengthen upper body musculature, especially in the arms.

Rowing

The rowboat offers a number of attractive features to the boater with disability. Like canoes, rowboats are easy to transfer into and out of at a pier, shallow waterway, or beach. Whether a person transfers into the craft from a seated or standing position will depend on the specific disability, with each impairment requiring its own ad-

aptation. For example, if an individual has arm mobility to row, the only adjustment necessary may be to the length of the oars. To ensure proper balance and mobility, oars should be carefully selected with consideration to their weight, durability, and length. Custom-contoured seats are routinely adapted for those with lower limb impairment to permit these individuals to sit comfortably for prolonged periods of time.

There are many easy and inexpensive modifications that can be added to a rowboat, enabling the individual with amputation to participate in this physically energizing recreation form. Prostheses, too, have been effectively adapted to accommodate the boater **(Fig. 7)**.

The Veterans Administration has designed an ankle unit that permits free ankle movement while in the boat, but allows a stable foot for facility while walking on the dock. The stability during walking is obtained by using rubber tubing instead of dorsi and plantar flexion bumpers as used in single-axis prosthetic feet **(Figs. 8a and 8b)**. Once in the boat, the individual can simply remove the tubing. This prosthesis is waterproof, buoyant, and its posterior proximal brim is fabricated to allow maximum knee flexion with minimal (or no) discomfort in the area of the hamstring tendons.

For more information on this sports-compatible assistive device, contact:

- Drew Hittenberger, C.P.
  Prosthetics Research Study
  1102 Columbia
  Seattle, WA 98101
  (206) 622-7717

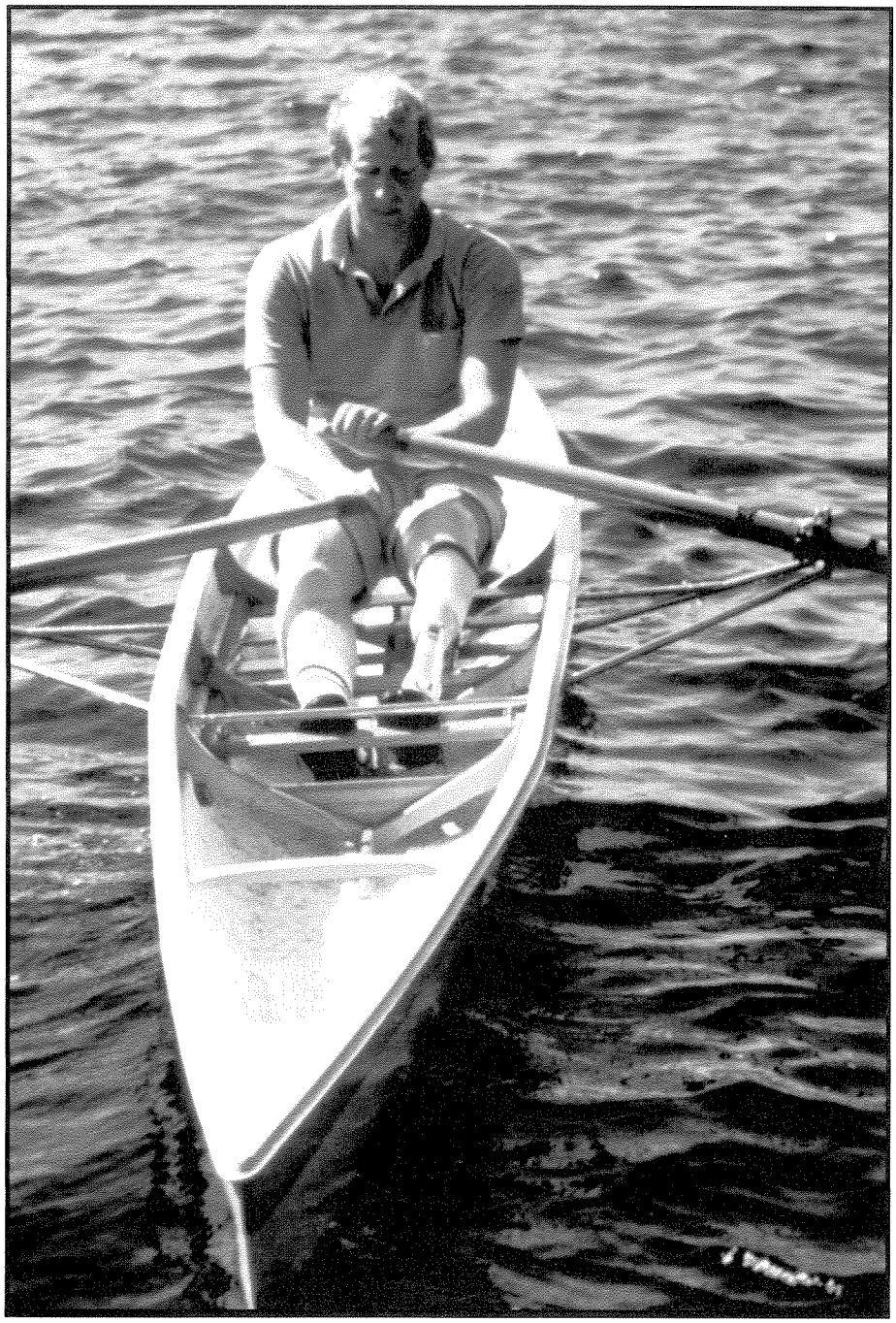


Fig. 7. A unilateral below-knee amputation rower wearing a VA boating prosthesis. (Photo courtesy of Prosthetic Research Study)

Kayaking

Individuals with amputation who kayak sometimes choose to strap their prosthesis to the boat (rather than to their body) because protrusion of the prosthetic foot could entrap the boater in the event of a capsize. For the same reason, the use of a peg leg may be desirable.

By using a water sports-adapted prosthesis, buoyancy is sufficiently reduced, thus lessening the risk of the person's head going underwater if the boat capsizes. (The water-modified prosthetic limb, described in the Swimming section, is weighted for proper balance between shank and toe.) In addition to this special prosthesis, the boater should probably consider thigh

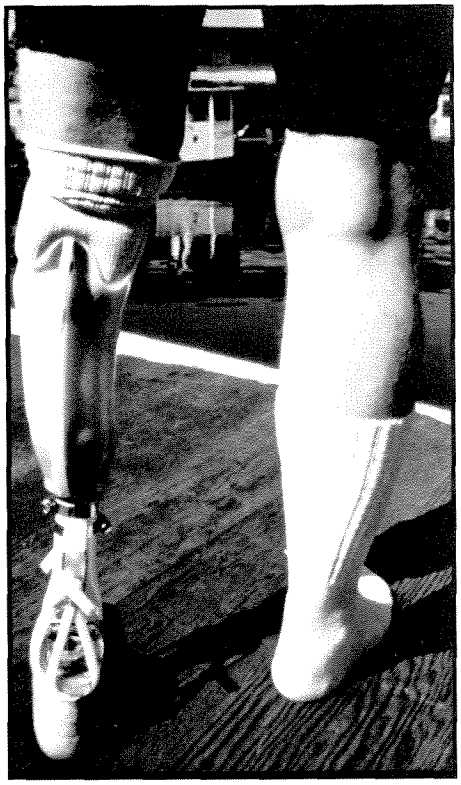


Fig. 8a. Rear view of the rowing prosthesis. Note design of the proximal posterior brim, relieving pressure on the hamstring tendons.

straps which fit high around the thigh and allow the user to lean, maneuver, and even rescue himself from a capsizing boat.

A recent development in kayaking is a specially designed, standard size kayak for individuals with lower limb impairments. Because entrapment is a concern to every kayaker—those with disability and those without—modifications to the seating system and to the cockpit are constantly being studied. Customized seating and bracing together with a longer cockpit enable individuals with a wide variety of lower limb impairments to kayak successfully.

In the selection of a boat, cockpit opening size is critical. The "Sporty" is an excellent choice for a beginner. This boat is available from:

- Folbot Corp.
  Stark Industrial Park
  P.O. Box 70877
  Charleston, SC 29405
  (803) 744-3483

Fig. 8b. The VA rowing prosthesis showing range of plantar flexion. (Photos courtesy of Prosthetics Research Study)

Sailing

Enumerating the range of commercially available sailing craft would take many pages to accomplish. These include board boats (e.g., Sunfish and Sailfish), catamarans, keels, and yachts. The type of craft selected will obviously determine the type of sailing one will do, so it is a good idea to crew in a boat before buying or even renting one. The variety of sailboats commercially available allows the person with physical impairment to pick and choose the craft that best meets his or her individual needs, is affordable, and is compatible with the kinds of boating available in one's geographical region.

The British-designed trimaran, the Challenger, for example, can be handled easily and safely by the individual with disability. Though conceived primarily for paraplegics, the Challenger appeals to most anyone who enjoys an exhilarating, uncomplicated sail (**Fig. 9**, on the following page).

A slide, hooked onto the main beam connecting the three hulls, eases the transfer from wheelchair to cockpit. At the helm is a customized seat equipped with a cushion filled with polystyrene granules that contour to the sailor's body.

Virtually no body movement is required to steer the craft, as the tiller and mainsheet are within easy reach of the helmsman. The single sail is fully battened, and a sail-tensioning device in front of the mast allows the whole rig to rotate so that the sailor can spill the wind from it.

The trimaran has been sailed successfully in wind strengths of up to Force 6. Constructed of glass-reinforced plastic with foam-filled floats, it is one of several sailboats suitable for use by the marine enthusiast with amputation or lower limb impairment.

Boating

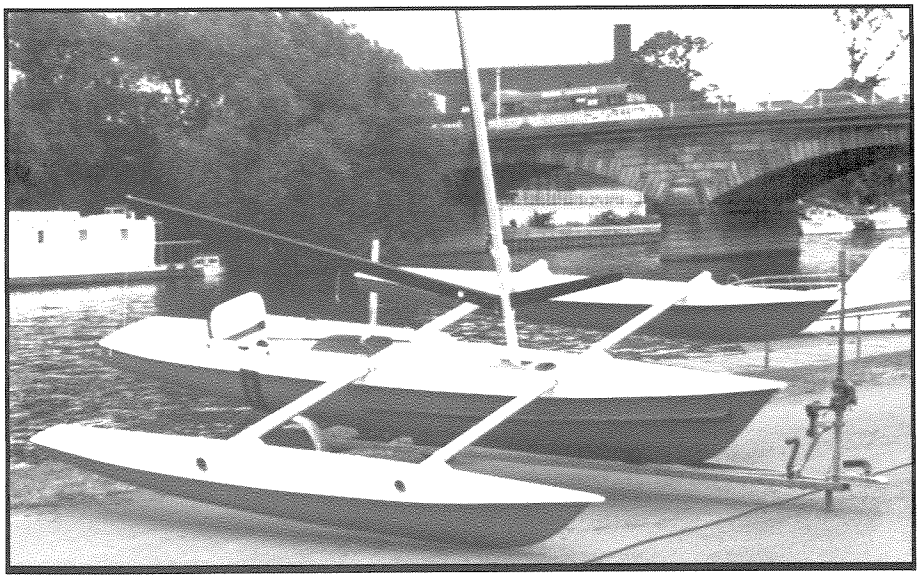


Fig. 9. The Challenger, a trimaran suitable for use by the disabled. (Photo courtesy of Cheeseman, Rollo, and Co.)

More information about the trimaran is available from the builder: Cheeseman Biffins Boat Yard, Staines Bridge, Staines, Middlesex, England TW183ON.

Safety standards in sailing must be stringent. All safety equipment should be readily accessible with its location known by everyone on board. Though the possibility of obstacles is an omnipresent one to the person with, and without, disability, this concern has not deterred many sailors including those with lower limb amputation.

For more information on general boating, contact:

- Bunny Johns, Head of Instruction
  Nantahala Outdoor Center
  Box 41/U.S. 19 West
  Bryson City, NC 28713
  (704) 488-2175

- Mission Bay Aquatic Center
  c/o Tod Bittner
  1001 Santa Clara Point
  San Diego, CA 92101
  (619)488-1036

- Water Safety and Boating Program for the Disabled
  Parks and Recreation Office
  Sailboat House
  1520 Lakeside Drive
  Oakland, CA 94612
  (415) 273-3091

In addition, relevant literature on boating includes the following:

- *Boating for the Handicapped/ Guidelines for the Physically Disabled* by Eugene Hedley, Ph.D., 1979. (To obtain a copy, write to the Research and Utilization Institute of the Human Resources Center, Albertsen, NY 11507)
- *Boating World Unlimited* (This magazine can be obtained by contacting Handicapped Boaters Assoc., NY)
- *An Introduction to Kayaking: for Persons with Disabilities* by John H. Galland. (Available from Vinland National Center, 3675 Ihduhapi Road, Box 308, Loretto, MN 55357)

Bowling

The person with an amputation who is able to walk can probably bowl, too. Learning to bowl takes time and effort, especially in learning to maintain balance. Muscles and joints undergo changes in adapting to the new motions associated with the game. Beginning bowlers may experience hand swelling and arm and shoulder discomfort, but as the flexibility and strength needed for the game are acquired through regular activity and practice, these minor problems usually work themselves out.

The individual with amputation can either bowl from a stationary position at the foul line or use a two- to four-step approach, with the steps generally short and the feet fairly wide apart. Some bowlers with amputation tend to turn the left foot at a right angle to the line of approach when releasing the ball, thereby shifting swing and follow-through far to the right. Others encounter difficulty in achieving a smooth approach, with the first two steps too fast, an abrupt stop at the foul line, and an uneven backswing. A right-handed bowler who has a right leg prosthesis can slide to the foul line on his or her left leg and release the ball in the usual manner. A right-handed person with a left leg prosthesis may prefer to stand with the feet together about a meter, or 1 yard, behind the foul line and swing the ball backward while leaning forward to aid advancement of the prosthesis and the ball, which is then bowled. These problems can be resolved with practice. Some people with right leg prostheses prefer to bowl off the left leg.

There are physical benefits to bowling. The exercise helps to build muscle tone, aid cardiovascular circulation, maintain hand/eye coordination, and offer an

overall feeling of physical well-being. Bowling provides important mental, emotional, and social benefits as well. The bowler has to think, judge, concentrate, and interact with others. As such, bowling is often a catalyst in getting the individual with amputation out of the house and back into mainstream society.

Another advantage of bowling is that this is a sport in which participants can see immediate results. A bowling score, for example, is a form of instant positive feedback. The game also offers those with and without impairment a chance to enjoy group and family activity. Most of all, bowling is fun. (See separate section on wheelchair bowling.)

For additional information on bowling, see the **Sports Organizations and Resources** section.

Dancing

Dancing is an activity that causes much self-consciousness among people with amputation. The potential dancer should practice in private with a partner with whom he or she feels comfortable, since the partner is likely at first to get his or her toes stepped on. Partners should keep a slightly wider than normal stance to allow for clearance of the prosthesis, especially if the amputee is wearing a thigh lacer for suspension.

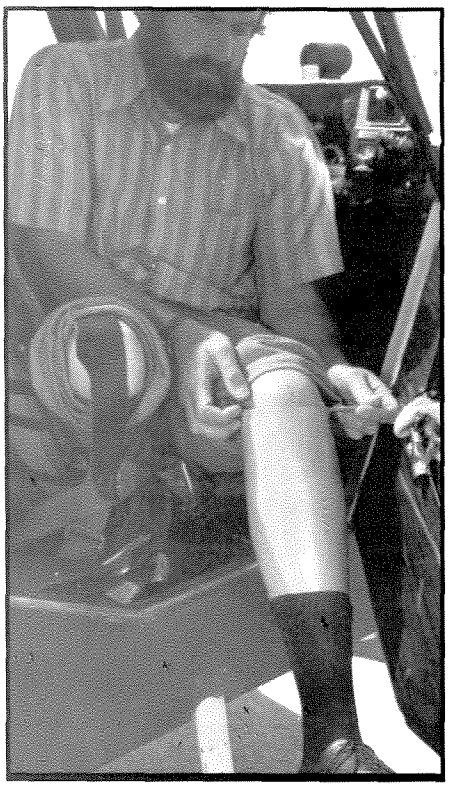
With patience, however, dancing is an excellent activity for regaining coordination and learning control of the prosthesis without constantly looking down.

Flying

There are some 10,000 pilots with physical disability in the nation's skies. These pilots enjoy an excellent record for safety, according to the Federal Aviation Administration (FAA) in Oklahoma City. While adaptation of the aircraft is necessary for the pilot with physical disability, once in the cockpit, flying depends far more on good judgment than on physical strength **(Figs. 10, 11a, and 11b)**.

As long as one flies with a licensed pilot, a medical examination is not mandatory. Before flying solo, however, one must have a student pilot license and at least a third-class medical examination issued by an FAA flight surgeon. A roster of qualified medical exam-

Fig. 10. A unilateral below-knee amputee using a removable pylon takes to the air. (Photo by Bernice Kegel)



Figs. 11a and 11b. Once in the aircraft, the flyer with lower limb amputation has little difficulty. Before taking off, the flyer removes the lower portion of the prosthesis and uses the upper portion to help work the special controls. (Photos courtesy of Bruce Cruikshank)

iners is maintained by local flight schools.

When a local FAA examiner is designated, the prospective pilot can apply for a third-class medical certificate. Once the doctor has indicated on the application the precise nature of disability, the material is forwarded to the FAA Aeromedical Certification Branch, Oklahoma City, for a determination. In cases of certain functional losses, such as loss of a limb, the FAA can issue a medical certificate with the limitation "valid for student pilot privileges only."

At the conclusion of a flight test, assuming that it is passed, the FAA flight inspector will issue a temporary private pilot certificate, the new medical certificate, and a Statement of Demonstrated Ability ("waiver"). Appropriate limitations may be placed on the pilot and/or medical certificate. For example, in the case of a pilot with lower limb amputation, the medical certificate may state that it is valid only while wearing his or her prosthesis.

Although the rules governing flying for those with physical disability are stringent, many have become avid flyers. Bill Blackwood who cannot walk went on to become the first wheelchair pilot to get an instructor's rating from the FAA. Today, Blackwood heads the Wheelchair Pilots Association of America, an organization active in designing aircraft hand controls to meet the needs of people with amputation and other severe impairments who are interested in flying airplanes.

Choosing an Aircraft

The kind of aircraft that the pilot decides to fly is essentially determined by the ease it offers in getting into and out of the cockpit.

The Weick control system designed for Piper PA 28s (the Cherokee series), PA-28Rs (Arrows), and PA-32s (Saratogas and Lances) requires no bolts and simply clamps to the aircraft. This control system allows the pilot with a disability the option of positioning his or her wheelchair (for those confined to a wheelchair) along the wing. Another advantage of these aircraft and the low-winged Grumman American is the baggage area, which is sufficiently large to accommodate a wheelchair and other equipment.

In fact, with help in the installation of controls and the procurement of a modified FAA-approved flight manual, almost any aircraft can be made suitable for the pilot with amputation. Ercoupe designer Fred Weick, and others, have come up with approved hand controls that fit various rudder-pedal airplanes. These conversions put brakes and the left and right rudders in the pilot's hands by simply touching a lever.

Other aircraft that pilots with disability favor include the Piper Tri-Pacer which is equipped with a partially coordinated control system and hand brake. Mooneys, Beechcraft, Musketeers and other low-winged aircraft offer relative ease of climbing into the cockpit. A few twin engines such as the Cessna 337 Skymaster, which displays simple single-engine procedures, is recommended. High-winged, multi-engine aircraft and taildraggers are generally not suggested, however, except for very skilled pilots.

Hand Controls

Hand controls for certain Cessna and Grumman American aircraft are manufactured by Union Aviation, Inc., P.O. Box 207, Sturgis, KY 42459 (502) 333-5918.

There are also several fixed, or permanent, hand controls for aircraft that are commercially sold, but in order to avail oneself of these controls, the pilot must own the airplane. Sources of fixed hand controls are: Aircraft Inspection & Maintenance, 2680 East Wardlow Road, Long Beach, CA 90807 (213) 595-5738; or, Union Aviation Inc., P.O. Box 207, Sturgis, KY 42459 (502) 333-5918.

Modification of the Prosthetic Foot

For those individuals with amputation who choose to pilot an aircraft without hand controls, modification of the prosthetic foot is sometimes helpful in operating the rudder pedal and in keeping the foot from inadvertently hitting the brake pedal, although this problem is rare. For operation of the toe brake, most fliers prefer the two-part SACH (solid ankle/cushion heel) Foot designed by the Navy Prosthetic Research Laboratory in Oakland, California. This prosthesis can be worn for everyday use; for flying, the prosthetic toe section can simply be disconnected **(Fig. 12)**.

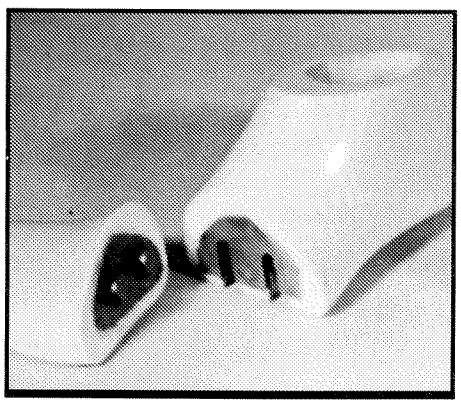


Fig. 12. The SACH foot showing the disconnected toe section. (Photo courtesy of Navy Prosthetic Research Laboratory, Naval Regional Medical Center, Oakland, CA)

To facilitate the pivoting action necessary for operation of the aircraft, it is helpful to move the seat as close to the pedals as possible. Then, the flier moves his body down in the seat, and forward, in order to pivot the entire leg forward and downward. Although this generally can be accomplished without special modification, research is constantly being conducted to discover a better way. For example, a foot that pivots when pressure is applied to the heel could be a significant adaptive device for the leisure-time flyer with amputation.

For additional information on flying, contact:

- American Wheelchair Pilots Association
  c/o Dave Graham
  1621 East Second Avenue
  Mesa, AZ 85204
  (602) 831-4262

- CA Wheelchair Aviators
  c/o Bill Blackwood
  1117 Rising Hill Way
  Escondido, CA 92025
  (619) 746-5018

- Handicapped Fliers Intl.
  c/o Bill Blackwood
  (see above)

- The Soaring Society of America, Inc.
  P.O. Box 66071
  Los Angeles, CA 90066
  (213) 390-4448

- Union Aviation, Inc.
  c/o Leroy Laneve
  P.O. Box 207
  Sturgis, KY 42459
  (502) 333-5918

Ultralight Flying

Ultralight aircraft have opened many doors to people with physical disability who wish to partake in the exhilarating experience of flying. One aircraft in particular, the Pterodactyl Ascender II, consists of two axis controls, thus obviating the need for extensive modifications. In fact, the pilot with upper limb function, may require no more modification to the craft than slight adjustment to the seating and steering mechanisms. Once the pilot is in the air, he or she can be as functionally capable as any pilot **(Figs. 13a and 13b)**.

The Pterodactyl's flight controls consist of a joystick, which is typically mounted for right, upper limb operation. Movement of the joystick in an anterior/posterior plane controls the pitch (nose up and nose down) of the aircraft. The lateral motion of the joystick controls yaw (right turns and left turns), while the throttle and kill switch usually are operated with the left hand.

During training activities and ground maneuvers, the pilot with disability may choose to avail himself or herself of certain additions to the plane in order to facilitate maximum independence in the skies. For example, the addition of a nosewheel with remote steering, caliper brakes, a repositioned starter rope, and various seat

Fig. 13a. Getting the Pterodactyl Ascender II ready for flight.

Fig. 13b. The ultralight aircraft is equipped with leg support straps, side car for carrying a wheelchair, and hand controlled ground steering and brakes. (Photos by Toni James, courtesy of Beneficial Designs, Inc.)

modifications can be accomplished with virtually no change to the flight controls or to the control surfaces.

Today, an increasing number of cooperatives are being formed that enable groups of pilots to collectively own ultralight aircraft. Through these cooperatives, the pilot with amputation can participate in flying at far less expense than this activity generally costs.

For additional information on ultralight flying contact:

- Aircraft Owner's Pilot Assn.
  c/o Glenn Rizner
  421 Aviation Way
  Frederick, MD 21701
  (301) 695-2000

- Beneficial Designs, Inc.
  c/o Peter Axelson, President
  5858 Empire Grade Road
  Santa Cruz, CA 95060
  (408) 429-8447

- California Wheelchair Aviators
  c/o Bill Blackwood
  1117 Rising Hill Way
  Escondido, CA 92025
  (619) 746-5018

- Freedom Flyers, Inc.
  c/o Gary Vicks
  P.O. Box 479
  2802 Singleton Street
  Rowlett, TX 75088
  (214) 475-8870

- University of Tennessee
  Rehabilitation Engineering
  c/o Douglas Hobson, Technical Director
  682 Court Avenue
  Memphis,TN 38163
  (901) 528-6445

Gardening

Gardening often poses difficulty for people with amputation. The main problem is assuming the kneeling position because of the lack of plantar flexion ability of the prosthetic foot. When kneeling, the amputee often feels that his or her upper body is being pushed forward. For the person with above-knee amputation who wishes to be a gardener, a hydracadence knee unit that allows marked ankle plantar flexion may be considered. The gardener with below-knee amputation may experience pressure in the popliteal fossa area when in the kneeling position. The person with amputation also needs to be careful of wet slippery ground when watering a garden.

A solution is to garden at waist level while standing such as planting in flower boxes **(Fig. 14a)**. Planting in hanging baskets can be done at a table and hung afterwards. For wheelchair gardeners, it is best to work with plants that are low in height, such as dwarf fruit trees. A rigid garden hose extender may be useful for reaching far into the garden bed **(Fig. 14b)**.

Amputees who want to dig in the ground, however, can work in a sitting position using a blanket to sit on. Or, if kneeling is necessary, the gardener can request that his or her prosthetist fabricate a protective knee pad. If the padding is thicker for the sound leg than for the prosthetic side, there would be room allowed for toe clearance on the prosthetic side. The gardener also can make a kneeling pad by placing foam rubber in a heavy plastic bag and sealing it with waterproof tape. Commercially made kneeling pads are available

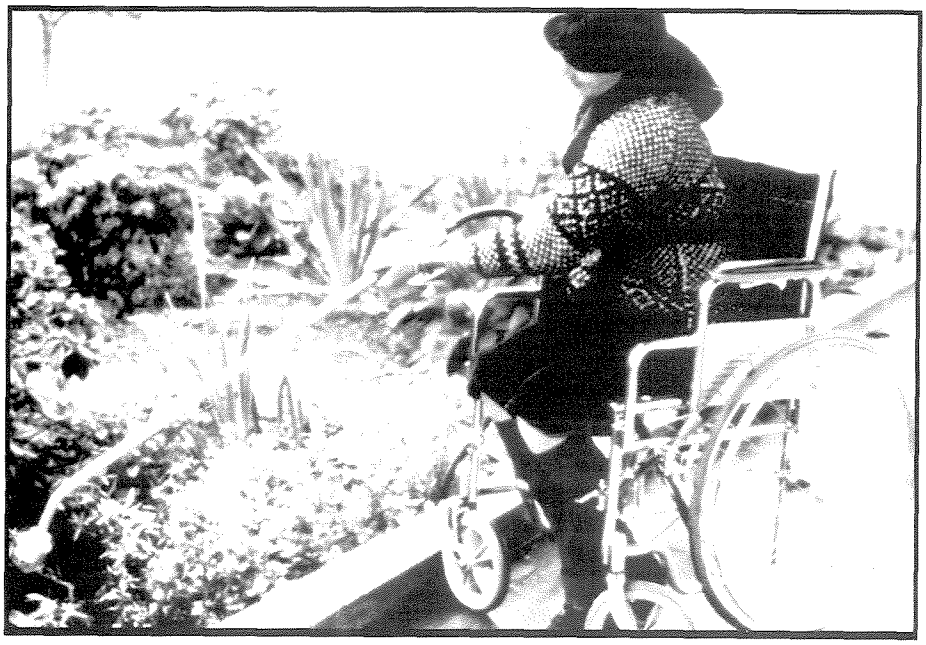


Fig. 14a. Window box gardening from a standing position. (Photo by Bernice Kegel). **Fig. 14b.** A rigid watering hose extender. (Photo courtesy of Maureen Phillips)

Gardening

at many gardening stores. Another device, called the Easy Kneeler, allows the amputee to either sit and work, or turn the stool over and kneel on it **(Figs. 15a and 15b)**. Both the kneeling pad and the Easy Kneeler are available from Gardener's Supply Company, 133 Elm Street, Winooski, VT 05404 (802) 655-9006.

Fig. 15a. Easi-Wheeler Kneeler/Seat. **Fig. 15b.** Adjusted for kneeling. (Photos courtesy of Maureen Phillips)

Golf

The greatest challenge facing the individual with amputation who wants to play golf is maintaining proper balance and rhythm. The player with amputation requires practice at first in achieving distance (of the ball) due to somewhat limited follow-through in his or her swing and possible difficulty in rotating on the prosthesis, while others golf successfully without a prosthesis **(Fig. 16a)**. And, although the golfer with unilateral amputation encounters relatively few problems with this game, bending over to tee off requires exceptional equilibrium and thus can be difficult for some people until the skill is mastered **(Fig. 16b)**.

For the golfer with lower limb amputation who wears a prosthesis, a rotator might be helpful. This assistive device is also useful for playing baseball, cricket, and several other games. The rotator, which is incorporated into the

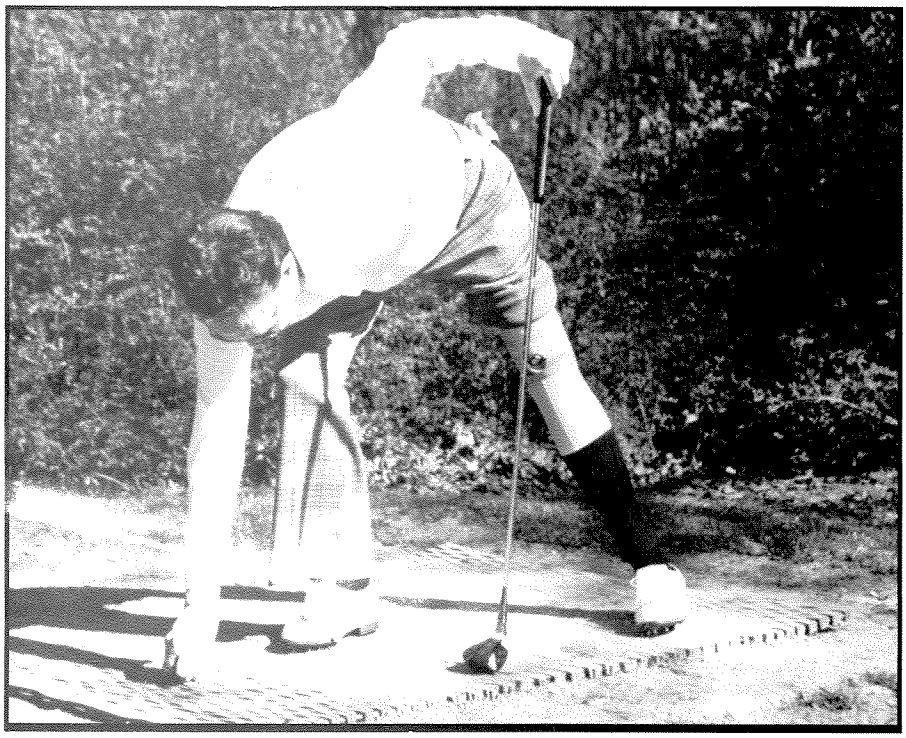


Fig. 16a. A golfer with unilateral above-knee amputation plays without a prosthesis. **Fig. 16b.** Bending down to tee off requires exceptional balance. (Photos courtesy of Bernice Kegel).

shank of the prosthesis, simulates normal body rotation by allowing the hips to rotate independently from the position of the foot **(Figs. 17a and 17b)**. The prosthetic foot returns to the aligned position once the axial torque is removed. The rotator is attached at the junction of the ankle and shank and can be incorporated into most conventional prostheses.

The rotator offers significant benefits. First of all, it absorbs torque. Second, it aids in reducing shear stress at the residual limb/socket interface, thereby reducing the possibility of skin abrasion. Finally, most individuals with amputation find that the use of a rotator facilitates balance and rhythm on teeing off. (Since subtalar motion is absent or limited in prosthetic foot/ankle units, tibial rotation takes place within the rotator itself.) The type of terrain is especially important to the golfer with amputation.

Of the manufactured rotators currently available, the Otto Bock Rotator and U.S. Manufacturing Company's R.O.L. (Rochester Orthotic Laboratories) Rotator are the most widely used.

For additional information on rotators, contact:

- Otto Bock Orthopedic Industry, Inc.
  c/o Al Pike
  4130 Highway 55
  Minneapolis, MN 55422
  (612) 521-3634

- U. S. Mfg Co., Inc.
  c/o Dan Edwards
  180 North San Gabriel Blvd.
  Pasadena, CA 91107
  (213) 796-0477

The right-handed golfer who has a left-leg amputation should always wear a rotator and begin his or her swing with the foot

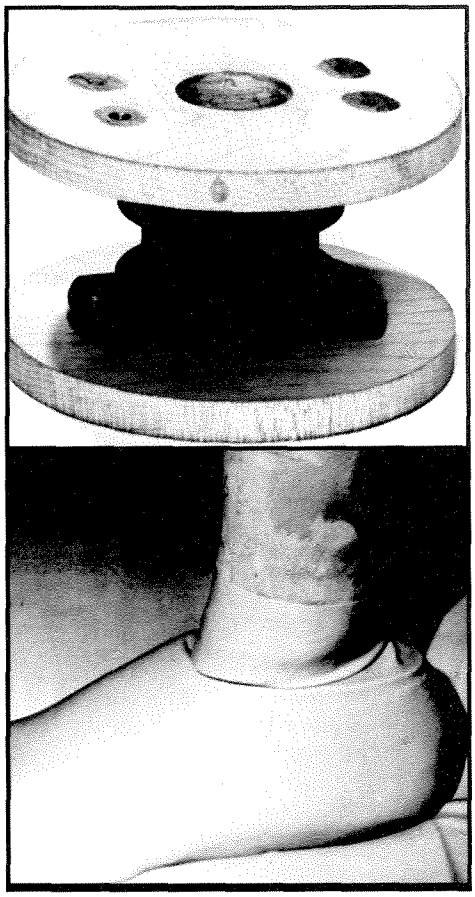


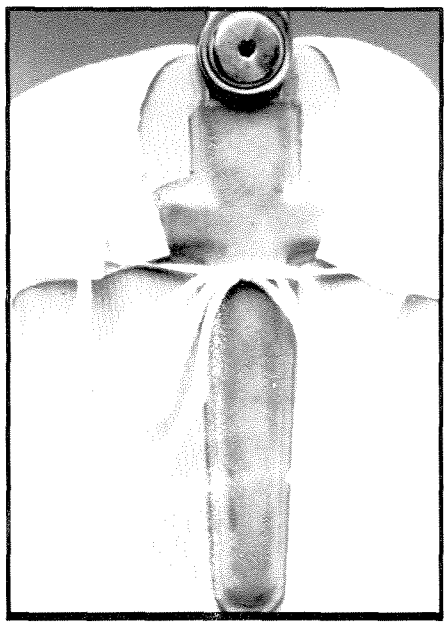
Fig. 17a. A STAR (Shank torque ankle rotator). **Fig. 17b.** Rotator incorporated into prosthesis. (Photos courtesy of the Archives of Physical Medicine and Rehabilitation)

rotated inwards. While it is not necessary to wear spiked shoes, it can be annoying to see the foot moving around during the swing. The person with a right-leg amputation who is also right-handed is at a disadvantage. He or she may tend to keep all weight on the left leg during a swing. It may be better for this person to play the game left-handed.

In addition to the rotator, Daw Sheaths, which are similar to residual limb socks, can be used to minimize friction and to protect the skin at the residual limb/socket interface **(Figs. 18a and 18b)**. Daw Sheaths are very smooth, thin liners that are worn underneath residual limb socks as added protection. The sheath is made of ventilated mesh that allows perspiration to escape, thereby helping to reduce breakdown of epithelial tissue. Any friction thus occurs between the sheath and prosthesis rather than between the human skin and the prosthesis. Daw Sheaths are available in a variety of sizes. To ensure proper fit, one should consult a prosthetist.

For additional information on the Daw Sheath, contact:

- Daw Industries
  14946 Minnetonka Industrial Road
  Minnetonka, MN 55345
  (612) 933-1240



Figs. 18a and 18b. The Daw Sheath for suction socket wearers. (Photo courtesy of Daw Industries).

The S.A.F.E. Foot

Some individuals with amputation prefer not to wear golf shoes with spikes as they tend to interfere with rotation on the prosthetic limb. Alternatively, this group generally chooses to wear an ankle unit such as the S.A.F.E. (stationary attachment flexible endoskeletal) Foot since it offers the capability of remaining flat on the ground while teeing off **(Fig. 19)**.

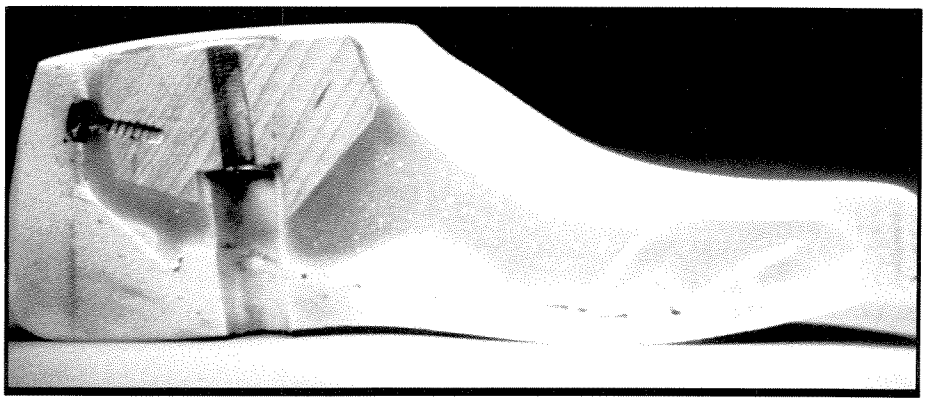


Fig. 19. The S.A.F.E. (stationary attachment flexible endoskeletal) Foot. (Photo by Bernice Kegel)

Manufactured by Campbell-Childs, Phoenix, Oregon, the S.A.F.E. Foot is designed to simulate the shape and action of the human foot, where movement is dictated by articular surfaces and ligamentous restrictions. The S.A.F.E. Foot provides dorsiflexion-plantar flexion, eversion-inversion, pronation-supination, and transverse rotation.

Forty-five people with amputation participating in 1981 clinical trials reported that the S.A.F.E. Foot allowed a smoother gait and was less fatiguing to wear than the conventional walking prosthesis. They also found the S.A.F.E. Foot easily adaptable to irregular terrain. Finally, they noted that this prosthesis afforded a relatively wide range of motion.

In addition to the findings of those surveyed, prosthetists involved in the clinical trials directly noted that the S.A.F.E. Foot offered users a smoother transition from heel strike to foot flat to toe-off in the stance phase of the gait cycle. Prosthetists participating in the subject trials also found that the S.A.F.E. Foot necessitated fewer adjustments in alignment than conventional single-axis feet.

The Swivel Golf Shoe

If the individual with amputation does not have a rotator built into the prosthesis, or if he or she has undergone a Symes amputation (in which case a rotator cannot be used), the Swivel Golf Shoe is an alternative to consider **(Fig. 20)**.

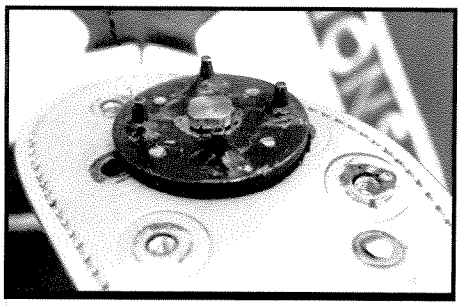


Fig. 20. Swivel golf shoe. (Photo courtesy of War Amputations of Canada)

After experimenting with several prototypes, the Swivel Golf Shoe, a device which can be built into a conventional golf shoe to allow rotation, was developed by Armand Viau and Cliff Chadderton. Designed to facilitate the golf swing and reduce strain on the spine, the Swivel Golf Shoe can be fabricated by the following step-by-step procedure:

(1) Obtain a quality golf shoe with a genuine leather sole.

(2) Remove the cleats from the sole, but leave the heel cleats in place.

(3) Bore a hole of roughly 5 centimeters (2 inches) in diameter in the leather sole at approximately the metatarso-phalangeal joint.

(4) Cut a metal plate of 1.58 centimeters (1/16 inch) to the shape of the innersole, from the toe to the longitudinal arch.

(5) Weld the housing of the bearing to the innersole so that it extends through the hole at the metatarso-phalangeal joint.

(6) Fasten metal innersole to the leather sole with rivets.

(7) Cut two pieces of Celeron (a Nylon-type material) of 5 centimeters (2 inches) in diameter, i.e., of a size compatible with the thrust bearing and to, in fact, fit inside the thrust bearing housing.

(8) Weld three cleats to a 2.54 centimeter (1 inch) steel washer of roughly 3.17 millimeters (1/8 inch) in thickness; one piece of the Celeron is then riveted to the steel washer.

(9) A stud of 7.9 millimeters (5/16 inch) is then fabricated, preferably of very fine thread.

(10) The stud is then inserted into the hole in the metal

plate whereupon two small holes are punched into the upper part of the shoe.

The Swivel Golf Shoe depends on the artful use of two pieces of Celeron. Since one piece of the fabric is riveted to a metal plate at the bottom of a golf shoe it remains stationary. The second piece of Celeron, which is riveted to a washer containing a cleat, must rotate in order for the shoe to swivel. Celeron is an ideal fabric in that it provides an oil-free surface-to-surface contact, thereby facilitating rotation.

The total weight of the Swivel Golf Shoe is only about 113.4 grams (4 ounces), so it is entirely possible to walk 18 holes on this modified shoe without undue fatigue. Moreover, reports indicate that breakdown of the Swivel Golf Shoe is rare. It is water resistant and has been used for as many as three complete golf seasons without any problem, or need for repair.

For more information on the Swivel Golf Shoe, write to:

- Armand Viau or Hugh Clifford Chadderton
  The War Amputations of Canada
  2277 Riverside Drive
  Suite 210
  Ottawa, Ontario KIH7X6

Maintaining Balance and Rhythm

The golfer with bilateral above-knee amputation who experiences difficulty maintaining balance, might consider the following:

(1) He/she can modify a standard camera tripod by placing a bicycle seat on top (where the camera would normally be). In this way, the golfer can sit on the seat, while bearing some weight on his legs **(Fig. 21)**.

(2) One can play from a wheelchair using a thick pillow under the buttocks. On approaching the green, he or she simply gets out of the chair and sits on the ground. (A wheelchair with desk arms or no armrests at all is preferable.)

(3) Golf can be played from a sitting position in an electric golf cart equipped with a swivelseat, or one can play from a standing position while leaning against the golf cart for support.

(4) Golfers operating from a seated position should use clubs that have a flatter lie than normal. This reduced angle is helpful because of the flat swing plane induced by the seated position.

The amputee golfer should also consider terrain. Electric golf carts are useful on hilly golf courses and reduce fatigue by eliminating some of the walking. Pleasant alternatives to a golf course are miniature golf areas and driving ranges.

For more information on golfing, contact:

- Amputee Sports Assoc.
  c/o George C. Beckmann, Jr.
  11705 Mercy Boulevard
  Savannah, GA 31419
  (912) 927-5406

- Internatl. Senior Amputee Golf Society
  c/o Dale Bourisseau
  14039 Ellesmere Drive
  Tampa, FL 33624
  (813) 961-3275

- Natl. Amputee Golf Assoc.
  c/o Bob Wilson
  5711 Yearling Court
  Bonita, CA 92002
  (619) 479-4578

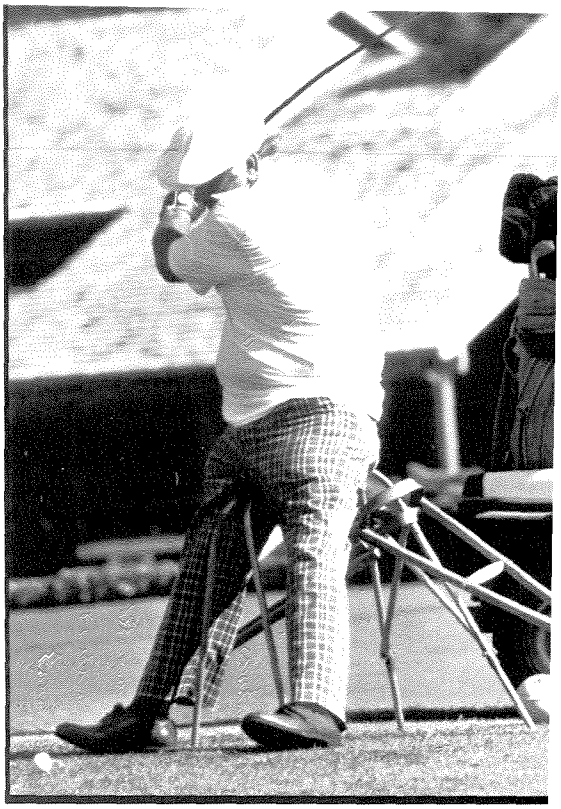


Fig. 21. A golfer with bilateral amputation demonstrates a device he designed to facilitate his teeing off. (Photo courtesy of Dick Bell)

- National Handicapped Sports and Recreation Association (NHSRA)
  c/o Jack Benedick
  P.O. Box 18664
  Capitol Hill Station
  Denver, CO 80218
  (303) 232-4575

- Project Fore, Golf for the Physically Disabled
  c/o John Klein
  Singing Hills Country Club
  3007 Dehesa Road
  El Cajon, CA 92021
  (619) 442-3425

- Recreational Center for the Handicapped
  c/o Janet Promeroy, Director
  207 Skyline Boulevard
  San Francisco, CA 94132
  (415) 665-4100

- U.S. Amputee Athletic Assoc.
  c/o Richard Bryant
  Rt. 2, Couny Line Road
  Fairview, TN 37062
  (615) 670-5453

Hiking

Most individuals with amputation hike while wearing a prosthesis rather than relying on crutches alone. A below-knee prosthesis with a silicone gel liner may be helpful in preventing trauma to the residual limb.

The previously discussed S.A.F.E. (stationary attachment flexible endoskeletal) Foot, or a rotator unit, is often recommended for avid hikers, especially those with above-knee amputation.

For the hiker with below-knee amputation, a gluteal-ischial weight-bearing thigh corset is generally helpful in providing mediolateral stability when hiking over rough terrain **(Fig. 22)**. This complement to the below-knee prosthesis is typically fabricated of heavy leather. The rigidity of the leather makes it ideal for maintaining quadrilateral shape and preventing hyperextension of the knee. Leather is also desirable because of its compatibility with the biomechanical principles of weight support in the thigh area. (Body weight is borne high above the knee joint.) Equidistant spacing between corset eyelets is important for optimal performance of the gluteal-ischial weight-bearing thigh corset.

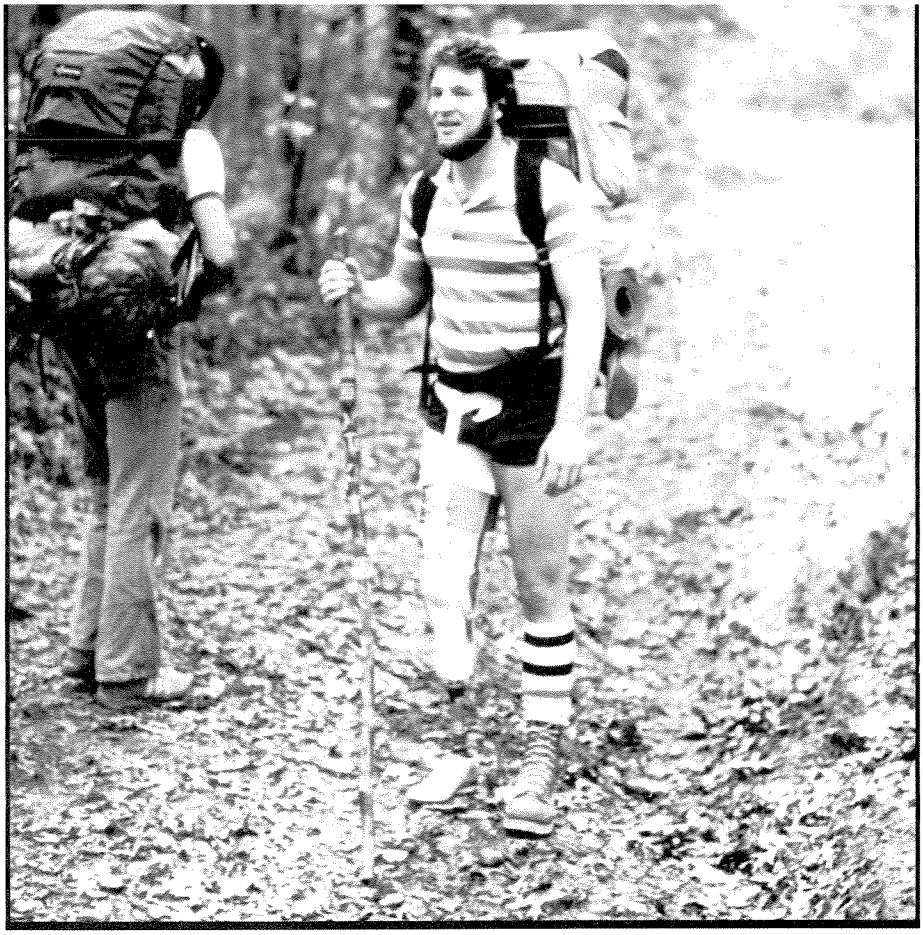


Fig. 22. A hiker with unilateral below-knee amputation using a suspension belt and thigh corset. (Photo courtesy of Prosthetics Research Study)

Several facilities provide outdoor recreational programs for individuals with physical disability interested in hiking. The Colorado Outdoor Education Center in Breckenridge, Colorado is one such facility. This is a non profit organization dedicated to the concept that everyone, including those with severe disability, can enjoy the great outdoors. Hiking can improve the disabled person's self-confidence, eliminate social withdrawal, increase independence, and develop outdoor adaptive skills. Situated on 38 acres of wooded mountain land, the Colorado Outdoor Education Center is ideal for individuals with disability who want to hike, horseback ride, fish, and enjoy nature. The center offers several year-round courses of 1, 2, 3, 5, and 10 days for persons ranging in age from 4 to 74. These courses are limited to six or eight students, so every attendee receives individual attention. Fees depend on the length and kind of program that one chooses. Scholarships are also available.

For more information, contact:

- Breckenridge Outdoor Education Center
  c/o Mike Mobley, Exec. Dir.
  P.O. Box 697
  Breckenridge, CO 80424
  (303) 453-6422

A similar facility is the Vinland National Center located some 20 miles west of downtown Minneapolis. Vinland offers a wide range of recreational programs for those with and without disability who are 16 years of age or older.

For more information, contact:

- Vinland National Center
  c/o Joan Saari
  3675 Ihduhapi Road
  Loretto, MN 55357
  (612) 479-3555

Another facility in Minnesota, Wilderness Inquiry II, offers week-long summer trips for people of all ages with physical disability. These trips are conducted in the Boundary Waters Canoe area of northeastern Minnesota.

For more information on these trips, contact:

- Wilderness Inquiry II
  c/o Greg Lais, Director
  Suite O
  2929 Fourth Avenue South
  Minneapolis, MN 55408
  (612) 827-4001

Shared Outdoor Adventure Recreation (S.O.A.R.) in Oregon caters to people with disability who are 16 years of age and older. S.O.A.R.

provides programs in sled skiing, three-track and four-track skiing, cross-country skiing, hiking, and camping.

For more information, contact:

- S.O.A.R.
  c/o Linda Besant
  P.O. Box 14583
  Portland, OR 97214
  (503) 238-1613

S'PLORE (Special Populations Learning Outdoor Recreation and Education) is a private, nonprofit agency that provides adaptive outdoor education and recreation to those with disability. Programs in cross-country skiing, river rafting, and hiking are available free of charge to youths between the ages of 12 and 18 with congenital or surgical amputation.

For more information, contact:

- S'PLORE
  c/o Patti Mulvihill, Exec. Dir.
  255 East 400 South/Suite 107
  Salt Lake City, UT 84111
  (801) 363-7130

Other resources available to those individuals with disability who are interested in outdoor recreational activities include:

- Adolescent Amputee Camp
  Physical Therapy Dept.
  Children's Hospital of Pittsburgh
  c/o Gay Gregg
  125 DeSoto Street
  Pittsburgh, PA 15213
  (412) 647-5480
- Ski for Light, Inc.
  c/o Budd Keith
  1455 West Lake Street
  Minneapolis, MN 55408
  (612) 827-3611
- Voyageur Outward Bound School
  c/o Ted Mooras
  P.O. Box 250
  Long Lake, MN 55356
  (612) 473-5476

Horseback riding as recreational therapy for those with physical disability is not a new concept. In 1965, the British Horse Society organized a program called The Advisory Council on Riding for the Disabled. Even earlier, similar programs were being organized in Scandinavia. Although the United States has been less ambitious than certain other nations in popularizing riding, excellent American centers have been created through the NARHA (North American Riding for the Handicapped Association) established in 1969. Today, there are 140 NARHA riding centers serving some 400 people with disability annually in 37 states and Canada.

The individual with amputation who wants to horseback ride needs few, if any, modifications to the bridle and reins unless use of the hands and arms is affected. **(Fig. 23)**. Ordinarily, the saddle itself will not require changes, though handholds can be attached across and in front of the pommel of the saddle. In this way, the student has more than the reins to grasp and is afforded better balance. Heavy-duty square Ds can be placed under the front of the saddle skirt, or slightly behind those square Ds used for the breast plate or martingale. A rolled leather handhold (buckled to each square D), which can be made longer or shorter to accommodate one's size, helps the student not only to maintain balance but to keep from grasping the pommel of the saddle in a way that might pinch the fingers.

Some horseback riders who wear limb prostheses have had a problem with the prosthetic foot slipping through the stirrup and getting caught. This can be pre-

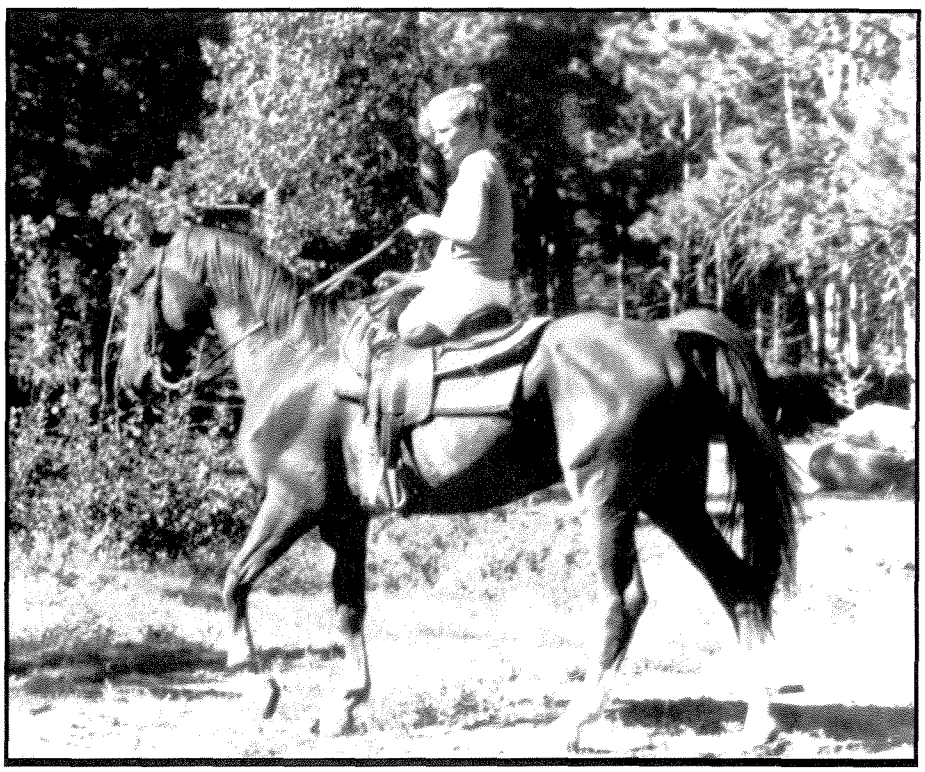


Fig. 23. A horseback rider with unilateral above-knee amputation prefers to ride without a prosthesis. (Photo courtesy of Becki Conway)

vented by using Devonshire boots (which look like a boot toe over the front of the stirrups) or safety stirrups. While NARHA instructors generally recommend safety stirrups, some individuals with amputation have sufficient control of the prosthetic limb to manage without them. Stirrup modifications fit on an English saddle which is usually equipped with a safety latch on the stirrup bar to release the entire setup in case of falling and concomitantly trapping the foot. While a properly fitted Western saddle gives the rider more stability, it lacks the safety options of the English saddle. If horse and rider are not properly matched in size and shape, or if the rider has unusual balance problems, some type of "residual limb stirrup" should be used to help the rider maintain balance on the horse.

If a rider chooses to ride without a prosthesis, he or she has to decide whether or not to construct a boot or other stirrup modification to fit the residual limb. The modified device must not fit too tightly or it might defeat its purpose by increasing the risk of entrapment **(Figs. 24 and 25)**.

Although riding without a prosthesis does not necessarily upset the rider's equilibrium, most prefer to wear their prosthetic limb because of the grace and naturalness it affords. The popliteal area of the below-knee prosthesis may need to be lowered, however, to allow necessary knee flexion. The prosthesis may also require alignment so that the foot is canted inward and the toe upward and outward. The medial aspect of the prosthetic calf can be flattened so that it allows optimal contact with the saddle.

The individual with a very short residual limb or a socket that develops pressure points will choose not to wear a prosthesis for horseback riding and will want to use a

Figs. 24 and 25. A rider with unilateral above-knee amputation doing "gaming." He rides without a prosthesis, using a leather strap to stabilize the residual limb in the saddle. (Photos by Bernice Kegel)

"residual limb stirrup" to maintain balance. Equilibrium also can be upset when the size of the horse is not compatible with that of the rider. Above-knee amputees wearing a prosthesis may sometimes have problems with pinching of gluteal tissue between the prosthesis and the saddle, which can be very painful.

Those who wear an above-knee prosthesis may want to also use a pelvic band with a double-axis hip joint for flexion, sufficient abduction, and comfortable sitting. The active individual with amputation generally favors the kind of suspension provided by a Silesian bandage since it does not restrict motion.

Silesian bandage suspension is lightweight, comfortable, and resistant to weight fluctuations and other factors that affect suction suspension. This bandage is easy to use because it simulates a waist belt. In addition to being less restrictive than a metal or plastic hip joint with a pelvic band, the Silesian bandage is cosmetically more acceptable under clothing. Finally, this type of suspension offers specific control of rotation and adduction of the prosthesis on the residual limb, though it does not provide as much overall flexion, extension, adduction, and abduction as does the hip joint/pelvic band suspension. For this reason, hip joint/pelvic band suspension is indicated for individuals with severely diminished capacity to control their prostheses (e.g., those people with very short residual limbs).

Those persons with bilateral above-knee amputations and very short residual limbs, or those with hip disarticulations, might consider bucket-type devices for horseback riding. In fact, some health-care professionals even recommend buckets to the person with unilateral above-knee amputation. In most cases, both English and Western saddles are adequate, with Western saddles generally easier to use. Stirrups with rubber inserts and rubber-soled boots might also be considered to prevent the prosthetic feet from sliding off the stirrups.

Those individuals with hip disarticulation and above-knee amputation usually benefit from a string or strap (positioned from the heel of the boot to the upper part of the prosthesis, or waist), which keeps the prosthetic knee flexed in a similar manner as the natural knee. Alternatively, a knee-locking device such as a Mauch S-N-S (Swing-N-Stance) Knee which is capable of locking in a flexed posture is useful. (See section on bicycling for further discussion of the Mauch S-N-S Knee.)

For those who use a wheelchair, if mounting a horse from the chair is a problem, an approach ramp (16 feet long by 15 feet wide) might be considered. For the ambulatory equestrian, a mounting platform composed of two to three steps might be helpful. (Since horses are typically trained to be mounted from their left side, the rider with right-sided amputation might experience less difficulty than those with left-sided amputation.)

The individual with amputation who is learning to ride a horse will first and foremost benefit from the guidance of an experienced physical therapist. Once on the bridle path, the riding student will probably need someone to lead the horse, and someone on either side to help maintain balance and avoid falling off the horse. Safety helmets are usually required, while a sturdy safety belt is also recommended, at least until good balance and rhythm are acquired. Of course, a well-trained and cooperative horse can make all the difference — it would be difficult, if not impossible, to develop equestrian skills or have fun while fighting a temperamental horse, or one with an uneven gait.

Finally, those people who wear a prosthesis while riding will want to make sure that the prosthesis is free from rough surfaces that might hurt the horse. While such an irregularity might not be a problem to the wearer during walking or even riding, it could irritate the flank of the horse if not fully protected by the saddle.

Choosing a Riding Program

Since horseback riding for those with disability is rapidly growing in popularity, there are a variety of programs that are available to find those most suitable. In evaluating the programs, one might look for these features:

(1) An enclosed ring, preferably with wood fencing to permit riding in every type of weather;

(2) A horse that is clean, of good temperament, and the right size;

(3) An instructor with sound knowledge of the rider's disability;

(4) Experienced personnel in charge of the horse;

(5) Availability of side-walkers;

(6) A physical therapist on staff or available on a consulting basis;

(7) Requisites for admission designed to protect the person with disability (e.g., a physician's referral may be appropriate);

(8) Special assistive equipment, including handholds on the saddles, a mounting ramp for wheelchairs, safety belts, Devonshire boots (covered stirrup irons so feet do not slide through);

Horseback Riding

(9) Affiliation with and full accreditation of these riding programs by the North American Riding for the Handicapped Association;

(10) A creative, goal-oriented, and positive environment.

Learning to ride a horse is a challenging activity for those with and without disability because it involves the total body. Since every muscle and joint is used, the person with one or more missing limbs obviously has much work to do if he or she wants to become a good rider. The effort spent, however, is usually highly rewarded and more than offset by benefits including improved musculature, balance, and coordination. With proper motivation, instruction, and practice, many individuals with amputation have become excellent horseback riders, even discovering that assistive devices can be reduced or eliminated as the activity is mastered.

For additional information on horseback riding, contact:

- North American Riding for the Handicapped Assoc.
  c/o Donald Warner
  P.O. Box 100
  Ashburn, VA 22011
  (703) 471-1621

- Vinland National Center
  c/o Joan Saari
  3675 Ihduhapi Road
  P.O. Box 308
  Loretto, MN 55357
  (612) 479-3555

- Winslow Therapeutic Riding Unlimited, Inc.
  c/o Virginia G. Mazza, Pres.
  3408 South Route 94
  Warwick, NY 10990
  (914) 986-6686

(See also the **Sports Organizations and Resources** section)

Ice Skating

The positions adopted for skating are very similar to those used in snow skiing. Constant changes in pace and position help promote prosthetic awareness skills. The below-knee skiing prosthesis may be useful for ice skating as well.

Ice skating can be used as a therapeutic activity to overcome gait deviations. For the below-knee amputee, ice skating will strengthen the quadricep muscles. For the above-knee amputee, moving forward at a slow rate of walking will aid the amputee in shifting weight over the ischial area. An uneven arm swing will be very obvious during skating, and also will increase markedly energy expenditure.

An adaptive device that could be very useful especially for the beginning skater is the Hein-A-Ken Skate Aid **(Fig. 26)**. Development of the skate aid was based on the principle of learning to skate with a chair. The skate aid, however, provides a more natural position, ensures proper posture and balance, and is more stable than a chair. The skate aid is built on the concept of a hospital walker with runners. For stability, it has a pyramidal design. The device provides physical and psychological security, and is useful in providing maximum group participation with minimum supervision.

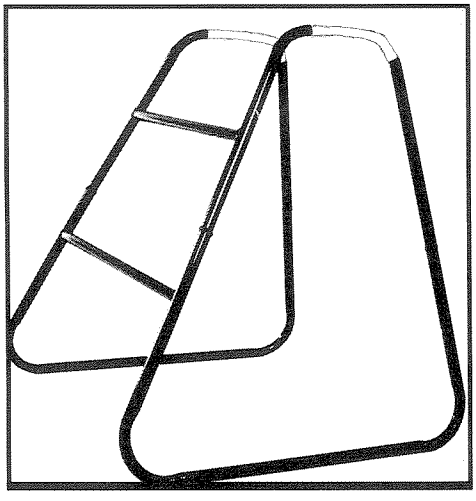


Fig. 26. The Hein-A-Ken Skate Aid, a modified walker for ice scating. (Photo courtesy of Hein-A-Ken Corporation)

Skate Aid is available in a 71 cm (28-inch) children's model or 89 cm (35-inch) adult model. For more information contact the manufacturer:

- Hein-A-Ken Corporation
  102 Fosse Court
  Thief River Falls, MN 56701
  (218) 681-7420 or 2147

Distributors for this product include the following:

- Damschroder Skate Sales
  6850 Vineland Avenue, Unit 1
  North Hollywood, CA 91605
  (818) 766-6746 or 6115

- Flaghouse, Inc.
  18 West 18th St.
  New York, NY 10011
  (212) 989-9700

- Midwest Skate Co.
  P.O. Box 87
  24370 Indoplex Circle
  Farmington Hills, MI 48024
  (313) 477-4250

- Oberhamer Shoe Company
  689 North Dale St.
  St. Paul, MN 55103
  (612) 488-6629

- Sandler Skate Supply
  P.O. Box 301
  60 Concord Ave.
  Belmont, MA 02178
  (617) 484-5100

- Select Service & Supply Co., Inc.
  2905 E Amwiler Road
  Atlanta, GA 30360
  (404) 449-5700

- Skate Supply, Inc.
  9 State St.
  Nashua, NH 03063
  (800) 225-3228

Another possibility is the outrigger skate aid **(Fig. 27)**. This consists of a figure skating blade mounted to a lofstrand or similar crutch. Using an outrigger skate increases the base of support for the skater and enhances balance. Propulsion is supplied by a rotary motion of the arms which forces the edges of the blade into the ice, while the lower extremities maintain continual contact with the surface of the ice. Speed is maintained by digging the toe picks of the figure skate blades into the ice.

For more information on ice skating, contact:

- Breckenridge Outdoor Education Center
  c/o Mike Mobley, Exec. Director
  P.O. Box 697
  Breckenridge, CO 80425

- Courage Center
  3915 Golden Valley Road
  Golden Valley, MN 55422
  (612) 588-0811

- International Council on Therapeutic Ice Skating
  P.O. Box 13
  State College, PA 16801
  (814) 865-2563

- Skating Assn. for the Blind and Handicapped
  c/o Elizabeth O'Donnell, Pres.
  3236 Main Street
  Buffalo, NY 14214
  (716) 833-2994

Fig. 27. The outrigger skate aid is especially useful for those with above-knee amputation. (Photo courtesy of Ron Adams)

Ice sledding as a recreational pastime for persons with physical disability began in Norway in the early 1960s. The ice sled used for speed skating activities consists of a metal frame of about 106.7 centimeters (42 inches) long. At the top of the frame is a wooden platform to which a seat can be attached, and along the bottom are 91.4 centimeter (36-inch) steel runners, which are sharpened to provide the skating edge.

Carbide or tempered steel tipped cross-country poles (with the baskets removed) propel the ice sled. Most persons using an ice sled would do well to obtain or fabricate a backrest for support while poling. A plastic office chair seat with the legs removed can be securely bolted to the wooden platform, thus creating a backrest. Choice of pole length is dependent on the skier's arm length and level of expertise. Beginners generally find a shorter pole of 85 centimeters (33.4 inches), or less, easier to use in learning poling techniques. When the technique is mastered longer poles of 105 centimeters (41.3 inches) are better.

For additional information on ice sledding, contact:

- Breckenridge Outdoor Education Center
  c/o Mike Mobley, Exec. Dir.
  P.O. Box 697
  Breckenridge, CO 80424
  (303) 453-6422

- S'PLORE (Special Population Learning Outdoor Recreation and Education)
  c/o Patti Mulvihill, Exec. Dir.
  255 East 400, South, Suite 107
  Salt Lake City, UT 84411
  (801) 363-7130

- Vinland National Center
  c/o Joan Saari
  3675 Ihduhapi Road
  Loretto, MN 55357
  (612) 479-3555

Martial Arts

Karate, wrestling, boxing, and other martial arts are probably not activities that a large number of individuals with amputation have considered, yet these recreational forms are available to people with disability, including those confined to a wheelchair.

Most individuals with amputation do not wear a prosthesis while participating in martial arts. In wrestling, for example, wearing a prosthesis would compel the participant to compete with a heavier wrestler since the prosthesis would increase the weight of the wearer. While a residual limb protector can be used, this usually is not necessary as the distal end of the limb is generally not directly subjected to trauma **(Fig. 28)**. Recent interest in martial arts among those with amputation has resulted in the manufacture and marketing of a variety of assistive devices that make karate, wrestling, and boxing a viable recreational option, even from a wheelchair. In addition, organizations have been formed to cater to those with physical disability interested in the martial arts.

For additional information on martial arts, contact:

- American Alliance for Health, Physical Education, Recreation, and Dance Programs for the Handicapped
  c/o Dr. Razor, Exec. Vice Pres.
  1900 Association Drive
  Reston, VA 22091
  (703) 476-3461
- West Valley Karate Club
  7041 Eton Avenue
  Conago Park, CA 91303
  (818) 887-5467

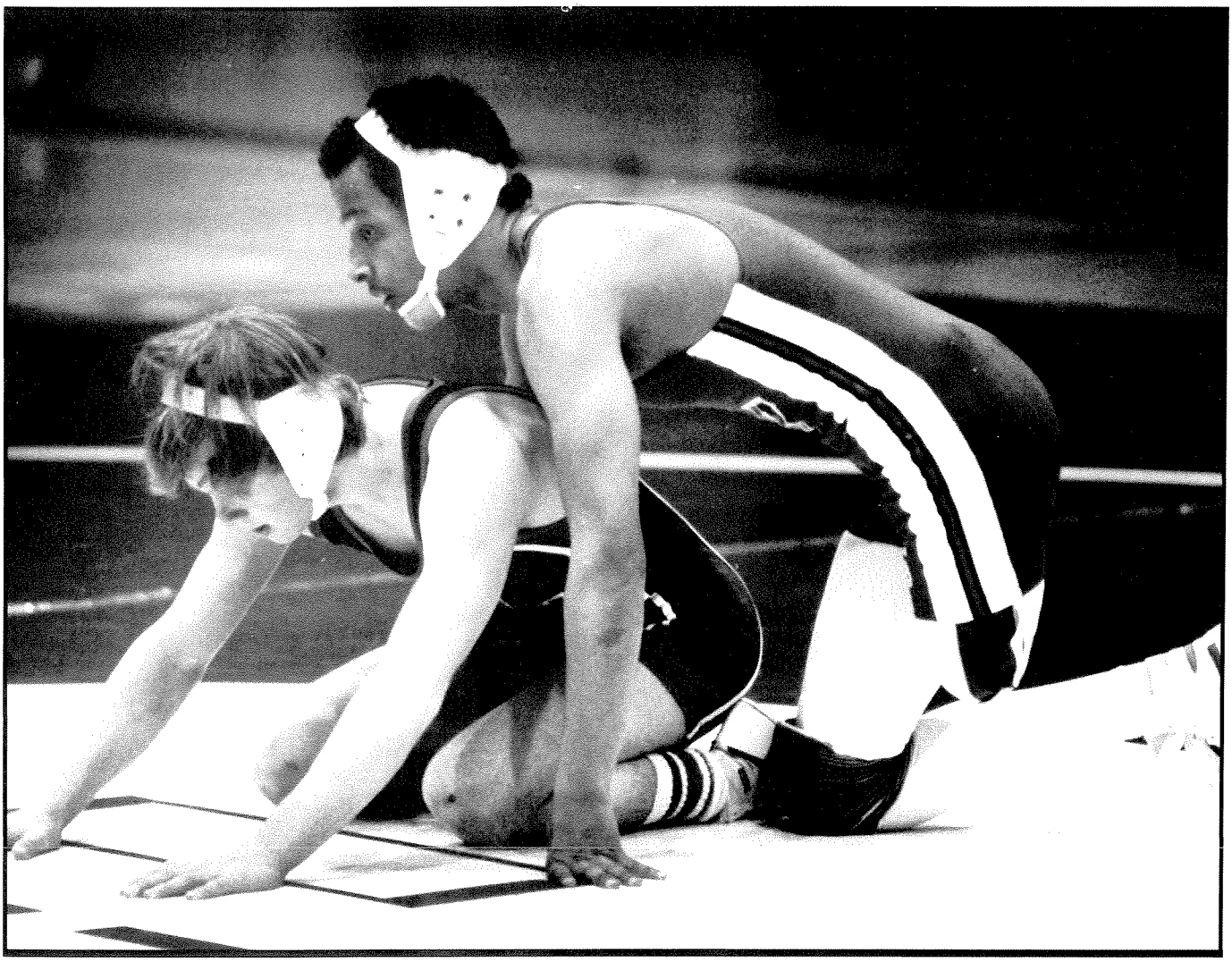


Fig. 28. Martial arts are recreational activities available to those with amputation. (Photo by Duane Hamamura, courtesy of the *Daily Record Chronicle*, Renton, WA)

Motorcycling

For motorcycling enthusiasts with physical disability, this activity is certainly possible, although the participant will require a motorcycle suited to his or her special needs **(Fig. 29)**. A range of equipment is available, including completely hand-propelled bikes such as the Honda Odyssey.

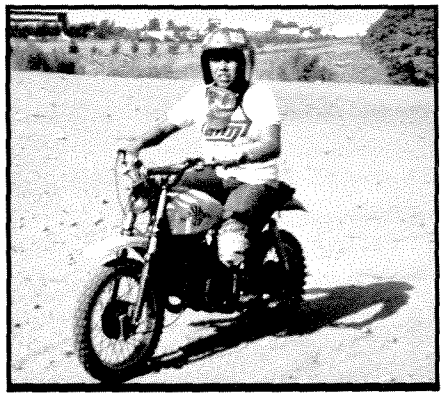


Fig. 29. A boy with bilateral below-knee amputation shown in his "trail-riding configuration." One prosthesis is worn to allow him to reach the ground. (Photo courtesy of Amputees in Motion)

Cyclists with disability include many individuals with bilateral above-knee amputation, although this group might want to use training wheels as a precaution against tipping over on the bike, especially when stopping. If the motorcyclist with above-knee amputation is a suction socket wearer, he or she would probably benefit from the use of auxiliary suspension (e.g., a Silesian bandage).

As an alternative to the commercially available training wheels, cyclists can make their own. The wheels should be spring-loaded with the capability to eject on command.

It is even possible to operate a motorcycle from a wheelchair by using a specially designed platform sidecar. For further information, see the section on wheelchair motocycling and the **Sports Organizations and Resources** listings.

Mountain Climbing

The challenging activity of mountain climbing can be, and is, successfully pursued by individuals with lower limb amputation and other impairments.

One assistive device, the Daw Sheath, is generally quite effective in reducing friction between the residual limb and the prosthesis, thus offering significant benefit to the mountain climber with amputation. The Daw Sheath is discussed and illustrated on page 19. A foot assembly which provides motion in all planes is also helpful, especially in climbing over typically rough mountain terrain. In addition, ski poles are useful for mastering climbing techniques. Stringent adherence to safety rules, such as avoiding solo climbing, is essential **(Figs. 30a and 30b)**.

Fig. 30a. A bilateral above-knee amputation mountain climber. (Photo courtesy of Everest & Jennings)

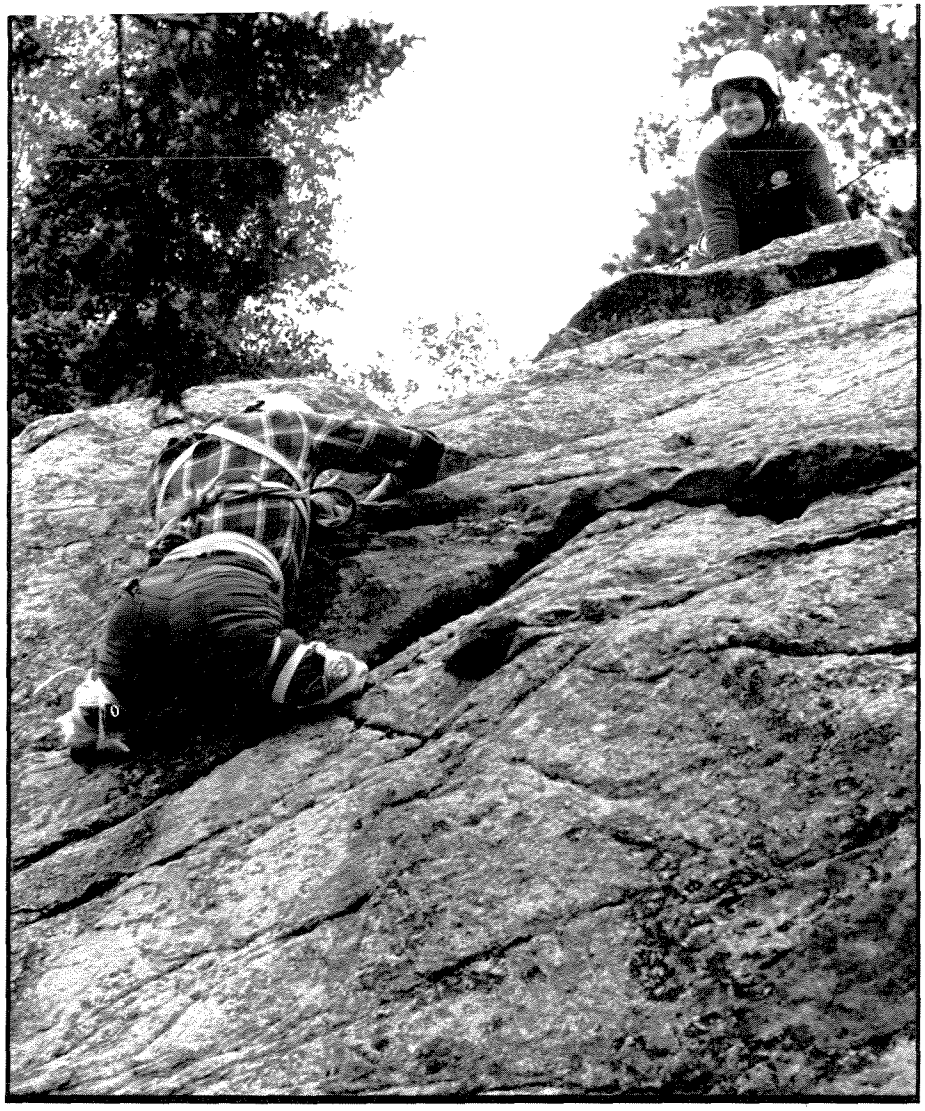


Fig. 30b. Note the use of the helmet in climbing. (Photo courtesy of Everest & Jennings)

Mountain Climbing

Various modifications to manufactured assistive equipment might be considered as well. For example, in order to facilitate Don Bennett's famous climb of Mt. Rainier, which is 4267.2 meters (14,000 feet) high, a pair of forearm crutches were modified **(Fig. 31)**. Other climbers interested in this modification can take two regular adjustable forearm crutches and pad the cuffs with ¼-inch Plastazote to help absorb the force transmitted through them. The handgrips are also cushioned, using somewhat thicker Plastazote, this time of ¾ inch width.

On long outings, the use of adjustable crutches are ideal, allowing the climber to shorten the uphill crutch and lengthen the downhill crutch. As a precaution against the crutches' sinking into the snow, a 12-inch basket might be attached near its lower end. Leather (waterproofed by dipping it into plastic) together with Dacron webbing provide the basket with a desirable 20 to 25 degree swivel motion. Also, a synthetic material simulating seal skin can be attached to the bottom of the basket to keep it from sliding in the snow. The ends of the crutches are adapted with removable ice points that extend approximately 12.7 centimeters (5 inches) below the basket. When not in use, the ice points can easily be removed, and conventional crutch tips can be attached in their place.

Fig. 31. Don Bennett on Mt. Rainier. (Photo courtesy of Don Bennett)

For more information on this crutch, contact:

- Lundbergs
  c/o Lloyd A. Stewart, C.P.
  1000 Broadway at Madison
  Seattle, WA 98122
  (206) 323-1106

The forearm crutch has since been modified by Drew Hittenberger, C.P., of the VA's Prosthetics Research Study in Seattle to facilitate Sarah Doherty's ascent of Mount Rainier. Doherty (a hemi-pelvectomy amputee) is the first woman with an amputation to climb Mount Rainier, a feat which she accomplished in August 1984. During training for this event, she found her crutches too heavy and cumbersome. Moreover, because of their flat surface, the 12-inch basket would quickly fill with snow and become increasingly heavy, causing fatigue. To correct this problem, Hittenberger redesigned the basket-like tips, creating a convex upper surface. Spikes were then added to the tips so that they would function as crampons (the spikes that climbers wear on their boots for traction on snow and ice). In addition, a modified "ice pick" was permanently attached to one of the fore-

arm crutches so that in case of a fall, the mountain climber could protect himself or herself **(Figs. 32, 33, and 34)**. Because of the need to use both crutches all the time, the amputee is unable to carry an ice pick as well. To protect the hands and prevent slipping on the handgrips, the handgrips are padded with neoprene (material used in wet suits).

For more information on Hittenberger's forearm crutch modification, contact:

- Drew A. Hittenberger, C.P.
  Chief, Research Prosthetics
  Prosthetics Research Study
  Eklind Hall, Room 409
  1102 Columbia
  Seattle, WA 98104
  (206) 622-7717

For additional information on mountain climbing, contact:

- S.O.A.R. (Shared Outdoor Adventure Recreation)
  c/o Linda Besant
  P.O. Box 14583
  Portland, OR 97214
  (503) 238-1613

- Rick Riley
  c/o Orthotics and Prosthetics Association
  500 Jackson Street
  Methuen, MA 01844
  (617) 683-5509

- Don Bennett
  7401 91st Avenue, S.E.
  Mercer Island, WA 98040
  (206) 232-8151

(See also the **Sports Organizations and Resources** section)

Fig. 32. Sarah Doherty compares blisters with fellow climbers after climbing Mt. Rainier. (Photo by Craig Fujii, courtesy of the *Seattle Times*)

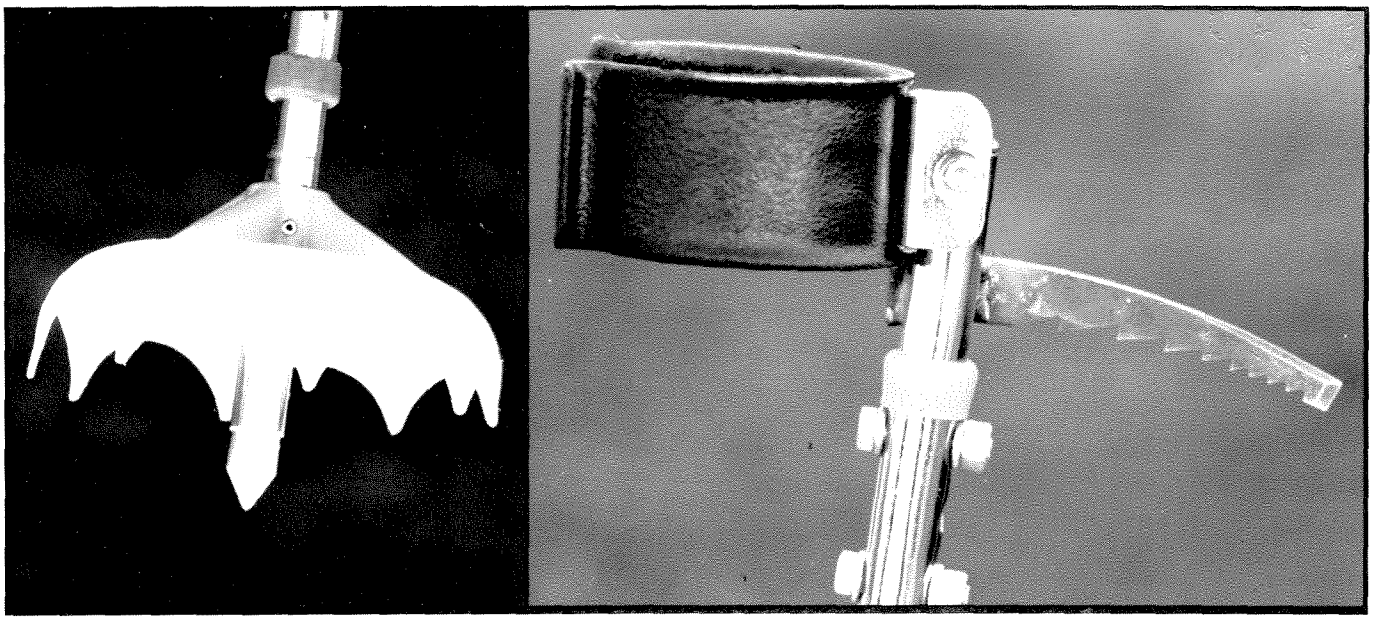


Fig. 33. Bottom of forearm crutch used for mountain climbing showing convex upper surface of the basket and spikes used as crampons. **Fig. 34.** Modified ice pick permanently attached to a forearm crutch. (Photos by Bernice Kegel)

Roller Skating

Skating with a prosthesis takes practice and good balance. Often the skater will demonstrate an uneven arm swing **(Fig. 35a)**. Skaters wearing prostheses also tend to prefer having the prosthetic leg closest to the inside of the rink.

A Hein-A-Ken Skate Aid, similar to that discussed in the section on ice skating, is also available for roller skating **(Fig. 35b)**. This device is made of a lightweight, tubular metal and is fully collapsible for ease of storage and transportation. Several models are available in sizes for children, teenagers, and adults.

Fig. 35a. Roller skater wearing a VA SEATTLE foot and additional waistbelt suspension. (Photo by Bernice Kegel)

Fig. 35b. Young skater demonstrates Hein-A-Ken assistive device. (Photo courtesy of Hein-A-Ken, Inc.)

For more information, see the discussion under the ice skating section and contact:

- Hein-A-Ken, Inc.
  102 Fosse Court
  Thief River Falls, MN 56701
  (218) 681-2147 or 7420
- Special Olympics, Inc.
  International and National Headquarters
  c/o Robert Montague, Exec. Director
  1701 K Street, N.W./Suite 203
  Washington, D.C. 20006
  (202) 331-1346

Running

While some individuals with amputation find running too difficult, and others have not even tried it, the VA's Prosthetics Research Study in Seattle and the Department of Kinesiology at the University of Washington have found that many people with disability can indeed run, and quite successfully. Some prefer a hop-skip-run technique where they begin with one step on the prosthetic leg, followed by two steps on the sound limb. Other runners use crutches, but no prosthesis. The technique is similar to running with a prosthesis—crutch, skip, skip; crutch, skip, skip... **(Fig. 36).**

Although the person with lower limb amputation is capable of running, he or she encounters certain challenges that people without disability do not face. For example, difficulties associated with a poorly fitted prosthesis are likely to be exacerbated during running and may lead to undesirable gait modifications such as knee hyperextension when stepping onto the prosthesis. In addition, excess perspiration of the residual limb during running necessitates changing residual limb socks frequently to safeguard against skin irritation.

A certain amount of movement of the residual limb in the socket is expected, but this problem can be minimized. For example, many individuals with below-knee amputation attach a fork strap and waistbelt to their prosthesis when running. The additional fork strap suspension is of greater importance when the amputee attempts faster running speeds, especially when the knee is bent. Many amputees also use a rubber latex sleeve for additional suspension because of its elasticity and suction effects. Some prosthetists also are considering a form of cream or denture adhesive that will stick to the walls of the prosthesis, holding the residual limb in place. The above-knee amputee may benefit from using a Silesian bandage for extra suspension.

The above-knee amputee may occasionally experience some rotation of the prosthesis around the residual limb during running so that, at heelstrike, the prosthetic foot is either turned in or everted too much. Because of the great motion between the residual limb and the socket in running, some above-knee amputees may find

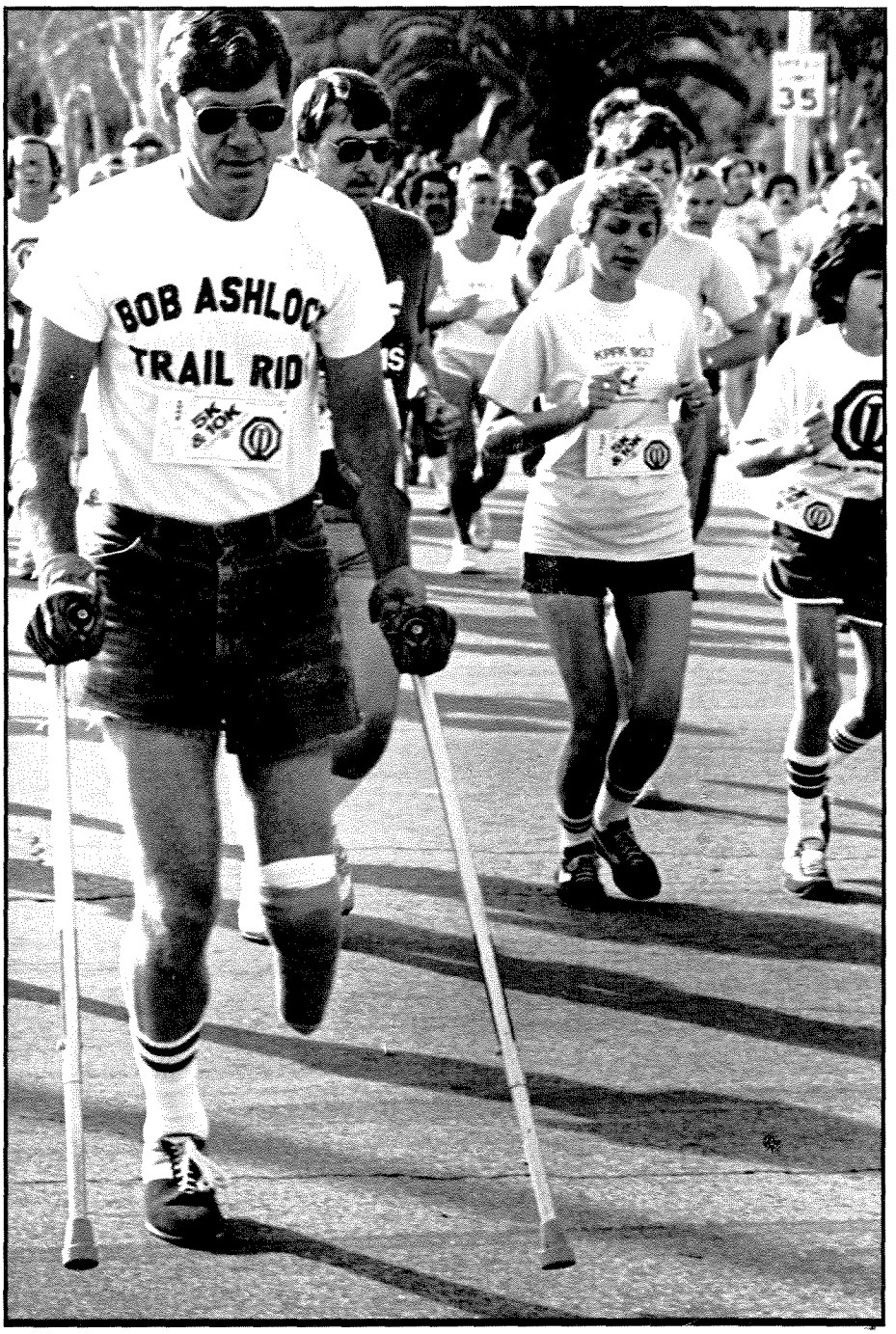


Fig. 36. Crutch runner wearing protective gloves and residual limb protector. (Photo by Roger W. Vargo, courtesy of the *Valley News*)

that the inner brim of the socket is too high to be comfortable when running. The medial wall of an above-knee prosthesis can be lowered considerably and/or the socket adducted. There is also a new socket that enables the prosthetic socket to be flexible. It is called the ISNY Socket (Icelandic-Swedish-New York University). The ISNY consists of a flexible, vacuum-formed, translucent socket for tissue support and an outside carbon-fiber-reinforced frame for weight transmission. The ISNY provides greater comfort than a conventional socket because of its capacity to change shape in response to muscular contraction of the residual limb **(Fig. 37a and 37b)**.

Fig. 37a. The ISNY (Icelandic-Swedish-New York University Socket. (Photo by Bernice Kegel)

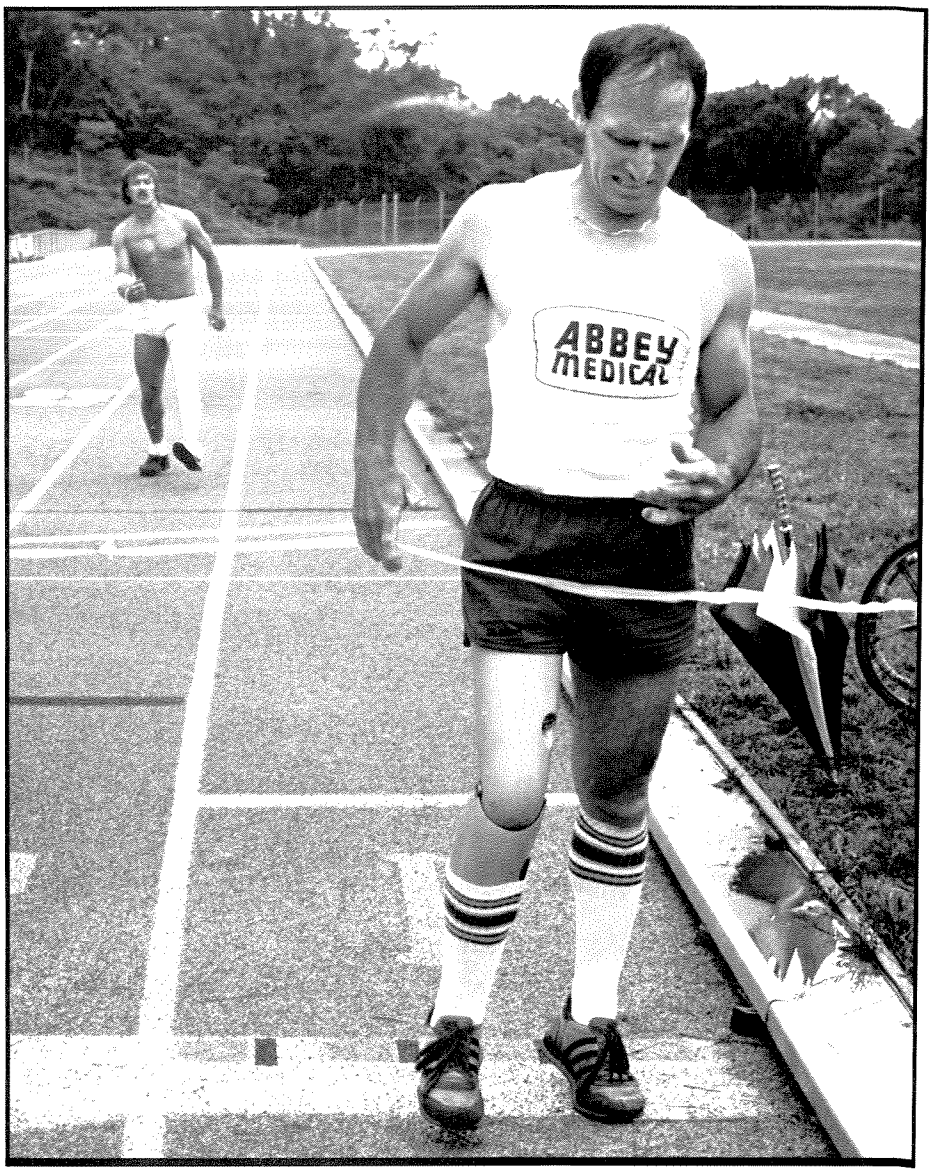


Fig. 37b. Runners with above-knee amputation. The proximal brim of the prosthesis often needs to be made flexible to facilitate comfort while running. (Photo courtesy of *Sports 'N Spokes*/Paralyzed Veterans of America)

Although a hydraulic knee may not be able to withstand the constant pounding to which it is subjected by one who runs 1.6 to 3.2 kilometers (one to two miles) a day, the Mauch S-N-S (Swing-N-Stance) offers the individual with amputation a high degree of control during vigorous activity. A knee with a friction control set for walking will not permit the foot to swing through quickly enough to be effective for a person running at moderate speed. In this situation, a change in setting would be necessary. The assistance of a prosthetist or physical therapist will be helpful in finding the optimal setting.

A study done at the University of Washington showed that many runners with unilateral lower limb amputation are capable of running short distances at speeds of 4 to 5 m/s and of maintaining paces of approximately 3 m/s for distances

of a half a mile or more. Thus many individuals who have lost lower limbs have the ability to participate successfully in running and other sports activities that require running.

The study also showed that when individuals with amputation ran while wearing their conventional prostheses, several undesirable characteristics were exhibited. First, an excessively straight knee (locked-knee) on the prosthetic side during heel contact reduced the shock absorption function of the residual limb and placed unnatural stress on the knee, hip, and vertebral column. Second, restricted range of motion of the intact limb and the knee and hip during swing phase was seen. Recovery of the limb with so little knee flexion could only be accomplished by additional contraction of the quadriceps muscles and could result in unnecessary fatigue.

A training program using a treadmill was part of the study. Emphasis was placed on correcting gait deviations by focusing on shortening the step onto the artificial foot and landing more on the midfoot, rather than the heel, making initial ground contact more underneath than in front of the body. These techniques facilitate more controlled flexion of the residual knee at the beginning of stance phase, promoting a more natural knee flexion-extension pattern, thereby reducing stress on the hip, knee, and spine. Videotaping or filming the participant, and allowing self-viewing by the participant, was also very helpful. The person with amputation could see that he or she ran in a similar manner to the general population of joggers.

Since the conventional prosthesis is intended for walking, the vertical ground reaction (or impact force) is rarely much greater than body weight. During running, however, this force reaches two to three times body weight. The net effect of the mismatch between design specifications and utilization is twofold—a shortening of the life of the prosthesis, and the development of a gait which is potentially damaging to lower limb joints.

To reduce these problems, the VA SEATTLE foot was designed **(Fig. 38)**. The runner with amputation lacks ankle control and the ability to push off with the foot, yet

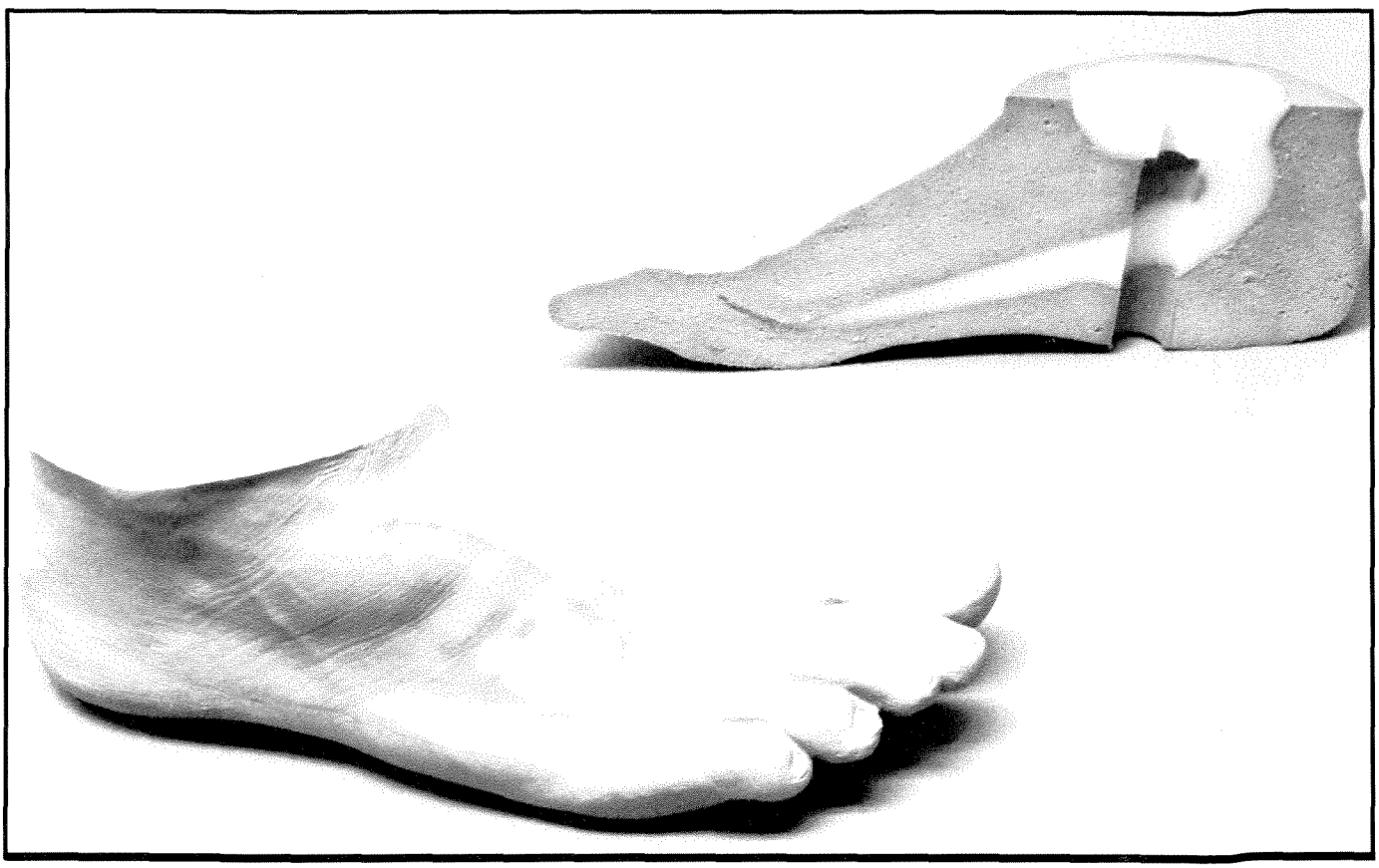


Fig. 38. A cross-section of the VA SEATTLE foot showing the keel energy generating component and the foot showing the excellent cosmesis. (Photo courtesy of Prosthetics Research Study)

this push off is a basic requirement for running. In an effort to simulate push off, the VA SEATTLE foot originally incorporated a series of leafsprings in the ball of the foot. When the jogger rolled onto the ball of the foot, the leafsprings compressed, storing kinetic energy for release in whatever direction one desired.

The most current design of the VA SEATTLE foot replaces the leafsprings with one integral beam, or keel, that runs to the ball of the foot. The foot is made out of thermoplastic material and has two components—the spring assembly and foam. This assembly operates in the same fashion as the leafspring foot (by storing and releasing energy), but it offers more simplicity in design.

At this time, the keel design and cosmesis have been standardized. Alignment of the prosthesis also is important. Preliminary studies show that the "running" prosthetic foot should be set in plantar flexion so the runner's weight can be centered over the ball of the foot during push off. Bench testing has included a thorough force/motion study of all parameters of performance together with breakage, fatigue, and endurance studies. In addition to these bench tests carried out at the Prosthetics Research Study and in contract facilities, the foot has been tested at the Army laboratories, Natick, Massachusetts. Gait research continues in VA facilities and in other established gait laboratories.

The outstanding acceptance of this component by users encourages its broad use in the large majority of adults with lower limb amputation. The above-knee amputee, Jeff Keith, who completed a cross-country run from Boston to Los Angeles in 1984, had a VA SEATTLE foot incorporated into his prosthesis.

The VA SEATTLE foot is ready for commercialization and general availability. Data gathered from the 550 individuals with amputation who have been wearing the foot for varying periods of time over the past 3 years are being compiled by the Evaluation Unit of the Rehabilitation Research and Development Service at the Veterans Administration Central Office in Washington, D.C. The Prosthetics Research Study will continue to improve and refine the concept that has resulted in the successful development of the VA SEATTLE foot.

For more information on the VA SEATTLE foot, contact:

- Drew A. Hittenberger, C.P.
  Chief, Research Prosthetics
  Prosthetics Research Study
  1102 Columbia
  Seattle, WA 98104
  (206) 622-7717

Another prosthesis, similar in concept to the VA SEATTLE foot but revolutionary in design, is the Flex-Foot **(Fig. 39)**. This prosthesis has a graphite core which is impervious to water, humidity, heat, cold, or corrosion. It has no bolts to rust or break, no wood keel, and no conventional foam heel to rot or break down. It also has infinite spring fatigue life, an inherent feature of the graphite composite structure. The Flex-Foot's graphite composite core, although it has a higher specific strength than steel, weighs just 40 percent as much as a comparable aluminum structure. At heelstrike, energy is stored in preparation for push-off. At midstance, the released high energy of the propelled drive combined with the inherent flexibility of the system overcomes the customary "break" or jerkiness. At toe-off, the flexed leg, with the stored energy from the forward momentum, can now release and spring-assist the leg to initiate mid-swing action.

The cosmetic cover is constructed of closed-cell, cross-linked, tear-resistant polyethylene foam. It is light, waterproof, and easily replaceable.

For more information on the Flex-Foot, contact:

- Flex-Foot, Inc.
  19600 Fairchild, Suite 150
  Irvine, CA 92715
  (714) 476-0650

Another prosthetic foot suitable for running is the S.A.F.E. (stationary attachment flexible endoskele-

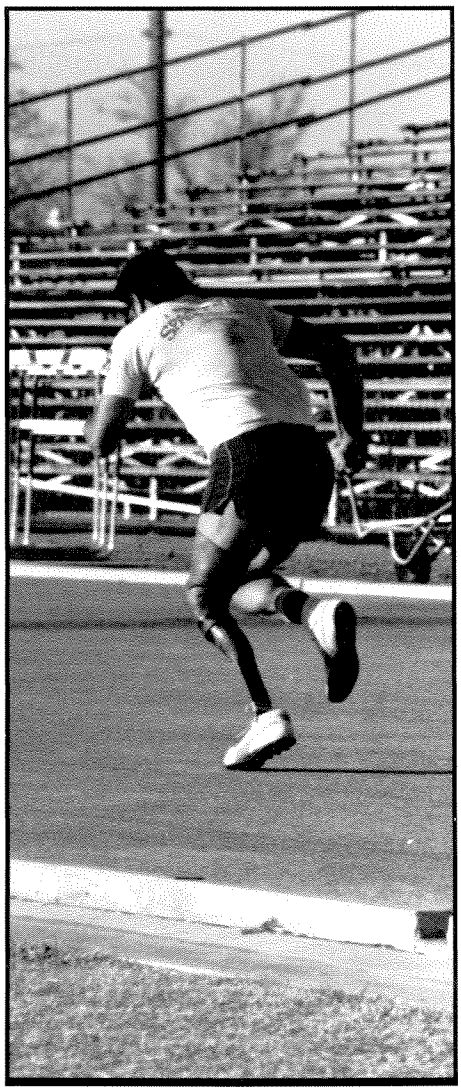


Fig. 39. Amputee runner using the Flex-Foot. (Photo courtesy of Van Phillips, Flex-Foot, Inc.)

Scuba Diving

ton) Foot developed by the Veterans Administration's Prosthetics Center (VAPC) and manufactured by Campbell-Childs, Phoenix, Oregon. Designed to simulate the shape and action of the human foot, this foot offers the runner smooth gait, minimal fatigue, and a relatively wide range of motion, including dorsiflexion-plantar flexion, eversion-inversion, pronation-supination, and transverse rotation. (See also page 20).

When selecting a prosthetic system, the avid runner will want to carefully consider design, alignment, suspension, and quality of materials used in fabrication. It is recommended that both the beginning and advanced runner consult regularly with a prosthetist and physical therapist interested in sports and fitness programs for those with lower limb amputation.

For additional information on running, contact:

- Adaptive Sports Program
  Kinesiotherapy Clinic
  University of Toledo
  c/o Dr. Leonard Greni
  2801 West Bancroft Street
  Toledo, OH 43606
  (419) 537-2755

- Amputee Sports Association
  c/o George C. Beckmann, Jr.
  11705 Mercy Blvd.
  Savannah, GA 31419
  (912) 927-5406

- Internat'l. Running Ctr.
  c/o Dick Traum
  9 East 89th Street
  New York, NY 10128
  (212) 398-0348

- Recreation and Athletic Rehabilitation-Education Ctr.
  University of Illinois
  c/o Brad Hedrick
  1207 South Oak Street
  Champaign, IL 61820
  (217) 333-4606

Scuba diving offers a unique experience to the water sports enthusiast with lower limb amputation and other impairments **(Fig. 40)**.

First of all, scuba diving is not a sport that requires very much adaptation for those with disability. The training is virtually the same for everyone, those with and without physical disability. Since the water is a foreign medium for all people, the differences between individual capabilities are minimized in scuba diving.

With an efficient arm stroke, the person with lower limb amputation might very likely consume less oxygen than the able-bodied diver as the use of arm muscles demands less oxygen than the use of leg muscles. Therefore, with proper instruction and equipment, together with a well developed arm stroke, the person with amputation can scuba dive well as long as the hands are free. Such individuals are encouraged to use webbed neoprene hand fins. These fins are called "power gloves" **(Fig. 41)**.

Power gloves are available from: B. G. Water Sports; 530 Sixth Street; Hermosa Beach, CA 90254; (213) 372-5063.

Scuba diving involves the purchase of often costly equipment, carrying heavy gear to the dive site, often feeling cold, wet, and salty, and carrying paraphernalia home and washing it and putting it away for the next adventure. For some people, these arduous efforts are too much. Thus, the dropout rate among scuba diving students without disability is as high as 80 percent. Many marine enthusiasts, however, find the preparation part of the fun.

Just as it takes a special able-bodied person to stay with scuba diving, rigors and all, it takes a special disabled person as well.

Fig. 40. A scuba diver with hip disarticulation amputation. (Photo courtesy of Prosthetics Research Study)

Scuba Diving

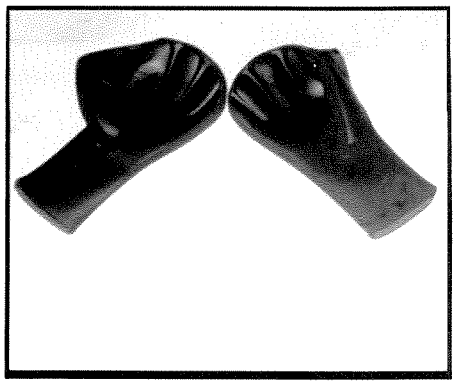


Fig. 41. Webbed gloves to facilitate upper limb power during scuba diving. (Photo courtesy of Bernice Kegel)

He or she must be comfortable in the water, know how to swim, and be dedicated to the sport. Every scuba diving student comes face to face with certain fears. Whether it is the fear of being without air while underwater or the fear of encountering sharks, the anxiety for some is part of the excitement that this activity offers. Another important requirement is the opportunity to dive. Once a disabled person is certified, diving opportunities can be hard to come by. Beach diving, although required for certification, is not practical on a day-to-day basis.

A major challenge for the disabled person is getting oneself and one's equipment to the water. In most cases, this requires assistance, although some individuals with amputation can manage alone by diving from a boat. When returning to the boat, the diver removes the gear in the water so that people on board the boat can pull it back. They then assist the diver into the boat. In either case, the basic wetsuit should be individually modified, which is a relatively uncomplicated task that most wetsuit repair facilities can handle.

Skin Care

Skin protection is a major concern to all divers, especially those with amputation. Skin breakdown can result from abrasions inflicted while transferring to a pool deck, while underwater, and from equipment pressing on various bony structures of the body. Skin self-examination in the shower following each diving session is recommended for all divers.

Underwater Locomotion

Methods of locomotion vary with the specific disability. For example, the individual with unilateral lower limb amputation generally finds that progressing from a dolphin kick into a modified flutter kick works well with the aid of specifically designed fins that will fit over a prosthesis.

The Veterans Administration's Prosthetics Center (VAPC) in New York has developed a water-resistant prosthesis with attachable fins. This device provides superb mobility for the individual with bilateral lower limb amputation who wants to scuba dive **(Figs. 42a and 42b)**. (For additional information, see Swimming section.)

The scuba diver's arm stroke, which begins with both arms extended forward, is a modified breaststroke similar to that used in swimming competition. The hands are pressed outward, downward, and toward the chest, while the elbows remain out to the sides. As the hands pass the chin, they are quickly pulled back in a deep, short, and quick movement. A protracted pull means a longer recovery, which is a negative effect. Once pulling efficiency is achieved, the diver with limb amputation can participate authoritatively with able-bodied companions.

Stability

A problem frequently encountered by divers with disability is that of limited ability to use the lower limbs to balance the body in a vertical position. One of the most valuable tools for overcoming this problem is the automatically inflated buoyancy compensator (BC), which allows the diver to control buoyancy by just touching a button. An inflatable bladder is connected to a low-pressure hose coming from a regulator. The diver ascends by pressing a button to fill the BC with air from the tank.

To slow the ascent rate, the hose is held overhead and the exhaust valve button is depressed to purge the air. Thus a diver can ascend, descend, or attain neutral buoyancy at any depth by merely pushing a button.

The buoyancy compensator comes in three configurations. The first is the old horsecollar type, which the diver wears on the front of the chest. Since this interferes with arm action it is not usually recommended for divers with limb disability who depend on their arm strength. The second configuration is the back inflation unit (BIU), which is a horseshoe-shaped bag attached to the tank's backpack. Although this type leaves the arms free for pulling, it does not provide frontal buoyancy, so it is not generally recommended either. The third type of BC is a buoyancy jacket, which is a combination of the other two. It attaches to the backpack, has armholes like a vest, and effectively distributes buoyancy. The BC jacket also allows the diver to maintain vertical posture without relying heavily upon the lower limbs for balance. In addition, the buoyancy jacket is easier than other BCs to put on and take off. Either in or out of the water, it provides excellent buoyancy control and can be easily inflated, automatically or orally.

Weight Distribution

Another concern to the diver with disability is weight distribution. Placing greater weight over

the amputation side of the body obviously allows for more efficient neutral position in the water. To achieve this ideal weight distribution, a belt made of neoprene (rather than of webbing) is suggested. The neoprene tends to stick to the wetsuit so that, once correct weight adjustment is achieved, the belt will not slip.

Modified Buddy Breathing

Running out of air is a problem seldom experienced by the careful scuba diver. It is a good idea to be prepared for this eventuality. Buddy breathing, or sharing air from a single tank, is frequently the solution to the problem. For the able-bodied person, buddy breathing is done face to face when ascending and side by side when swimming. For divers who are unable to propel themselves with their legs the side by side method is difficult because it requires that both hands be used to pass the regulator frequently from one diver to the other. In a buddy system modified for those with lower limb disability, the divers are positioned one on top of the other, in piggyback fashion. While the diver on the bottom provides the locomotion, the diver on top manages the breathing apparatus, or regulator. Even better is the octopus adaptor and other dual regulators which allow both the diver on top and bottom both some locomotion.

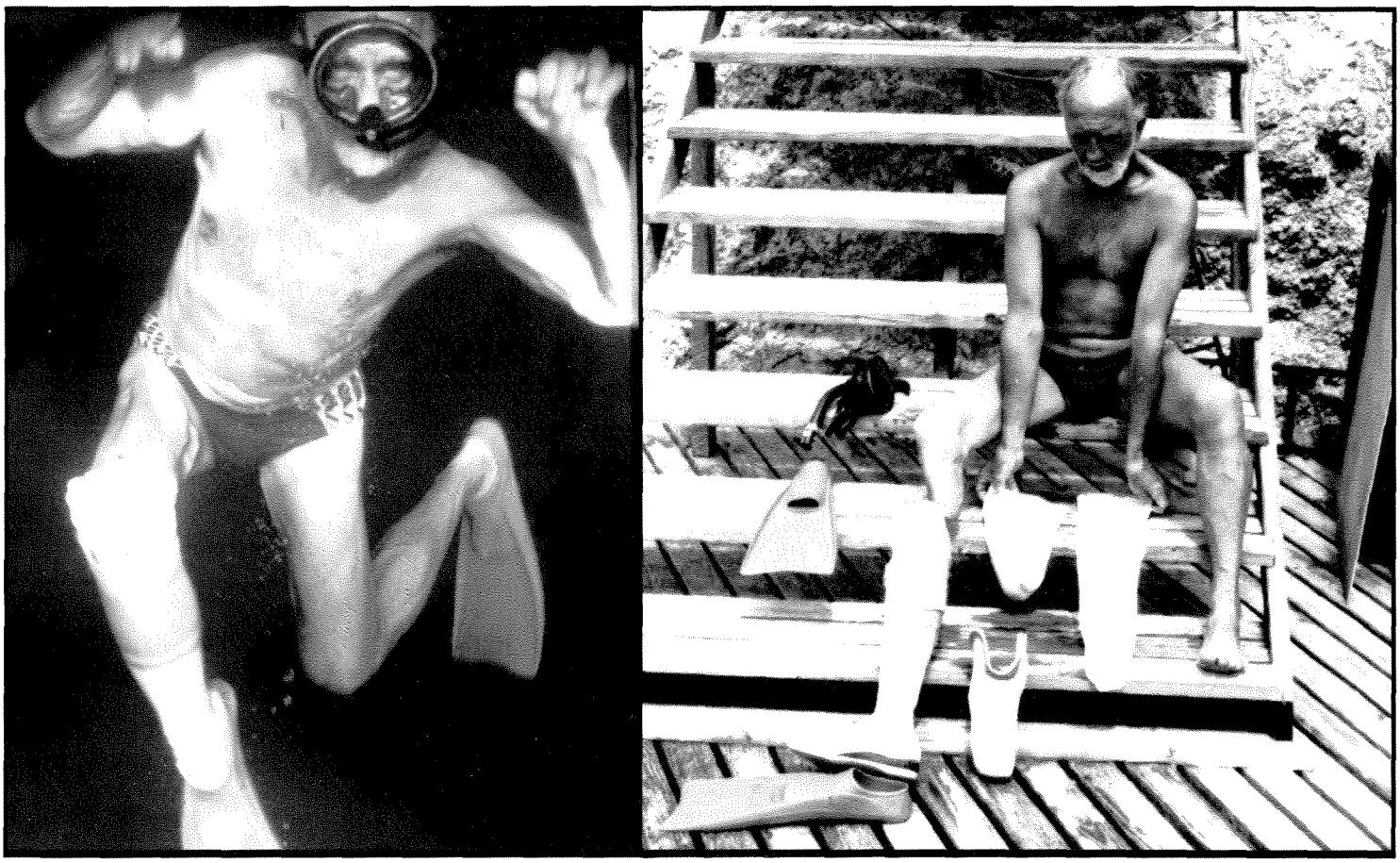
For additional information on scuba diving, contact:

- Handicapped Scuba Assoc.
  c/o Jim Gatacre
  1104 El Prado
  San Clemente, CA 92672
  (714) 439-6128

- Mission Bay Aquatic Center
  c/o Tod Bittner
  1001 Santa Clara Point
  San Diego, CA 92109
  (619) 488-1036

- Professional Assoc. of Diving Instructors
  c/o Jenny Garmendia
  1243 East Warner St.
  Santa Ana, CA 92706
  (714) 540-7234

(See also the **Sports Organizations and Resources** section)



Figs. 42a and 42b. Scuba diver using VA developed water-resistant swim leg and fins. (Photos courtesy of VA Prosthetic Center, New York, NY)

Skateboarding

Figs. 43a and 43b. A young boy with congenital lower limb amelia demonstrates his skill on a skateboard. (Photos courtesy of George Barksdale and Amputees in Motion)

Skateboarding is another recreational option available to the individual with lower limb amputation and other impairments.

For the young person with bilateral limb deficiencies, the skateboard provides a recreational outlet and can be an appealing alternative to a wheelchair for getting from one place to another **(Figs. 43a and 43b)**.

For additional information on skateboarding and other activities for children, contact:

- Adaptive Sports Program
  Kinesiotherapy Clinic
  University of Toledo
  2801 West Bancroft Street
  Toledo, OH 43606
  (419) 537-2755

- American Special Recreation Association
  c/o John Nesbitt, Ed.D.
  Recreation Education Program
  University of Iowa
  Iowa City, IA 52240
  (319) 353-2121

- U.S. Amputee Athletic Association
  c/o Richard Bryant
  Route 2, County Line Road
  Fairview, TN 37062
  (615) 670-5453

Skydiving

There are more people with amputation who are sky divers than one would expect. Most well known among them are eight people from four states who met for the first time on March 29, 1980 to attempt making the first all-amputee 8-way, free-fall formation. Calling themselves "Pieces of Eight," the group included two people with upper limb amputation and six people with lower limb amputation. The total number of jumps they had done among them was over 12,000. The team made eight attempts, achieving a maximum formation of seven people. In making formations it is difficult for persons with limb deficiency to compensate for their assymetry. Eight and a half months later, the group met again. The seventh attempt was successful. Jumping from 15,000 feet, they held the formation for 4.66 seconds.

Many sky divers with amputation prefer not to wear conventional prostheses during this activity, although they do use padding to protect the residual limb when landing. The disadvantage to not wearing a prosthesis is some loss of independence, since the person with amputation will probably need help in getting himself and his equipment back to the launching area. If so, a companion would have to be nearby with a pair of crutches.

One alternative is jumping with a detachable pylon **(Fig. 44)**. While jumping, it can be placed in a well-padded pocket in the jumper's skydiving suit. Then, upon landing, the pylon is reattached to the socket. In this way, the skydiver with amputation can get around the launching area without assistance from another person.

One must be 18 years of age (16 years with parental consent) to sky dive. There are two categories of jumping: static line and free fall.

For static line jumps, the person with amputation faces the same challenges as the able-bodied person. When falling freefall, however, symmetry becomes a special challenge for those with amputation. In order to fall through the air in a stable position while maintaining a specific direction, the body must be symmetrical when in the air. To prevent spinning, the sky diver with below-knee amputation needs to bend the knees toward the chest, thereby presenting a symmetrical shape against the resistance of the wind. Another alternative would be to keep the hips extended to neutral and bend both knees to a 90 degree angle.

The person with above-knee amputation should use an assistive device for the residual limb to match the length of the intact thigh. He or she could then dive by using the same techniques that the person with below-knee amputation uses. If a leg extension device is not used, the diver will need to compensate for asymmetry by abducting the arm on the opposite side of the amputation. When doing somersaults, the arms also will be needed to prevent spinning.

For additional information on skydiving, contact:

- United States Parachute Association
  c/o Mike Johnston
  1440 Duke Street
  Alexandria, VA 22314
  (703) 836-3495

(See also **Sports Organizations and Resources** section.)

Fig. 44. An amputee sky diver wearing a prosthetic socket with a removeable pylon. (Photo by Bernice Kegel)

Snowmobiling

Snowmobiling is an activity in which most individuals with amputation can participate. The sport is especially appealing since it offers access to remote areas that may not be otherwise accessible.

While few modifications are generally necessary for the person with amputation to adapt to snowmobiling, a buddy system is recommended. Also, most individuals with below-knee amputation prefer a snowmobile with a relatively elevated seat. If the seat is too low, the knees have to be bent more than 90 degrees, which can cause discomfort in the popliteal area **(Fig. 45)**.

The task of keeping one's prosthetic foot on the footrest can be difficult. (The ideal footrest provides good support, but does not limit leg movement.) Many people with amputation choose to custom make their own footrest against which they brace their prosthesis.

Many individuals with amputation have achieved notable success in snowmobiling. One such example is Bill Jirkoiwic of Neenah, Wisconsin. Against all odds, including severe paralysis, harsh weather conditions of 20 below zero, and an 11-year old snowmobile in disrepair, Jirkoiwic completed a 428-mile journey from Neenah to Eagle River, Wisconsin in time to catch part of the January 1984 World Championship Snowmobile Racing Derby. Although this unusual individual made the trip solo, the importance of snowmobiling with a companion need not be detailed.

Fig. 45. The snowmobiler with amputation needs to find a snowmobile with the correct seat height to allow for a comfortable angle of knee flexion, especially for long trips.

For additional information on snowmobiling, contact:

- New England Handicapped Sportsmen's Association
  c/o Earl Plummer, Pres.
  26 McFarlin Road
  Clemsford, MA 01824
  (617) 256-3240

- Seattle Handicapped Sports and Recreation Association (NHSRA Chapter)
  c/o Del Melchow
  17017 Tenth Avenue, N.E.
  Seattle, WA 98155
  (206) 362-2449

- Veterans Administration Medical Center
  Prosthetic Treatment Center
  c/o Ellis Hensley
  1660 South Columbian Way
  Seattle, WA 98108
  (206) 262-1010
  Extension 435

- Vinland National Center
  c/o Joan Saari
  3675 Ihduhapi Road
  Loretto, MN 55357
  (612) 479-3555

- Winter Park Sports and Learning Center
  c/o Hal O'Leary
  P.O. Box 36
  Winter Park, CO 80482
  (303) 726-5514, Extension 179

(See also the **Sports Organizations and Resources** section.)

Snow Skiing

Snow skiing for those with amputation made inroads in Austria and Germany in the late 1940s. Subsequently, the Swiss introduced crutch skiing. It was not until the 1960s, however, that avid interest was seen in the United States. By 1967, the National Amputation Ski Association was formed, and today skiing is taught to those with amputation in organized classes throughout the United States. In fact, the ski enthusiast with amputation can sometimes learn to ski intermediate and expert slopes in less time than his or her able-bodied friends.

While the individual with unilateral below-knee amputation can ski with or without a prosthesis, the person with bilateral below-knee amputation usually skis four track, using two prostheses, two skis, and outriggers. Those with above-knee amputation generally ski three-track **(Figs. 46a and 46b)**.

Below-Knee Skiing Prosthesis

To achieve skiing proficiency, it is important that the skier's center of gravity be located ahead of the ball of the foot for proper balance, ease in turning, and adjustment of speed. While individuals with two sound legs maintain balance by increased ankle dorsiflexion and a forward lean, which most ski boots are designed to encourage, the skier with amputation may require certain adaptation.

A conventional prosthesis can be adapted by placing a 2.54 centimeter (one inch) wedge under the heel of the ski boot to achieve the desired forward cant. The resultant increase in socket flexion, however, may raise the socket's posterior brim in relation to the patellar tendon bar, thus causing excessive and painful pressure on the hamstring tendons.

One way to relieve excess pressure on the hamstring tendons is

Fig. 46a. Unilateral knee disarticulation amputee sking three track. (From Kegel, B: Prostheses and Assistive Devices for Special Activities. In *Am. Academy of Orthopaedic Surgeons: Atlas of Limb Prosthetics*, St. Louis, The C.V. Mosby Co., 1981)

by moving the socket forward linearly without significantly increasing flexion. The prosthetist aligns the limb as he or she would align a conventional prosthesis. After doing so, the socket is moved forward in a linear manner so that the anterior brim falls approximately 2.54 centimeters (one inch) behind the toe of the prosthetic foot **(Fig 47a)**. Moving the socket forward, however, affects cosmesis, as can be seen by the anterior bulge. **(Fig 47b)**. Finally, the overall length of the prosthesis is reduced to equal the length of the intact lower limb when the ankle is dorsiflexed roughly 25 degrees. By moving the socket forward linearly, without increasing socket flexion, the skier can adjust his center of gravity more easily.

Fig. 46b. A unilateral hip disarticulation amputee skiing three track. (Photo courtesy of *National Magazine*)

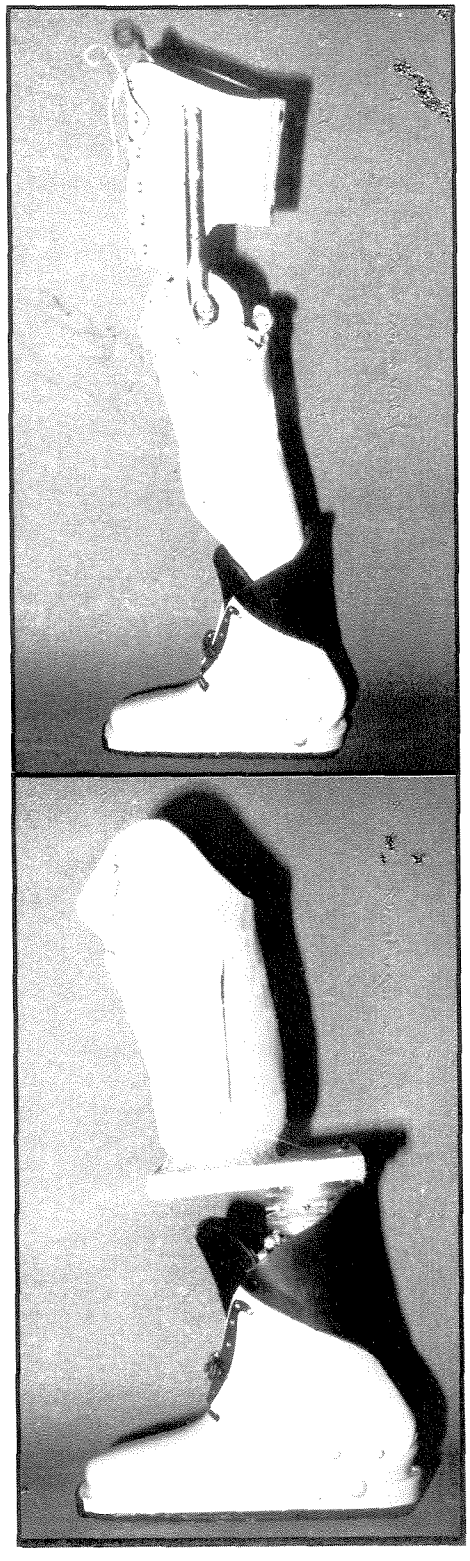


Fig. 47a. Below-knee skiing prosthesis with modified alignment. **Fig. 47b.** Prosthesis with anterior bulge. (From Kegel, B: Prostheses and Assistive Devices for Special Activities. In *Am. Academy of Orthopaedic Surgeons: Atlas of Limb Prosthetics*, St. Louis, The C.V. Mosby Co., 1981)

Snow Skiing

For the beginning skier with amputation, Kingsley Manufacturing Company's SACH (solid ankle/cushioned heel) Foot is often recommended. The SACH foot permits the selection of a sufficiently soft plantar flexion resistance, is available in a variety of sizes, and is compatible with virtually every lower limb prothesis.

For the advanced skier who desires greater flexibility, a four-way ankle joint could be used. This device provides the extra forward flexion that is required on steeper terrain.

Flexion and extension at the knee and hip are basic to skiing, yet these motions create a rather unusual residual limb-socket interaction. The prosthetic liner used should offer as much protection and cushioning as possible. One such cushioning device on today's commercial market is the silicone gel insert, which acts as a protective layer of fatty tissue and helps to evenly distribute pressure. If displacement of the silicone is of concern, another option for the amputee skier is nickelplast.

To reduce the reaction time between leg movement and movement of the prosthesis, little, or no, piston action is important. For this reason, the skiing prosthesis is often fabricated with a thigh lacer and waistbelt pick-up strap. These suspension mechanisms help prevent losing one's prosthesis while sitting on a chair lift. Some skiers choose to cut a hole in their ski pants, wear the waistbelt on the outside of their clothing, and thread the pick-up strap through the hole **(Fig. 48)**. On the ski itself, the addition of a so-called step-in binding is convenient, while a lightweight, rear-entry ski boot facilitates donning. A lightweight ski boot is usually recommended.

An above-knee prosthesis designed and aligned specifically for skiing is being developed in Switzerland. For more information, contact:

- Hr. P. Botha (Prosthetist)
  Neuhausstr. 23
  2500 Biel/Switzerland

- Prof. Dr. Rene F. Baumgartner
  Orthopadische Universitats-
  klinik Balgrist
  Forchstrasse 340
  CH-8008 Zurich
  Switzerland
  Tel: 01/532200

The skiing prosthesis is specialized, and for this reason, a conventional prosthesis is still needed for walking and après-ski activity.

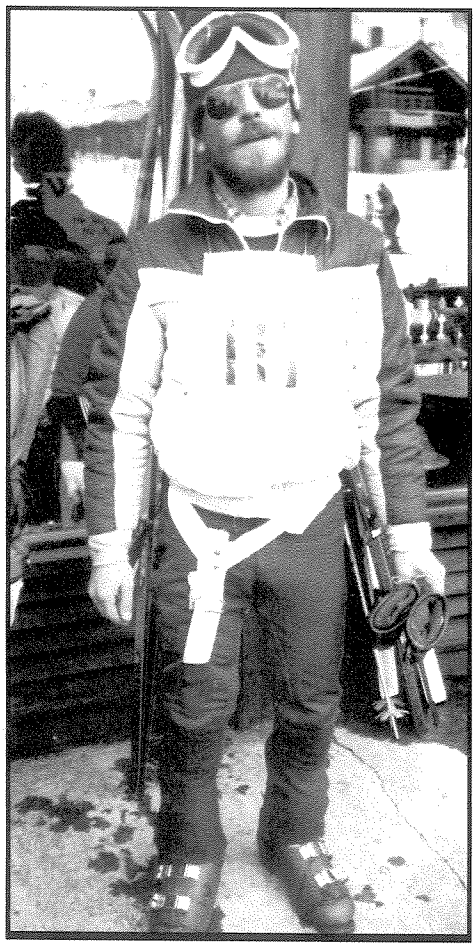


Fig. 48. A below-knee amputee skier showing modification of clothing to allow for adjustment of pick-up strap. (Photo by Bernice Kegel)

Lateral Canting for Those Who Ski Without a Prosthesis

Canting is the corrective process of placing a bevel or shim between the ski and binding, or between the foot and boot. Individuals with lower limb amputation sometimes require lateral canting to ski on a single ski.

To keep the body upright the skier with unilateral above-knee or below-knee amputation frequently displaces the hip slightly laterally to compensate for unsupported weight on the amputated side. For example, a skier with a right, above-knee amputation might turn the inside edge of the left foot slightly upward which tends to make turning to the left easy and turning to the right difficult because the left side of the ski (outside edge) is already slightly weighted into the snow. The right turn, however, requires the edge of the ski to incline to the right, and is therefore more difficult. The skier will have much further to go to angulate to the right side to compensate for initial offset.

One might shim or cant the inside edge of the ski, between skin and binding. This allows the skier to continue to shift weight to accommodate the missing limb, while the ski glides flat on the surface. The primary problem and one that requires considerable experimentation is that of deciding just how much to cant. Lateral cants are available at most ski shops.

Body Conditioning

It is important that one's sound leg be in optimal condition before a ski trip. Those individuals having recently undergone amputation would be wise to follow a good program of strengthening exercise under the supervision of an orthopedist or physical therapist.

A beginning skier, indeed any skier, can become fatigued rather quickly and should rest as often as necessary by sitting down in a place off the trail or slope to take the weight off his or her legs. A burning sensation in the leg is usually a symptom of muscle exhaustion.

Ski Boots

It is often difficult to buy a single ski boot and it is a poor substitute to buy a used, old style pair of boots inexpensively and discard one of them.

Most ski shops will special order a single boot from one of the major manufacturers. However, special orders usually take a long time to fill, so it should be done several months before the ski season begins.

Residual Limb Protection

Individuals with amputation who ski without a prosthesis are advised to pad the residual limb as protection against cold and injury. For those with below-knee amputation, several stump socks are usually adequate. One such sock, called the Easy Care Prosthetic Sock, can be machine washed and dried and is relatively shrink-resistant. For additional information about this sock, contact:

- Comfort Products, Inc.
  705 Linton Avenue
  Croydon, PA 19020
  (215) 781-0300

For those skiers with above-knee amputation, a modified socket can be fabricated. This protective device is made to match the knee length of the intact leg, thus making it much easier to rest by kneeling and then to get up from the ground **(Fig. 49a and 49b)**.

Some skiers with amputation like to attach a removable pylon to the socket so that they can walk around on the snow when not skiing **(Figs 50a and 50b)**. When skiing, the pylon is detached and stored in a padded backpack **(Fig 50c)**, or it can be left in the lodge. While riding the chair lift, exercising the residual limb helps to maintain proper circulation.

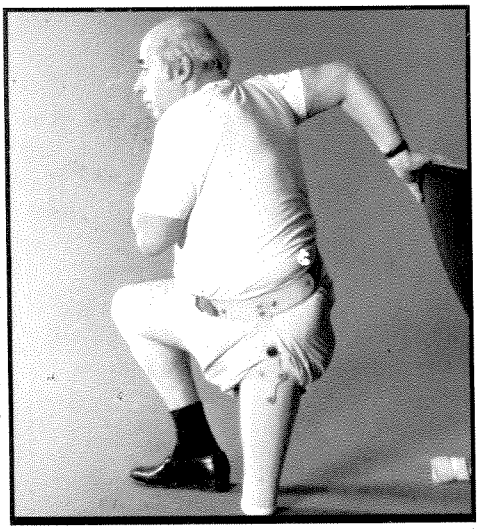


Fig. 49a. Socket segment of an above-knee prosthesis. (Photo courtesy of VA Prosthetic Center, New York, NY)

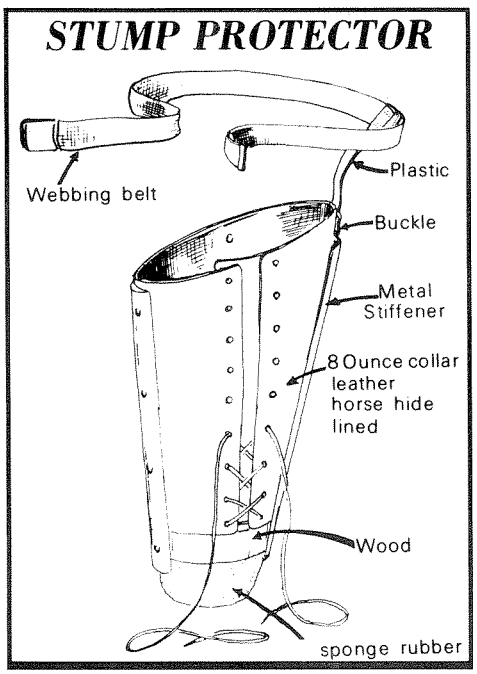


Fig. 49b. A residual limb protector that also allows one to rest between activities. (Photo courtesy of the Portland, OR Junior Chamber of Commerce)

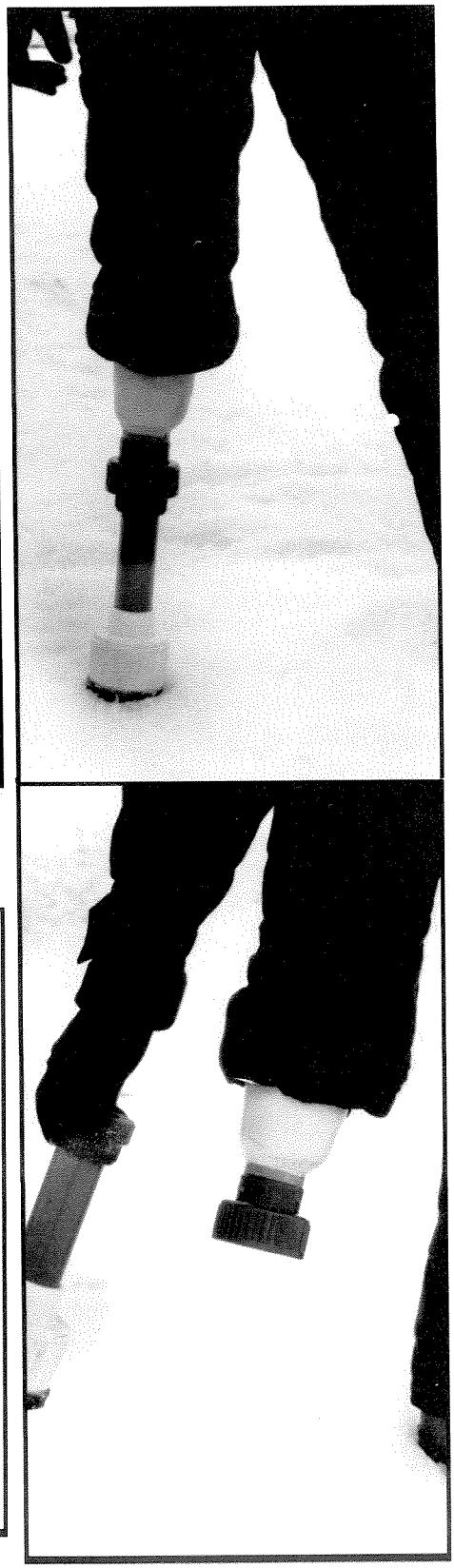


Fig. 50a. A detachable pylon. **Fig. 50b.** Pylon detached. (Photo by Bernice Kegel)

Snow Skiing

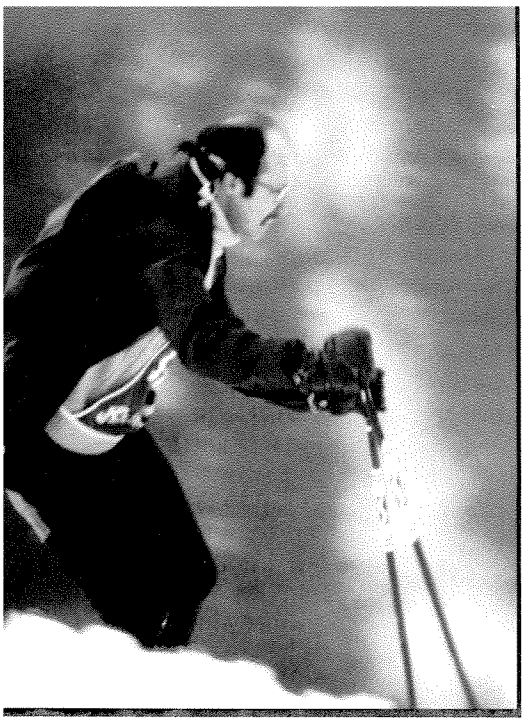


Fig. 50c. Skier with below-knee amputation skiing with pylon stored in a padded backpack. (Photo by Bernice Kegel)

Skis

Lange U.S.A. has a special program for skiers with disability. One service offered is the filling of orders for single boots, single skis, and bindings (at discount). Head, Nordica, Rossignol, and others also have attractive merchandising programs. Whichever manufacturer/designer is chosen, it is best to invest in quality equipment, particularly if one skis often.

For the three-track skier, a lightweight ski is undesirable as he or she necessarily carries all body weight on one ski. A "Three Tracker's Ski Tote" was developed to allow the skier with amputation to carry his or her ski over the shoulders while using outriggers **(Fig. 51)**. The ski tote has a thick felt pad to protect clothing from the ski's sharp edges, three velcro closure straps (adjustable to any binding length) to hold the ski in place, and a strong, one-piece carrying strap.

For more information on the "Three Tracker's Ski Tote," contact:

- NHSRA of Michigan
  c/o Betty Lessard
  4424 S. Pennsylvania Ave.
  Lansing, MI 48910
  (517) 394-5850

Fig. 51. Three Tracker's Ski Tote. (Photo courtesy of Lee Helms, NHSRA of Michigan)

Ski Bras

Ski bras are frequently used in four-track skiing and also for skiing with two skis and two poles. They hold the tips of two skis together for those who lack the leg power to do so. The bra consists of two metal devices that are affixed to the tip of each ski. One part functions as an eyelet, and the other part as a hook. The hook on one ski tip is latched to the eyelet on the other, thus connecting the skis **(Fig. 52a)**. Ski bras can also be handcrafted from bungie cord **(Fig. 52b)**.

Even though the skis are hooked together, the ski bra allows for flexibility of movement while maintaining a constant position of the skis, approximately three or four inches at the tip of the skis. The skier can do a snow plow, parallel ski, and train. If necessary, ski bras also can be attached to the tail end of the skis. For more information contact:

- Multi-Leisure Products Inc.
  11952 Vose
  N. Hollywood, CA 91605
  (818) 983-1717

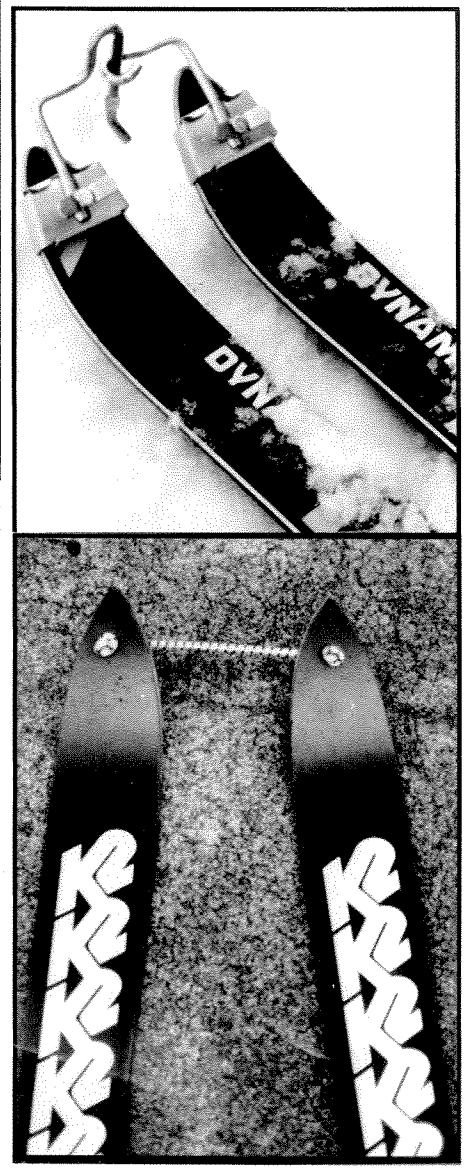


Fig. 52a. Ski bra attached to the anterior tip of the skiis. **Fig. 52b.** Ski bra made from bungie cord. (Photos by Bernice Kegel)

Outriggers

Outriggers are specially adapted ski poles (that are a cross between a crutch and a mini-ski), which enable a person to achieve better balance through a superior base of support than that possible with the use of standard poles **(Fig. 53a)**. The complete outrigger system consists of a short ski, a Lofstrand or similar forearm crutch, and a hinge device to connect them, allowing some 30 degrees of motion at the junction **(Fig. 53b)**. The hinge is deliberately designed to limit the forward and backward movement of the crutch, thus providing stability. The outriggers should be adjusted to a length that allow the ski tips to hang an inch or two above the snow surface when the skier is in an upright posture and holding the outrigger handles. The skier should be wearing a ski boot and ski when making this length test. A plunger-type component is also used to assist a three-track skier over flat terrain, or up a small slope. Obtaining a satisfactory plunger, however, can be difficult and costly.

One popular outrigger, the Flipski, functions as a balancing aid in skiing and as a skid-resistant walking crutch as well **(Figs. 54a and 54b)**. The skier with amputation merely squeezes a cord located at the handgrip, and the ski "flips up" to lock in a vertical position, producing a walking crutch. Metal claws attached to the tail end of the skis provide additional braking action.

Some amputees add a semicircular disc just behind the vertical

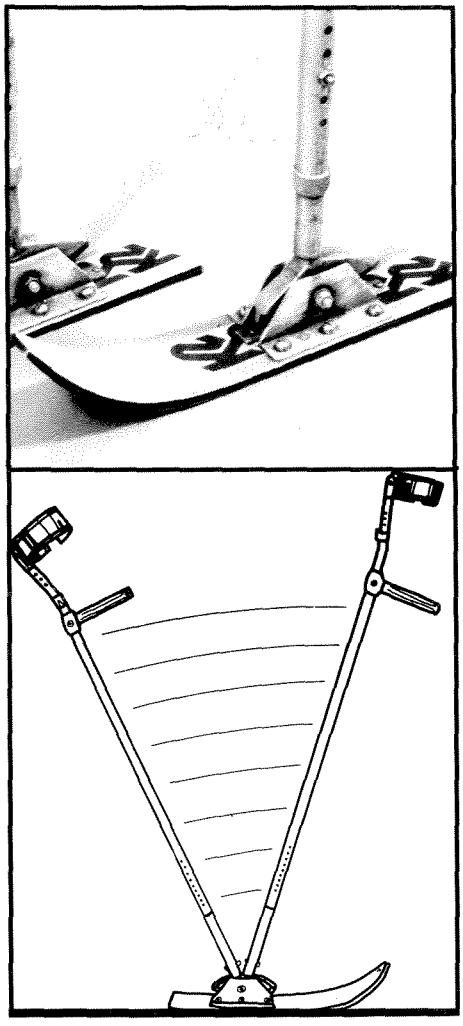


Fig. 53a. Outriggers. **Fig. 53b.** Outrigger crutches showing range of mobility. (Photos by Bernice Kegel)

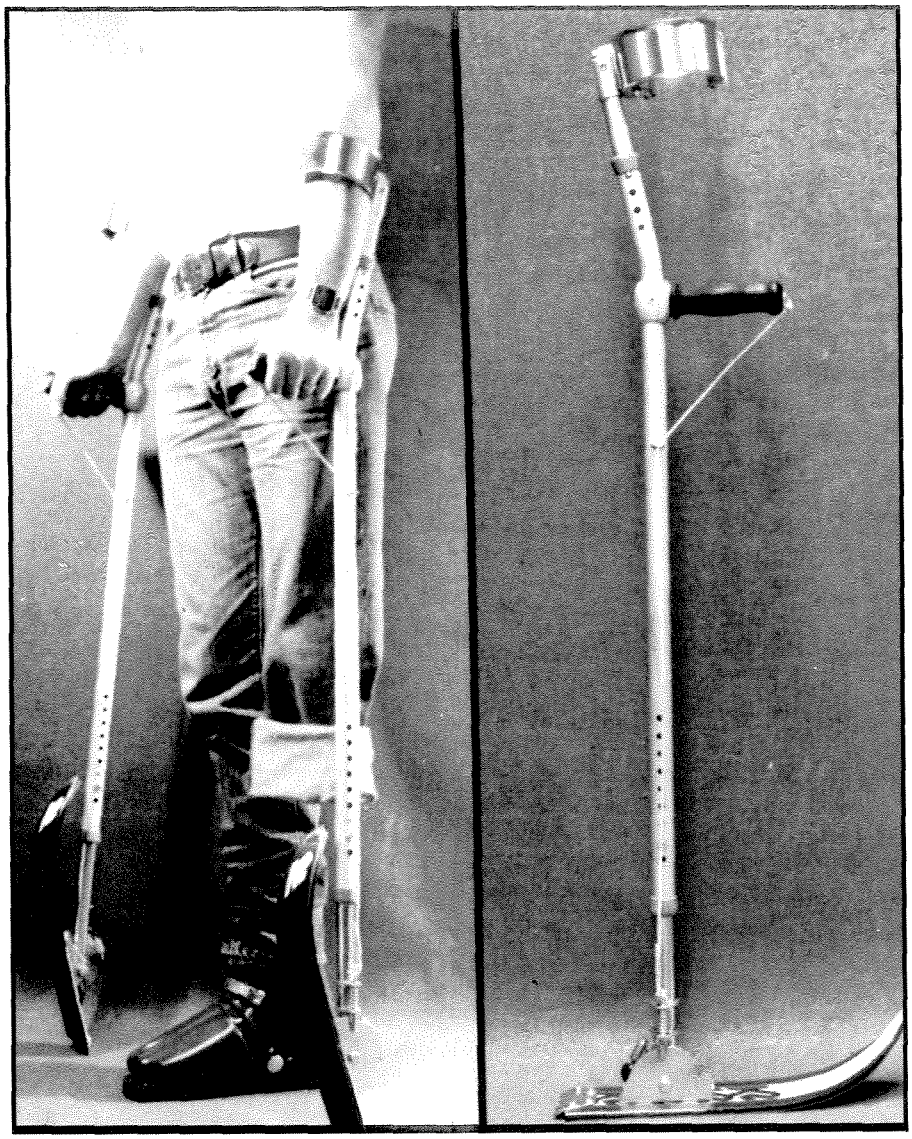
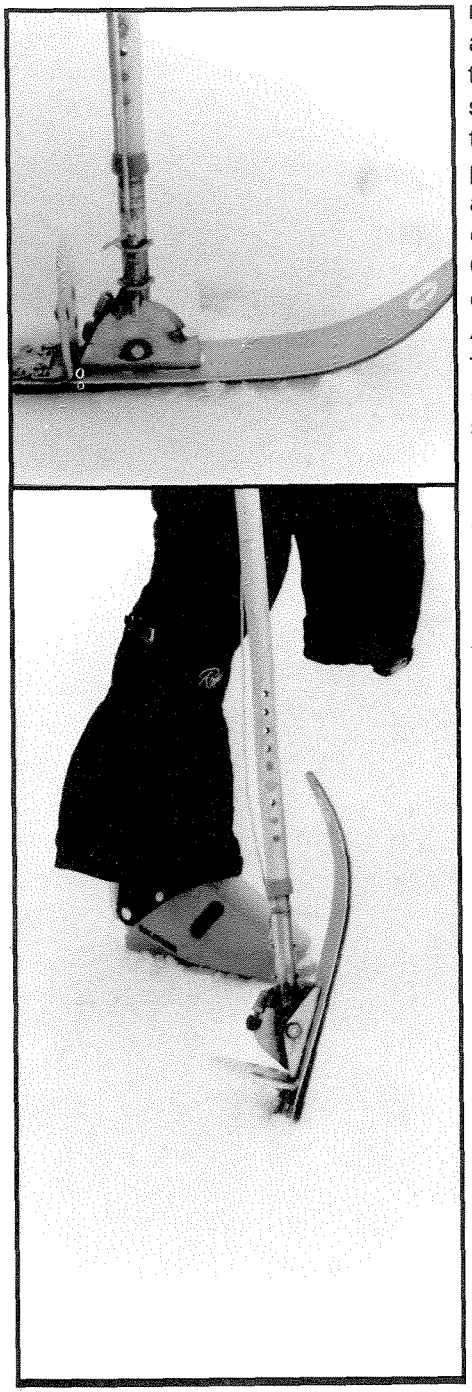


Fig. 54a. Flipski positioned for ambulation. **Fig. 54b.** Flipski adjusted for skiing. Note the adjustment cord at handgrip. (From Kegel, Bernice: Prostheses and Assistive Devices for Special Activities. In *American Academy of Orthopaedic Surgeons: Atlas of Limb Prosthetics*, St. Louis, The C.V. Mosby Co., 1981)

part of the crutch. When the Flipski is in the walking position, this disc prevents the outrigger from sinking into soft snow **(Figs. 55a and 55b)**.



Figs. 55a and 55b. Outrigger with semicircular disk attached to prevent the crutch from sinking into soft snow. (Photos by Bernice Kegel)

The Flipski makes it easier for one to remain mobile when not actually skiing. This feature combined with the fact that the skier generally finds that he or she has more energy when using a Flipski makes the device desirable to many beginning skiers, those with above-knee amputation, and those who occasionally need the stability of a crutch. Walking with the non flip-up outrigger is accomplished by pushing the ski tips against the snow, a maneuver that demands considerable practice. Qualified veterans may obtain ski outriggers through the Veterans Administration with a prescription from a physician, but delivery might take several weeks. Another source is Paul's Sports, Inc., Route 1, Box 615P, Excelsior, MN 55331, (612) 448-6987. Manufacturing one's own outriggers is also feasible, provided that access to a machine shop is available.

By using outriggers, the three-track skier puts considerable pressure on his hands. Consequently, blood circulation may be impaired. The hands can get quite cold, necessitating various techniques for restoring circulation. These techniques include swinging the arms vigorously, shaking the hands from the wrists, and beating the hands together. Mittens are suggested since they are generally warmer than gloves.

Skiing Instruction

Good equipment and competent instruction is essential to the skier with amputation. The following manuals are also suggested:

- *The Winter Park Amputee Ski Teaching System* by Hal O'Leary, 1974
  P.O. Box 76
  Hideaway Park, CO 80450

- *National Amputee Ski Technique* by Jim Winthers
  National Amputee Skiers Association
  3738 Walnut Avenue
  Carmichael, CA 95608

- *Amputee Ski Technique* by Hal Schroeder and Lee Perry, 1965
  Portland Junior Chamber of Commerce
  824 S.W. Fifth Avenue
  Portland, OR 97204

- *Alpine Manual* by Jerry Johnston and Susan Clift, 1978
  Canadian Association for Disabled Skiing, Box 307
  Kimberly, B.C. VIA249, Canada

There are many organizations available to help the disabled individual get started or restarted in skiing. Some of these are:

- United States Ski Assoc.
  Central Division
  Program for the Handicapped and NHSRA
  Norbert Fischer, Director
  518 Lake Forest Drive
  Bay Village, OH 44140
  (216) 871-4494 or
  (216) 221-4058

- 52 Association, Inc.
  c/o Ellen Weinberger
  441 Lexington Ave. Suite 502
  New York, NY 10017
  (212) 986-5281

- Association for Disabled Skiing
  Box 875, Station M
  Calgary, Alberta
  T2 P2J6, Canada

- Disabled Skiers Assoc. of B.C.
  1200 Hornby Street
  Vancouver, British Columbia
  V6Z 2E2, Canada
  (604) 687-3333

- National Handicapped Sports and Recreation Association
  c/o Jack Benedick
  Capitol Hill Station
  P.O. Box 18664
  Denver, CO 80218
  (303) 775-0427

- Track Three Ski
  Box 1260, Station Q
  Toronto, Ontario
  M4T 2P4, Canada

- Canadian Association for Disabled Skiing (C.A.D.S.)
  Box 307
  Kimberly, British Columbia
  V1A 279, Canada
  (604) 427-7712

- Ontario Handicapped Ski Association
  1220 Sheppard Avenue East
  Willowdale, Ontario
  72K 2X1, Canada
  (416) 495-4210

- Winter Park Handicapped Skier Program
  Winter Park Sports and Learning Center
  P.O. Box 36
  Winter Park, CO 80482
  (303) 726-5541, Ext. 179

Skiing for the Bilateral Above-Knee Amputee

Some people with bilateral above-knee amputation are able to ski on short prostheses and skis. Others choose to ski in a bucket type device. The bucket prosthesis for bilateral above-knee amputees was originally developed by Dr. G. Neff of Tubingen, West Germany. More information can be obtained by writing to Dr. Neff at: Orthop. Univ-Klinik, Calwerstr. 7, D-7400, Tubingen 1, West Germany.

An American counterpart is the "Super Ski for Short People" **(Fig. 56)**. "The super ski for short people" was developed by Richard Moore, George Barksdale, and Dino Matsamura to allow the amputee with bilateral hip disarticulation amputations to three track ski. The device incorporates a socket on a steerable skateboard platform, providing a way for the skier to transmit strength from the upper body through the outrigger ski to the snow. For further information about the "Super Ski for Short People," contact: Richard Moore, (213) 532-9283, or Dino Matsamura, (213) 323-0263; or write to them at 17011 Raymond Place, Gardenia, CA 90247.

Fig. 56. Skiers with congenital lower limb amelia and above-knee amputation in close competition. The "Super Ski for Short People" has an advantage in tight slalom turns due to lower center of gravity. (Photo courtesy of George Barksdale and Amputees in Motion)

A commercial facility in Germany is distributing a device called the Mono-Ski-Bob for use by amputees and paraplegics. The bucket (or shell) rides on a specially reinforced ski that is capable of withstanding great pressure. The shell is made of fiberglass and is aerodynamically designed. Two short outriggers are used for initiating turns **(Fig. 57)**. The Mono-Ski-Bob skier can go anywhere the tow-bar lifts go, and is also now chair lift compatible. The precision towing assembly is activated by the touch of a button and allows lift access without any outside help. The Mono-Ski-Bob can be obtained from:

- GFL Technik GmbH & Co. KG
  Salacherstr. 94
  7332 Eislingen, West Germany

- Mobility Systems
  861 Robinwood Court
  Traverse City, MI 49684
  (616) 941-4626
  Attn: John Phillippo, Pres.

Similar to the German Mono-Ski-Bob, the Arroya Mono-Ski is a chair lift-compatible skiing system for persons with disabilities. It was unveiled at the Fourteenth Annual National Handicapped Ski Championships at Breckenridge, Colorado in April, 1985 **(Figs. 58a and 58b)**.

Skiers with and without disabilities are encouraged to try the Arroya Mono-Ski. Geared towards users with good upper body control, this device affords those with disabilities the same exhilarating feeling and contact with the snow as that enjoyed by stand-up skiers.

Mounted on a single ski with a molded shell-type seat, the Mono-Ski's frame mechanism is constructed of aircraft tubing and cables, providing suspension for the ski. With the use of short outriggers the user can maneuver the ski to carve a turn.

The Arroya Mono-Ski's seat is molded to support the skier's upper torso. An optional sports seat (a molded cushion that evenly distributes pressure) is designed to fit the body of one with disability just as a boot fits the foot of a stand-up skier, allowing greater control and maneuverability.

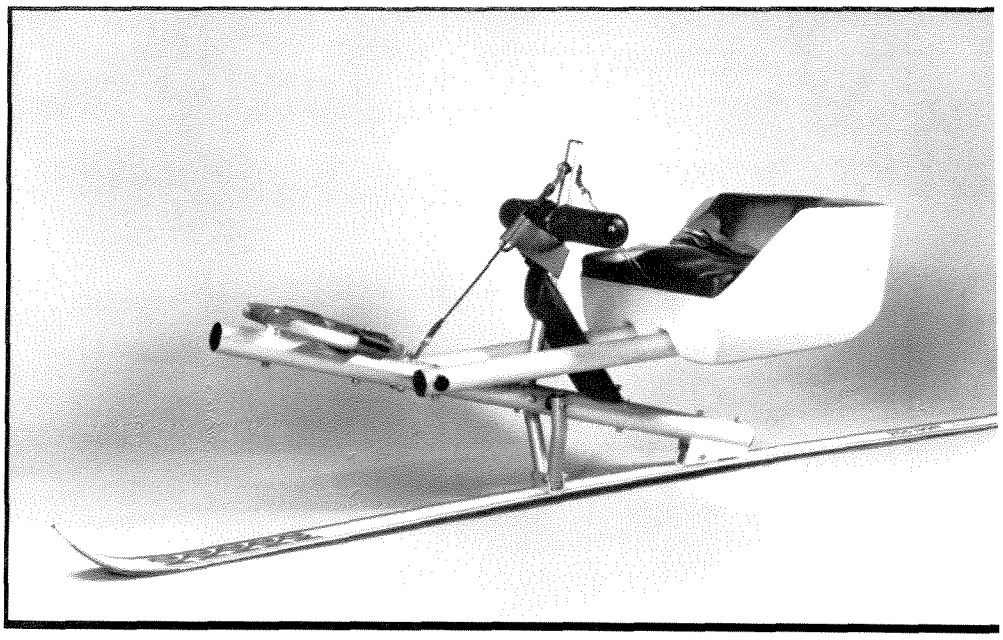
Outriggers are used for balancing the Mono-Ski when the skier leans side to side. They also aid in propelling on flat areas (such as lift lines), in loading onto the chair lift, and in getting up after a fall.

The mono-skier can "unweight" him/herself with an outrigger while being aided onto the chair lift by a ski partner. The frame mechanism pivots upward, allowing the seat portion to slide onto the chair lift without interrupting normal operation. The user can unload from the chair lift without assistance from others.

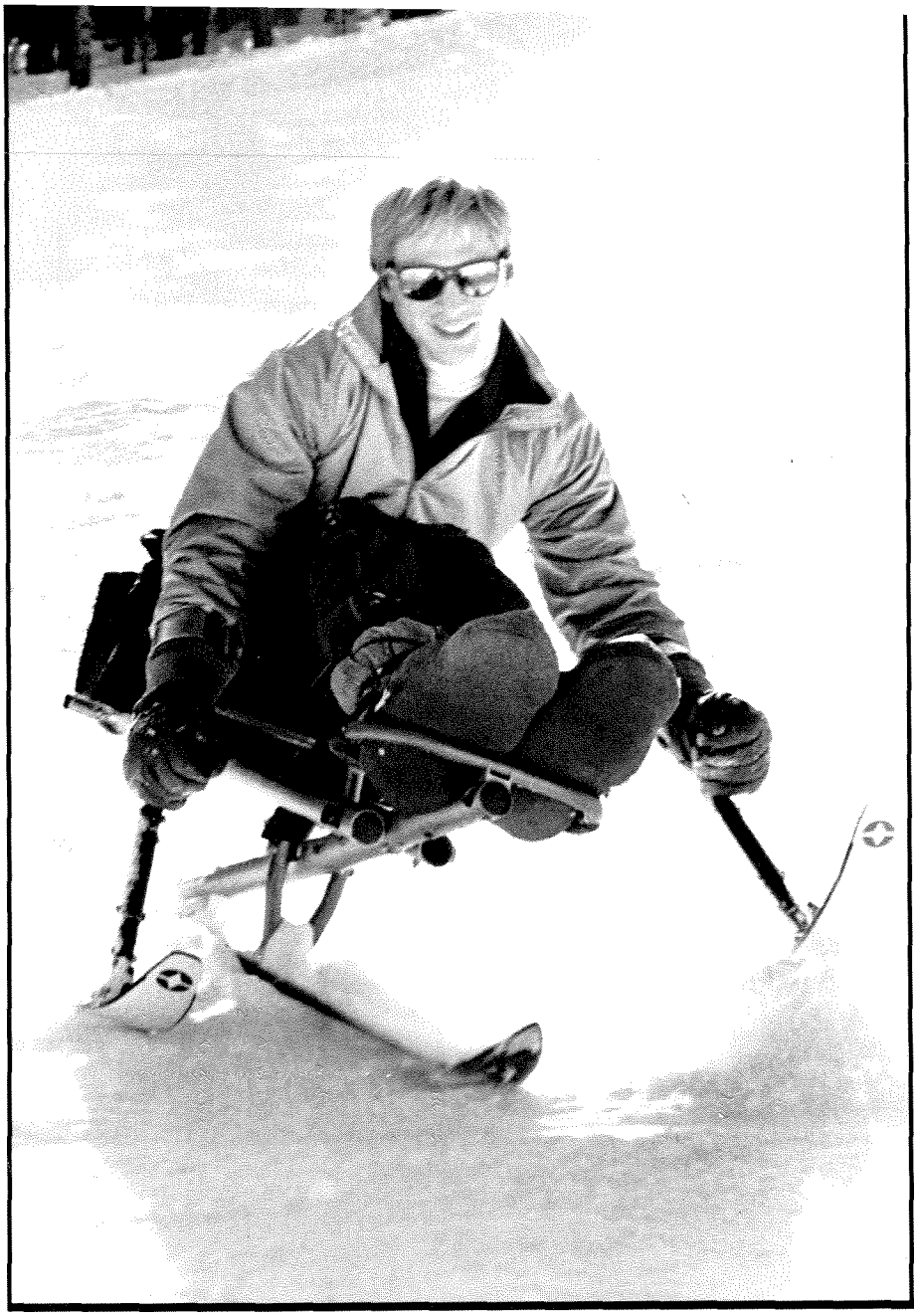
With the advent of snow surfing, it is apparent that able-bodied skiers are also searching for new ways to attack the slopes. The Arroya Mono-Ski offers a new challenge for this group, too.

Plans are under way by Intex (International Texas Industries), a San Antonio, Texas-based manufacturer and marketer of mobility

Fig. 57. The Mono-Ski-Bob. (Photo courtesy of G.F.L. Technik)



Figs. 58a and 58b. The Arroya Mono-Ski, developed by Peter Axelson, gives persons with disabilities feeling and contact with the snow as stand-up skies. (Photos courtesy of Beneficial Designs, Inc., Santa Cruz, CA)



equipment for people with disabilities, to organize a national open class mono-ski competition where people with and without disabilities can compete together.

For additional information on this mono-ski, contact:

- Beneficial Designs, Inc.
  5858 Empire Grade Road
  Santa Cruz, CA 95060
  (408) 429-8447

- Int'l. Texas Industries, Inc.
  14800 San Pedro
  Suite 204
  San Antonio, TX 78232
  (512) 494-5569

A third option would be to ski in a pulk or sit ski, which is a lightweight molded fiberglass sled, originally introduced in Norway. The amputee lowers himself or herself into the pulk (or sit ski), then adjusts a waterproof cover over the lower body. Poles are used and maneuvering the pulk is done by shifting the weight and pivoting around the ski poles. For practicing on land, an amputee can use special ski poles, and practice wheelchair "poling." Another way to practice on land would be to make a "roller sled" and poles, which is essentially a sled ski-skateboard combination. (See Fig. 64, page 56.) The body positions assumed are very similar to those in kayaking. To date, no sleds have been designed for use by young children, but custom fabrication should be encouraged. Transferring into a sit ski from a wheelchair can be difficult, so the skier should practice indoors on a dry surface until the movements are understood.

It is important when sit skiing to find a hill with a good slope. Without enough momentum it is more difficult to initiate turns with the sled. Another factor to consider are flat areas. The sledder must use the upper body to pull himself or herself through the snow with ski poles. The sledder must cross-country ski before reaching the next fall line. The sit skier usually skis with a partner or "tetherer." The tetherer does not control the ride unless the sit skier needs help **(Fig. 59)**.

Fig. 59. Sit skiing showing tetherer. (Photo by Bernice Kegel)

The sit skier, particularly when learning in a tethered situation, should avoid crowded ski runs because of the amount of space needed by the sit skier and tetherer. Sit skiers must learn to ski within the limitations of their equipment and abilities so their pace coincides with that of other skiers. The sit skier should be

aware that, due to his close proximity to the snow, visibility on the mountain is decreased. He or she should be sure to rest in places that are clearly visible to other skiers. The sit skier also realizes that he or she cannot see other skiers as well as standing skiers can.

For getting around in wheelchairs on the snow, trail bike tires for wheelchairs are suggested. To provide better friction, short segments of bicycle chain can also be wrapped around the wheelchair wheels. Ground grabbers (snow chains for wheelchairs) can be obtained from: K&R Specialties; 2809 Charles Court NW; Rochester, MN 55901; (507) 281-1351.

Poma or T-bar lifts are not easy for the sit skier to use. It is important not to tie a rope or hook a loop to a T-bar since it might be difficult to disengage. However, one end of the T-bar may be placed behind the frontmost cover strap of the sit ski, while the other end is held by the hands.

It is possible to load a sit ski on a chair lift, but this needs to be done with the aid of a lift attendant. When loading the sledder in his sled, the tetherer and one other skier approach the double chair lift. The lift is slowed down while the sledder is pushed to the loading area with a skier on either side of him. Neither lifter should be carrying ski poles, and the sit skier should have his poles inside the sit ski. Each lifter grabs one side of the sled and lifts it as the chair lift continues to move up from behind. The sledder is set down on the chair alongside the skier who is closest to the lift terminal **(Fig. 60)**. The skier closest to the lift line waits for the next chair. The sit skier should have the chair lift securing mechanism out and ready to use by laying it across his lap. As soon as the sled is on the chair lift, the securing mechanism is attached to the chair from the rear of the sled. The securing mechanism is designed for quick attachment and removal **(Fig. 61a)**. The fact that the weight of the sit skier rests far back in the chair assures a safe ride **(Fig. 61b)**. Each sit ski is equipped with an evacuation harness should the necessity arise for the sled to be lowered to the ground.

When the unloading area is approached, the lift is slowed, the securing mechanism released, and the sit ski pushed off when it is closest to the ground. To unload, the sit skier pushes himself from the chair upon reaching the ramp at the top of the chair lift. The assistant stays slightly behind the sit skier to prevent the chair lift from hitting the sit skier in the back of the neck. The assistant may need to help push the sit ski away from the chair. The instructor holds on to the tethering rope to make sure that the sledder reaches a safe area before beginning down the slope. With practice, many sit skiers can load and unload from chair lifts without stopping or slowing the lift.

The first thing to learn when sit skiing is how to turn. Three of the most common methods are spikes or brass knuckles, the kayak method, and the short swing. When using the spike method, short poles are used. The pole is planted with the arm outstretched to the side and slightly behind the skier. As the sled turns, the skier leans forward, then leans and plants the opposite pole to turn in the opposite direction.

The kayak method is similar to the short spike method, but a long pole, or two poles tied together are used. Both poles are held by both hands, similar to a kayaking paddle.

The swing uses two longer poles, and is more difficult. The amputee moves his hips by using

Fig. 60. Loading the sit skier onto the chair lift. (Photo courtesy of the Skiforall Foundation)

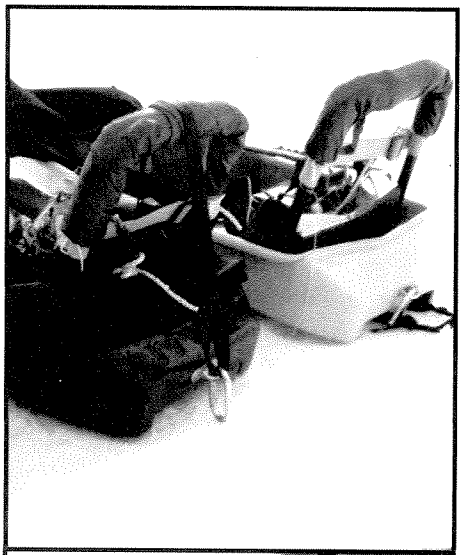


Fig. 61a. Rear view of sit ski sled showing attachement mechanism for securing the sled on the chair lift. (Photo by Bernice Kegel) **Fig. 61b.** The sled loaded on the chair lift. (Photo by Bernice Kegel)

the muscles of his lower torso. It is difficult to do smoothly, and this technique is usually used on steep hills with large moguls.

For all the techniques described, the skier needs to lean forward to prevent the ski from spinning and heading the skier down the hill backwards.

The quickest way to stop the sit ski is to roll it on its side. The tetherer can also stop the sit ski in several different ways. If going at a slow speed, merely snow-plowing would be effective. An alternative stop which can be executed is the swing hockey stop. The tetherer, who is following behind the sit ski, swings out to the side and down next to the sit skier. The sit skier will be turned sideways to the ski slope.

The sit skier should choose layered clothing for extra warmth. A t-shirt, long underwear, turtleneck sweater, water-resistant windbreaker, and down parka are recommended. For the sit skier without sensation in his legs and feet, it is a good idea to periodically check for signs of frostbite. Heavy socks, moon boots, or hiking boots provide warmth and comfort alike. Since sit skiers' hands are often in the snow, waterproof mittens are desirable. To protect the eyes against the sun glare while on the slopes, sit skiers should remember to wear sunglasses or goggles. Finally, downhill sit skiers are usually required to wear safety helmets.

People with a disability should be encouraged to participate in sit skiing as either a recreational activity, or competitive sport, or both. At present, sit skiing is essentially the only means by which a person who requires the use of a wheelchair can participate in downhill skiing. Varying degrees of adaptation are required.

Before tackling the slopes, learning as much as possible about the ski area(s) will undoubtedly result in more enjoyable and successful skiing. For this reason, it is suggested that the following information be obtained:

- a list of accessible lodging accommodations;
- a list of nearby restaurants;
- clothing requirements;
- a list of fees for sit ski rental, lift tickets, and lessons;
- rules for skiing untethered;
- affiliation with NHSRA (National Handicapped Sports and Recreation Association)
- recognition of NHSRA certification protocol for instructors and sit skiers;
- a schedule of days/hours when sit skiing is authorized;
- availability of runs and lifts for sit skiing.

There are now several different sit skis available. Anyone contemplating purchase of a sit ski should therefore shop around. The ideal sit ski provides adequate cushioning to prevent pressure sores. It has straps or other means of holding the skier in place. It is equipped with a cover to keep the skier dry and warm. It can be adjusted so that the height of the sit ski's back support accommodates the skier's disability. It is equipped with an evacuation harness for chair lift evacuation and a securing mechanism to attach the sit ski to the chair lift. With proper equipment, instruction, and motivation, the downhill sit skier can move freely through the snow in a way afforded by very few sports.

The Arroya downhill skiing system was designed by Peter Axelson/Beneficial Designs Inc., Santa Cruz, CA through support of the Veterans Administration **(Fig. 62)**.

Fig. 62. Peter Axelson on his Arroya sit ski, practices a start. Competitive events for sit skiers add to the excitement of this sport. (Photo courtesy of Beneficial Designs, Santa Cruz, CA)

The Arroya gives the sit skier excellent command of direction and speed alike thanks to four stainless steel runners at the bottom of its very lightweight, yet highly durable, shell design. The sit skier can comfortably lower his or her body into the device and onto its cushioned seat complete with an aluminum backrest and adjustable support strap. Seat and leg straps are fabricated of tubular webbing and serve as safeguards against cutting off circulation at the waist or knees. The Arroya's unique seating system also includes a knee cushion together with a high-density, contoured seat cushion which is constructed to absorb trauma to the body when traveling over problematical terrain. Beneficial Designs also makes a unique Lycra snow skirt sit ski cover. The recently launched cover does not have to be removed on entering and exiting the Arroya thanks to a heavy duty composite zipper. After a day on the slopes, the cover can easily be unsnapped to machine wash.

The Arroya is compatible with standard chair lifts and comes fully equipped with a safety line. Stainless steel gear at the stern provides a safe point for the attachment of a tether line. At the front of the sit ski is a special handle to facilitate towing.

The Smithsled is a cross-country and beginning/intermediate downhill sled. It has metal runners that allow it to track and be controlled down a hill. The sled is 52 and one-half inches long and 17 and one-half inches wide. It comes with a full waterproof riveted cover with locking zipper, ski poles, three cover straps, a 2-inch nylon quick-release seat belt, attached seat, a full closed foam cell insulation pad, six heavy nylon lift handles, two metal bottom runners, and front and back snow bibs. The Smithsled is available from Mountainsmith, Inc., 1100-B Simms Street, Golden, CO 80401, (303) 238-5823. A third sled is available from: Mountain Man; 720 Front St.; Bozeman, MT 59715; (406) 587-0310.

There are several places to contact for information about and instruction in sled skiing, including:

- Breckenridge Outdoor Education Center
  c/o Mike Mobley, Exec. Dir.
  P.O. Box 697
  Breckenridge, CO 80424
  (303) 453-6422
- Horizons
  c/o Christine K. Collins
  P.O. Box 2143
  Steamboat Springs, CO 80477
  (303) 879-4466
- NHSRA, Lake Tahoe Chapter
  c/o Larry Young
  Box 1636
  Truckee, CA 95734
  (916) 587-3911
- Skiforall Ski School
  c/o Joan C. Steck
  4160 86th St. SE
  Mercer Island, WA 98040
  (206) 232-3544
- Snowmass Ski School
  c/o Edwin Lucks
  P.O. Box 5429
  Snowmass Village, CO 81615
  (303) 923-4873
- Winter Park Sports and Learning Center
  c/o Hal O'Leary
  Box 36
  Winter Park, CO 80482
  (303) 726-5514, ext. 179

A publication on this topic is:

- "Pulk Skiing, Sled Skiing, and Ice Sledding for Persons with Mobility Impairments," by Larry Orr.
  Available from:
  Vinland National Center,
  3675 Ihduhapi Road,
  Loretto, MN 55357.

There are now certification exams for sit skiers. Once he or she has passed the National Handicapped Sports and Recreation Association (NHSRA) exam demonstrating ability to ski untethered, he or she may ski untethered with lifters at ski areas that recognize NHSRA certification.

In the U.S.A., there are now competitive events in existence for sit skiers. There is also a certification process that sit skiers must undergo if they want to ski without a training tether. The International Sports Organization for the Disabled (ISOD) does not as yet include sit skiing. At least four countries have to have competitors in an event before it can be included in the World Games. This situation does not yet exist.

Cross-Country Skiing

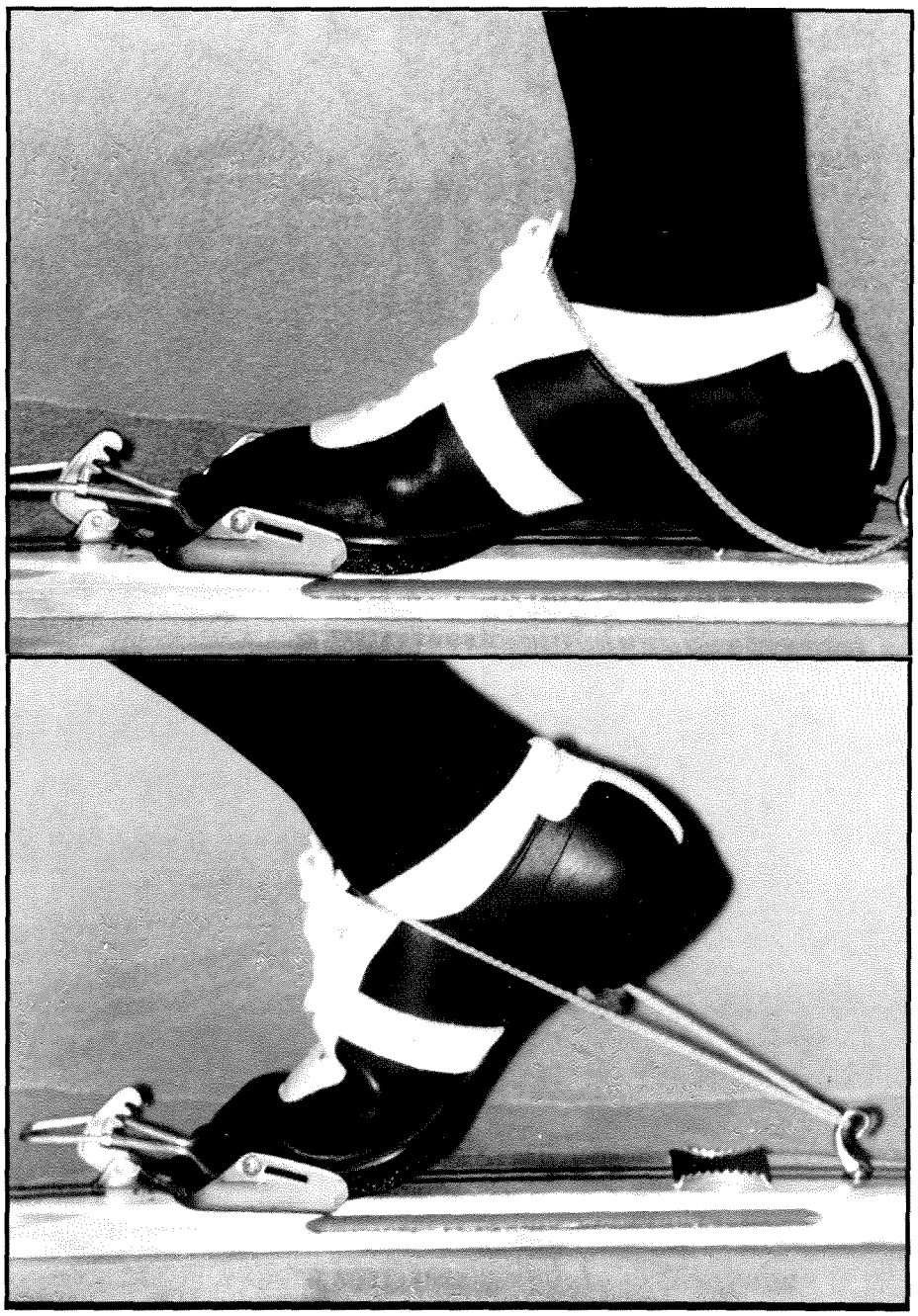
The repetitive alternating motion of cross-country skiing requires individuals with amputation to ski with a prosthesis on the slopes. Unlike Alpine skiing, where gravity helps propel the skier, cross-country skiers must use each leg to initiate the kick and glide. For the skier with below-knee amputation, a prosthesis with a thigh lacer is helpful in providing more control while turning. Most skiers find that using a prosthesis 2 to 3 centimeters shorter than standard will increase turning power. If the prosthesis is too long, he or she cannot extend the leg backward adequately.

The skier with above-knee amputation may require someone to tow him or her up certain slopes. Selection of terrain is important; touring routes that demand the least amount of climbing are desirable. The only special equipment required is tow rope of roughly 6 meters (20 feet) in length. The rope is slung over the shoulder of one of the skiers until

needed, at which time it is attached to each skier's waist. As discussed earlier, many skiers with amputation also use outriggers for assistance.

A major obstacle facing the cross-country skier with amputation is friction at the limb-socket interface. To minimize this friction, an assistive material called Spenco 2nd Skin, which has the feel and consistency of human skin, can be placed between the residual limb and the prosthesis. Dry residual limb socks are important, too, so it is a good idea to carry extra pairs. The Easy Care Prosthetic Sock (Comfort Products, Inc., Croydon, PA) is one that is often recommended.

Another challenge facing the skier with amputation is difficulty in maintaining control of the ski when it is extended to the rear. This so-called backsliding prevents the skier from keeping on top of his or her skis, resulting in loss of kick and forward leg drive. To avoid backsliding, a piece of elastic nylon can be looped over the top of the foot and attached to the ski at approximately 3.8 centimeters (1½ inches) behind the heel plate **(Figs. 63a and 63b)**. This nylon strap effectively limits the prosthesis from being lifted more than a few inches off the heel plate, thus preventing backsliding. While the strap also limits stride length, the skier with lower limb amputation can compensate for this by developing a strong upper body, enabling him or her to obtain a longer stride.



Figs. 63a and 63b. Modification to cross-country skis to help prevent them from slipping backwards. (Photos by Bernice Kegel)

Cross-country skiing in a sit ski is an enjoyable but vigorous activity. Uphill slopes can be difficult to traverse and may require a great deal of upper body strength to accomplish. An assistant skier wearing a harness and tow rope may be required to help the sit skier get up a hill. Another way would be to use a dog. The Vinland National Center has devised a "roller sled" for the sled skier to train on during the off season **(Fig. 64**, on the following page**)**.

Sled skis customized for cross-country skiing are available from Mountain Man **(Fig. 65**, on the following page**)**. For more information about this sled ski, contact the Mountain Man company.

The ideal surface for skiing is relatively flat with hard-packed snow, and the trail should be five to eight feet wide. For steep, uphill trails, it is helpful to install a rope along the side of the trail so that

Snow Skiing

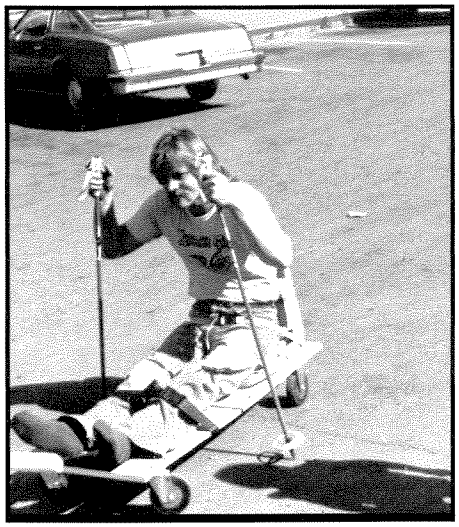


Fig. 64. "Roller sled" to train on during off-season. (Photo courtesy of Vinland National Center)

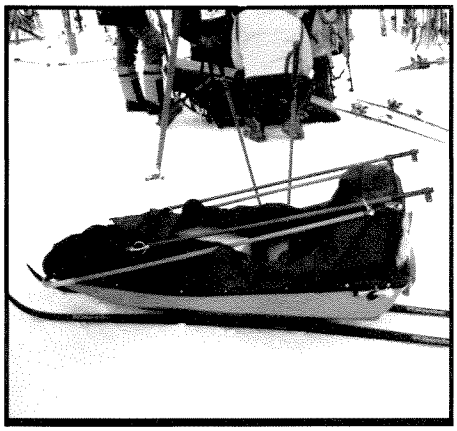


Fig. 65. Mountain Man cross-country skiing sled. (Photo by Bernice Kegel)

the skier can pull himself up when necessary.

The cross-country sled skier should experiment to determine the most efficient pole length for his or her needs. Poles vary in length from 50 to 135 centimeters. Beginning skiers usually use short poles, while experienced skiers prefer longer ones for more push length per stride.

For additional information on cross-country skiing, see **Sports Literature** and **Sports Organizations and Resources** at the back of this publication.

Soccer (Crutch Soccer)

Crutch soccer, a game that is rapidly gaining in popularity, can be played by the disabled and able-bodied alike on one team. Though the individual with amputation is permitted to use crutches, he or she cannot wear a prosthesis while playing **(Fig. 66)**.

By mounting a round disc to the lower end of a pair of forearm crutches, the individual with amputation is afforded greater control of the ball. This extra control enables a player to propel that ball over the opponent's goal line with relative ease. Some think that use of the disc is hazardous, however, as it tends to encourage players to lift their crutches in the air.

While crutch soccer presently is localized in the Pacific Northwest, it is hoped that the game will develop into regional and national competitions. The rules established for crutch soccer by the Seattle, Washington team are as follows. Players play according to the rules of regular indoor soccer, with two modifications. First, people with amputation use standard Canadian forearm crutches and no prosthesis. Contact between the ball and the crutches constitutes a violation. Able-bodied players use crutches and decide at the beginning of the game which leg will not bear weight. They are not allowed to switch support legs during the game. Two 30-minute halves are played. Second, because the goal keeper is usually an individual with upper limb amputation, no hands may be used in the game. The goal keeper is restricted to the use of the head and feet for his or her role in the game.

For additional information on crutch soccer, see the **Sports Organizations and Resources** section of this publication.

Fig. 66. Crutch soccer offers the opportunity for amputees and the able-bodied to participate together. (Photo by Bernice Kegel)

Swimming

People of all ages and disabilities can learn to swim. Though some individuals with amputation avoid this sport because of psychosocial prejudice, it is an excellent activity for increasing stamina and physical conditioning, particularly for those persons with lower limb impairments.

Another advantage of swimming is that it in no way traumatizes the often sensitive residual limb area. For swimmers with unilateral lower limb amputation, the scissors kick is usually more effective than the breaststroke, and few modifications are necessary for this group. The swimmer with bilateral lower limb amputation, however, should be monitored for safety, especially during initial instruction. Skill in self-rescue is very important.

The following is a partial list of the options available to the swimmer with amputation.

- Swimming without a prosthesis **(Fig. 67)**.
- Wearing a prosthetic leg designed for use in the water **(Fig. 68)**.
- Using swim fins attached to prosthetic sockets **(Fig. 69)**.
- Walking on the beach and/or swimming with peg legs **(Fig. 70)**.

The need for a special swimming prosthesis is determined by the individual swimmer and his or her physical therapist and prosthetist. One disadvantage to swimming without a prosthesis is that the individual might later have difficulty getting his walking prosthesis back on because the residual limb may swell while in the water. There are several advantages to wearing a waterproof prosthesis. Swimming with a prosthesis is an excellent way to exercise the entire body. If the

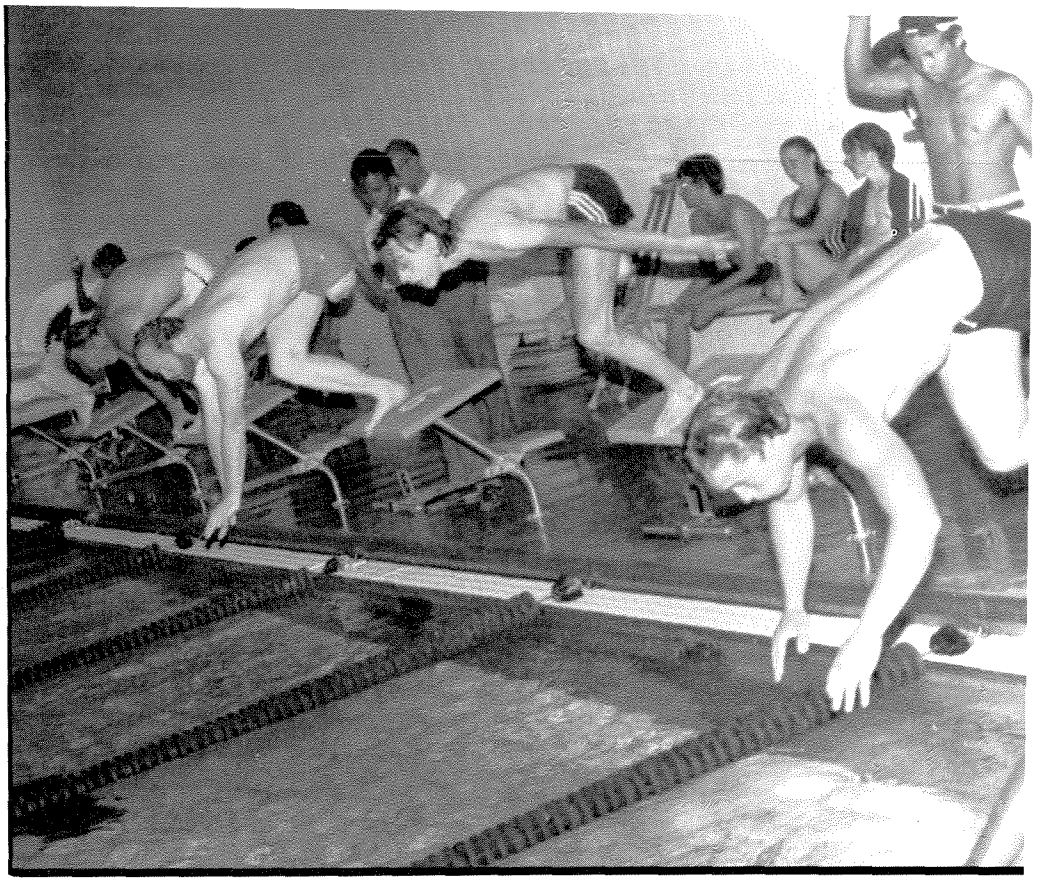


Fig. 67. Athletes with amputation swimming without prostheses. (Photo courtesy of *Ability Magazine*, Majestic Press, Copyright 1982)

Fig. 68. Below-knee amputee wearing VAPC swimming prosthesis. (Photo courtesy of Veterans Administration Prosthetic Center, New York, NY)

Fig. 69. Bilateral below-knee amputee wearing VAPC swim fins. (Photo courtesy of Veterans Administration Prosthetic Center, New York, NY)

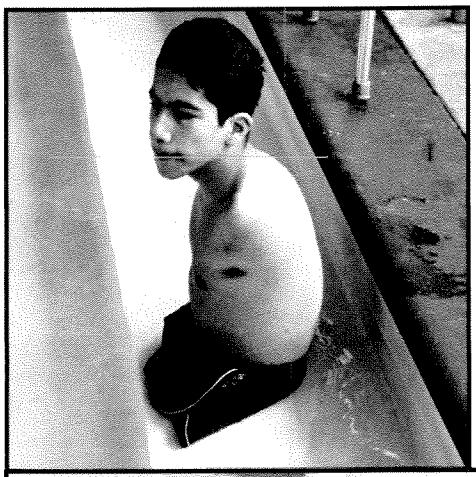
Fig. 70. Beach peg leg. (Photo reprinted with permission from Archives of Physical Medicine and Rehabilitation)

swimmer is using some form of "kick" for propulsion in swimming, he or she is also exercising the residual limb musculature. (This does not necessarily mean that the amputee will swim more proficiently with a prosthesis.) Wearing a swimming prosthesis has other advantages, including the ability to climb out of the swimming pool where there is a ladder, added stability when diving, and protection against injury to the residual limb.

There are many swimmers with lower limb amputation who have performed competitively without a prosthesis. In such cases, the three intact limbs do most of the work. The backstroke is usually the easiest to accomplish as the swimmer can compensate to a large degree by using the arms and upper body strength. The sidestroke is also relatively easy to accomplish, with the residual limb on the under side. Freestyle swimming and the breaststroke can be very tiring, and it may be difficult to keep moving in a chosen direction. There may be a tendency to swim in a circle.

The California Wheelchair Athletic Association offers so-called "Sink or Swim" clinics to swimmers with amputation. The participants are videotaped as they swim. Then, the tapes are shown to the entire group, while experts and students offer comments and suggestions for improving stroke and general technique. Groups interested in organizing "Sink or Swim" workshops should contact Farwest Wheelchair Athletic Association, P.O. Box 26483, San Jose, CA 95159.

Some individuals with lower limb amelia can swim backstroke and crawl by lifting their hips up and down in the water as an able-bodied swimmer might use the legs for a dolphin kick. To change direction, the swimmer with lower limb amelia rolls from side to side. Swimming is an excellent aerobic exercise for these people as virtually every muscle is used **(Figs. 71 and 72)**.



The Beach (Utility) Prosthesis

The beach (utility) prosthesis is used for walking along the beach, standing in a pool, boating, fishing, water skiing, wading, and other activities. This prosthesis can also be used in the shower, eliminating the need for a bench or special handholds.

The beach prosthesis is worn with or without a shoe, and can be waterproofed by incorporating an undercut, waterproof phenolic ankle block (instead of wood) to join the shank to the prosthetic foot **(Fig. 73)**. Another option would be to use a foam ankle block, which is lighter. If a socket liner is used, it

Fig. 71. A congenital quad-amelic prepares to launch himself into the water with a thrust of his pelvic girdle and the buttocks. **Fig. 72.** Once in the water, he steers by twisting the torso and kicks with thrusts of the pelvis. Floating is accomplished by keeping the lungs filled. (Photos courtesy of George Barksdale and Amputees in Motion)

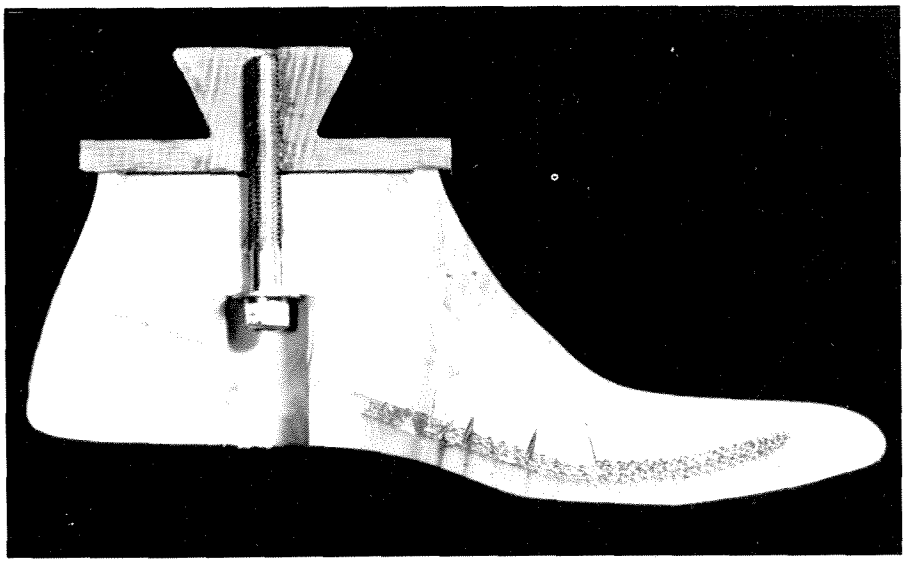


Fig. 73. Waterproof phenolic ankle block developed by Arthur Scheinhaus. (Photo courtesy of the Veterans Administration Prosthetic Center, New York, NY)

should be made of a waterproof material such as pelite.

If a SACH (stationary ankle/cushioned heel) prosthetic foot is used, some adaptations of the heel will be needed to allow the user to walk barefoot. In addition to the waterproofed phenolic ankle block, Arthur Scheinhaus of the Veterans Administration's Prosthetics Center (VAPC) has also developed a removable "heel leveler" fabricated of polypropylene molded over the SACH foot. A rubber heel and Velcro closure are then added. The bolt opening should be properly sealed to prevent water seepage to the wooden keel. (See page 14 for more description of the SACH foot.)

Another option is a flat-heeled, postoperative foot modified by the VAPC to allow the person with amputation to change from street shoes to sneakers or other shoes customized for specific activities.

The Otto Bock Swimming Leg

If an individual with lower limb amputation were to go swimming while wearing his or her regular prosthesis, the prosthesis would probably float. Moreover, it would more than likely be damaged from the water.

Accordingly, Otto Bock Orthopedic Industry, Inc. fabricated a hollow-walled plastic prosthesis designed for swimming **(Figs. 74a and 74b)**. This hollow, plastic prosthesis with a hole drilled through the ankle block allows the air space to fill with water, thereby nullifying undesirable buoyancy caused by trapped air. Then, when the swimmer leaves the water, the hole allows rapid evacuation of all water from the prosthesis. The limb is weighted, facilitating proper balancing between the shank and the toe. When the air space fills with water, the toe will point at the correct angle to provide an effective swimming "kick." The swimmer may also wear a swim fin with this device. Because of their strength, acrylic resins, rather than polyesters, are used to fabricate the Otto Bock limb. If a supracondylar cuff is used for suspension, it should be made from water-resistant, pliable plastic.

Figs. 74a and 74b. The Otto Bock swimming leg. Note the water draining upon climbing out of the pool. (Photos reprinted with permission from Archives of Physical Medicine and Rehabilitation)

Swimming

The Otto Bock above-knee swimming leg incorporates the same double-wall construction **(Fig. 75)**. In addition, this prosthesis utilizes a quick release knee-lock mechanism in conjunction with a waterproof nylon sole. The knee mechanism, which is completely functional in water, has a friction lock for walking or sitting on the beach. For suspension, a light harness can be made from waterproof material. Some suction socket wearers manage to keep the limb on without additional suspension. For convenient storage, the prosthesis may be disassembled by removing its axle.

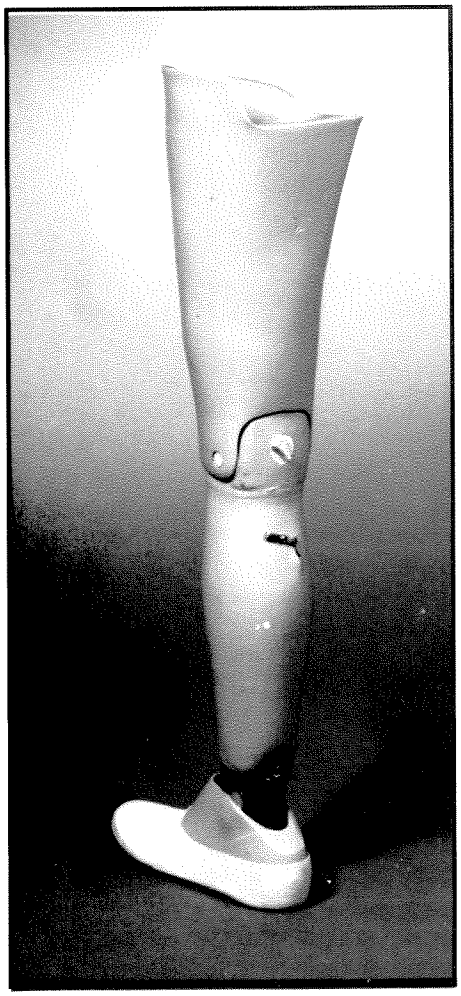


Fig. 75. Above-knee swimming or sports prosthesis with single-axis knee and manual lock. (Photo courtesy of Otto Bock Orthopedic Industry)

VAPC Swim/Walk Ankle

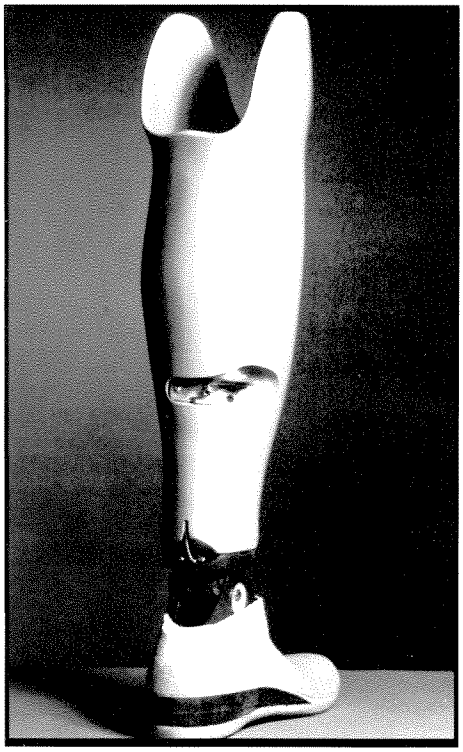
The Veterans Administration's Prosthetics Center, NY, developed the swim/walk ankle in response to a patient's request for a below-knee swimming prosthesis with a two-position lock ankle. The prosthetic ankle that resulted was constructed to lock at 90 degrees for walking and 120 degrees for swimming (toe pointed down). Each position is controlled by a spring-loaded pin which automatically locks in place. The swimmer can easily activate this prosthesis via a ring located in the posterior portion of the device's calf area **(Figs. 76a and 76b)**.

The highly versatile VAPC swim/walk ankle allows the water sports enthusiast to walk into the water, change the prosthetic foot from a walking to a swimming mode, and swim freely while wearing a prosthesis, thus exercising residual limb musculature and, in fact, the entire body.

The VAPC unit is constructed of polypropylene, so it is waterproof and resists corrosion in salt water. The Kingsley Symes foot, which is ideal for this set up, is fitted to the ankle joint. All other components, such as screws and tubes, are constructed of stainless steel. This prosthetic unit and the previously discussed beach prosthesis are made by:

- Kingsley Manufacturing Co.
  1984 Placentia Avenue
  Costa Mesa, CA 92627
  (714) 645-4401

For more information on swimming and swimming aids for persons with amputation or other impairments see the **Sports Literature** and **Sports Organizations and Resources** sections of this publication.



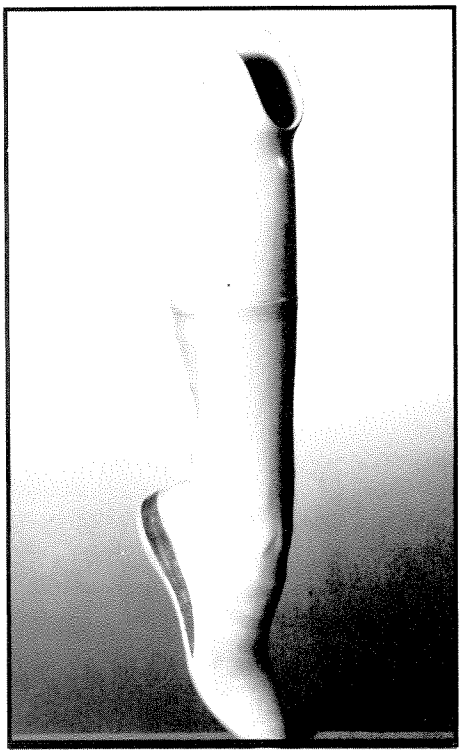


Fig. 76a. The VAPC swim/walk ankle in a neutral position. **Fig. 76b.** The VAPC swim/walk ankle in a plantar flexed position. Adjustment is made at the posterior portion of the calf. (Photos courtesy of the Veterans Administration Prosthetic Center, New York, NY)

Water Skiing

The British Disabled Water Ski Association (B.D.W.S.A.) was formed in 1979. The first training course for disabled students was held that year, followed by an even more successful course in 1980. This organization has been active in publishing suggestions for teaching techniques. The American Water Ski Association has not yet formally developed a subsection for people with disability.

Anyone who water skis should know how to swim because water skiing is a sport that involves many falls into the water at high speeds. For this reason it is essential that the skier wear a life jacket. If a wet suit is worn by an individual with amputation, it should fit snugly around the residual limb to give protection in the event of a fall. Dry suits are also now available. A powerful boat is needed, as the quicker the skier is on the plane the less the strain. The boat should have at least 100 horsepower for a single skier; if the boat tows three people on a wide bar, 200 to 250 horsepower is needed.

Adaptive Devices for Water Skiing

Most water skiers with unilateral lower limb amputation choose to ski on one ski, though some use two skis. When skiing slalom with a prosthesis, the prosthetic leg is usually placed behind the intact leg. The waterproofed prosthetic leg needs to be a little shorter than the sound leg in order to place weight further back on the ski. Alignment changes, such as outsetting and externally rotating the prosthetic foot to allow space for clearance of the sound knee, may be advisable.

If a skier with below-knee amputation chooses to ski on two skis, he or she should keep the prosthetic ski 3 to 6 inches ahead of the other ski. This will prevent the drag from pulling the artificial leg backwards, a position that would be difficult to manage. If the skier starts with the artificial limb trailing behind, it will usually be wrenched off by the force of the water. Another alternative would be to start off on two skis but to place the residual limb in the socket without tightening the suspension straps. Once up and stable on the skis, the amputee could release the prosthetic ski and prosthesis and complete the run on the sound leg only. This method would require that the skier return to the starting point at the end of the run to retrieve his or her ski and prosthesis.

The water skier with above-knee amputation often prefers to ski without wearing a prosthesis. Others choose to attach a bucket-type device to the ski, thus providing a place for the residual limb to rest. A broad, square-backed ski will give the largest planing area and best stability for a beginning skier. A deep slalom ski fin is helpful. For maximum control, the fin should be placed between the heel of the binding and the rear of the ski. To keep the weight back, the binding should be fixed so that the ankle joint is placed about one-third of the length of the ski measuring from the rear posterior.

For deep water starts, the "V" of the tow rope should be looped over the tip of the ski to help keep the ski steady. The body should be in a straight line with the pull of the boat. The residual limb has to be kept straight and pushed backwards hard to act as a rudder. The driver starts the boat off slowly until the skier is progressing straight, then full power is turned on until the skier is up. Once up, the residual limb should not wave about, but be kept close either to the side or in front of the sound leg. By "hugging" the sound leg, the muscles of the residual limb reinforce those of the sound limb, thus minimizing fatigue. The arms are kept bent and as low as possible, with the elbows close to the waist. The aim is to keep the level of pull as low as possible, with the thrust coming through the thighs.

Water skiers who have bilateral below-knee amputation generally use two skis, while individuals with bilateral above-knee amputation who do not ski with a prosthesis may find a saucer-like assistive device a good alternative **(Fig. 77)**.

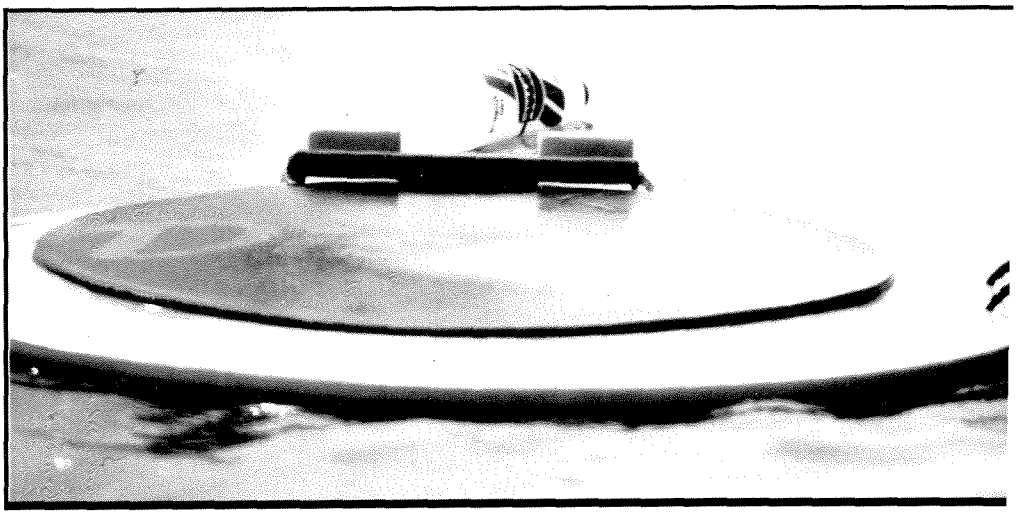
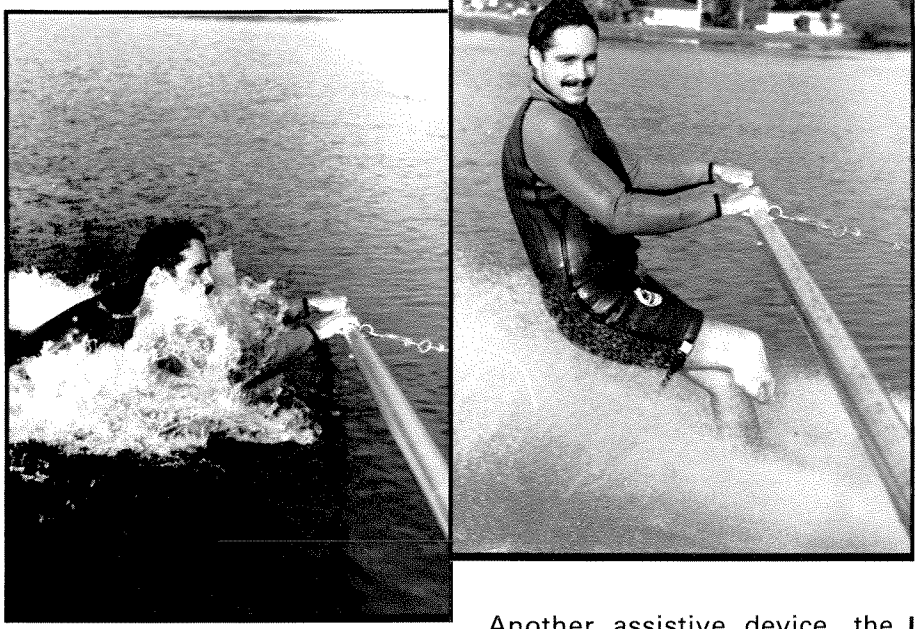


Fig. 77. Saucer for the water skier with bilateral above-knee amputation. (Photo by Bernice Kegel)

Water Skiing

Trick Bar (Ski Boom)

Perhaps the most basic tool available to the water skier with amputation is a device called a Trick Bar, or Ski Boom, that is used successfully by those without impairment as well **(Figs. 78a and 78b)**. This assistive device consists of a bar of roughly 15 feet long. The bar, which is attached to the boat, extends over one side of the boat (at a right angle to the keel). Heavy rope or cable is then attached to the end of the bar and simply hooked to the bow of the ski craft.



Figs. 78a and 78b. Water skiing using a Ski Boom. (Photos courtesy of George C. May)

The device allows the novice skier to take hold of the bar and be towed through the water, maintaining balance with the hands. Another advantage of this technique in learning to water ski is that the bar, if strong enough, will accommodate two skiers. In this way, the instructor and student can water ski side by side.

Since these bar devices are so popular, most marine shops sell them, or offer instructions for making them. One must be cautious, however, to construct the device with sufficient strength. The bar (or pole) should be at least an inch thick and long enough to properly distance the skier from the boat. The trick bar, or ski boom, usually is a permanent fixture on the boat and thus is most suited to a ski school situation.

Another assistive device, the wide handle, is an oversized handle which can be positioned at the end of the tow rope. This device also lets two skiers ski side by side. To avoid injury to the skier's residual limb in case the skier, or the instructor, falls, the instructor should ski on the side of the student's intact leg.

The tow handle is usually made from thin-walled conduit pipe that is reinforced on the inside with a piece of maple or oak doweling. The reinforcement makes the tow handle of some 3 feet long virtually unbreakable, though it might bend slightly with heavy use or unusual stress. To reduce this stress, it is a good idea to tie the tow rope to the bar in three places—the middle and either end. Drilling holes through the center section of the bar is best avoided as this could weaken it. By skiing side by side with the student, the instructor can steady the tow handle while the student makes horizontal corrections.

If two instructors are necessary, an extra wide tow bar can be used with an instructor on each side almost lifting the amputee skier under the arms. Each instructor places one hand inside that of the student on the bar so that support is given under the armpits on both sides. This method teaches the disabled student to ski on the water after being helped up. It is a successful method for getting the student up on the skis on the first attempt, making it an effective morale booster. The student should rapidly progress to require less help from the instructors.

A refinement to the wide tow bar is the edge triple bar which consists of three metal tubes that can be opened into three separate handles with three individual ropes. This enables the instructors to separate completely and smoothly from the student so that he or she can ski solo **(Fig. 79)**. According to the British Disabled Water Skiing Association, a novice can ski independently after only three days of practice using the triple bar as an assistive device.

Another option allows the instructor to ski tandem with the student using two tow lines and ropes. The instructor holds his or her own handle with one hand and the student's upper arm with the other. Once the student is up on skis, the instructor can let go and ski alongside, giving instructions as necessary.

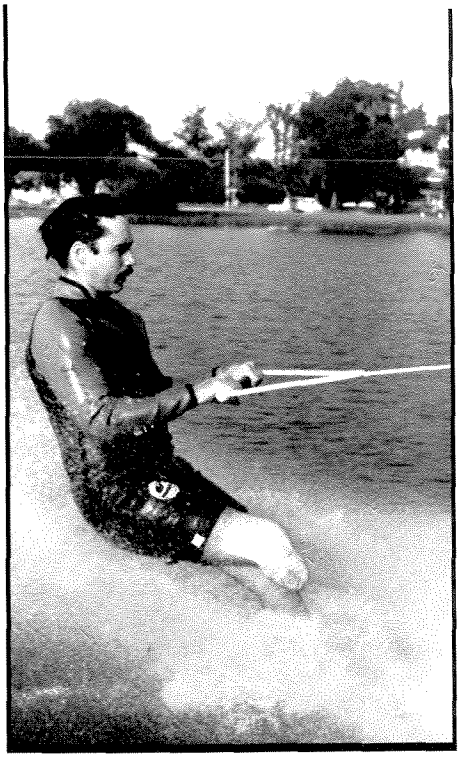


Fig. 79. Skiing solo without a prosthesis. (Photo courtesy of George C. May)

Water Ski Bra

The use of the water ski bra allows people with bilateral lower limb amputation optimal stabilization and tracking. Those water skiers who use two skis, but lack the lower leg strength to control lateral movement, also benefit from this device.

A relatively uncomplicated water ski bra can be made from a turnbuckle, two eye bolts, two wooden nuts, two standard nuts, and washers **(Fig. 80)**. The turnbuckle will ideally be of the closed-eye variety, while the eye bolts should be approximately ¼ inch in length. Two holes are then drilled through the tips or tails of the water skis to accommodate the shank of the two eye bolts. The turnbuckle eyes are slipped over the shank of the eye bolts, while a nut is screwed onto each bolt. The washer is slipped on after the nut is screwed onto each eye bolt. Next, the shanks are inserted into the drilled holes and fastened with wooden nuts. One pulls up the wooden nuts by turning the eye bolts until the threads are flush with the bottom of the ski. Now the turnbuckle can float on the shanks of the two eye bolts, thereby allowing some vertical and horizontal movement of the skis, but keeping them equidistant from each other. Ski bras can be made of Bungie cord, keeping the tips 20 to 30 centimeters apart **(Fig. 81)**.

Another stabilizing device is available to water skiers with lower limb amputation **(Fig. 82)**. The tow rope is attached to the base of the device instead of the skier holding onto the rope. When the skier pulls on the bar, the skis are held together by two wooden bars. When the skier lets go of the bar, the pull from the boat releases the stabilization from the skis, and the skier is free of the device.

The Hydro Slide

The Hydro Slide resembles a surfboard, but those with lower limb amputation use it as a water ski from either a sitting or kneeling posture, or just to float.

The novice skier should begin by placing the slide on the beach some 15 feet from the edge of the water. He or she can either sit or kneel on the device's foam padded board. The skier holds the tow handle firmly and leans forward while the driver idles the boat forward until the rope is taut. Upon the skier's signal, the driver accelerates slowly to desired towing speed (1 mile/hour for every 10 pounds of body weight).

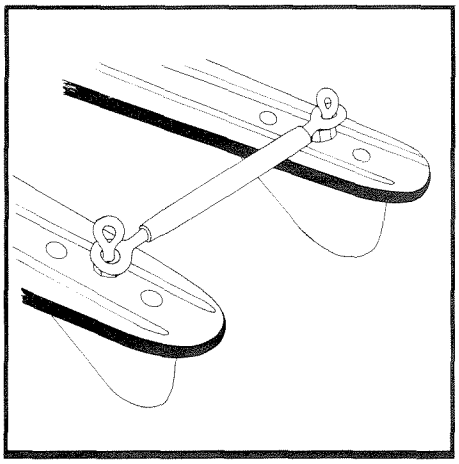


Fig. 80. Water ski bra. (Photo by Bernice Kegel)

Fig. 81. Water ski bra made with bungie cord. (Photo by Bernice Kegel)

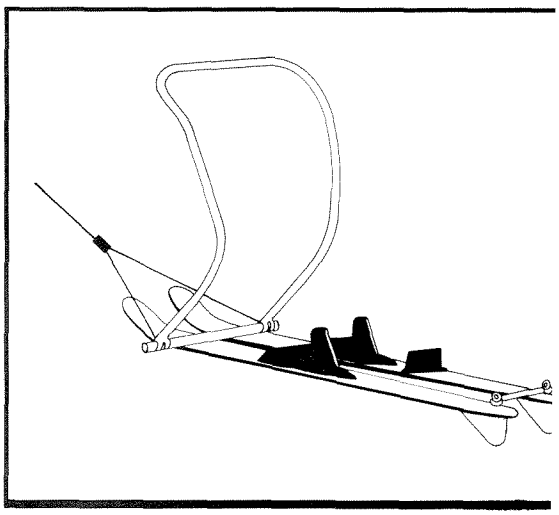


Fig. 82. Adaptive device for water skiers with amputation which acts as a stabilizer for the skiis when needed. (Photo by Bernice Kegel)

Water Skiing

In deep water, the tow rope is held in one hand while the driver idles the boat forward until the rope is taut. Next, the handle is grasped with both hands and placed on top of the board while both elbows rest on the nose of the board **(Figs. 83a and 83b)**.

The floatation of the Hydro Slide is equivalent to that of several ski vests. Thus, it can be used as a small life raft for floating.

The Hydro Slide can be obtained from most sporting goods stores, or from:

- Kransco
  P.O. Box 884866
  San Francisco, CA 94188-4866
  (415) 433-9360

Fig. 83a. Water skier with below-knee amputation demonstrating use of the Hydro Slide. (Photo by Bernice Kegel)

The Monoski

The Monoski is 8 feet long and 18 inches wide. At its tail is a fin, while at the front is a large towing eye. On top is an adjustable hand-held pelvic retainer of stainless steel tubing. An 8-inch cross bar supports the back of the skier's thigh and at the same time prevents undesirable forward movement. A 2-inch nylon strap covered with plastic tubing helps to keep the skier's foot from slipping off the ski.

The Monoski's large surface and metal apparatus provide excellent stability. In case of a fall, the skier can quickly clear the seat. The large surface of the ski enables one to sit on it while being pulled out of the water. The Monoski is steered by leaning in the desired direction.

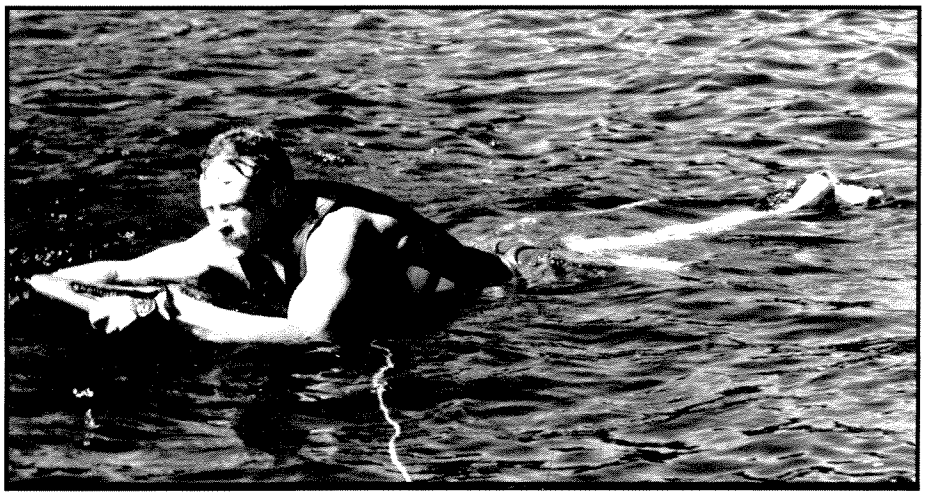


Fig. 83b. Water skier with above-knee amputation using the Hydro Slide. (Photo by Bernice Kegel)

At first, the device should be tried in shallow water. The instructor can stand to one side of the ski, push it in the water, and stabilize it, as necessary. At the same time, the student skier grasps the thigh support with his right hand (assuming that the instructor is on the left side), places the pelvis between the supporting bars, and, finally, the legs follow.

The Monoski is attached directly to the boat by the ski line. A "trick release," operated by the observer, is incorporated into the tow line. The rope is tightened while the instructor balances the ski and holds it pointing in the right direction because at low speeds the ski is not very stable. As the boat gains speed, the instructor can let go of the ski.

For the more advanced skier, skiing with the towline in hand is possible. The skier holds the handle in both hands while holding the top of the thigh support as

well. When the boat moves the skier bends forward to break the resistance of the water. Once the ski is stable, the skier lets go of the thigh support and holds onto the handle alone.

For additional information on the Monoski, contact:

- Mission Bay Aquatic Center
  c/o Tod Bitner
  1001 Santa Clara Point
  San Diego, CA 92109
  (619) 488-1036

There are assistive devices similar to the Monoski that are also commercially available to water skiers with lower limb amputation and other impairments **(Fig. 84)**.

Water Ski Seat

As in snow skiing, the water ski seat offers an interesting alternative to the sports enthusiast with amputation **(Figs. 85a and 85b**, on following page). Two skis, a frame, a plastic seat, and bindings make up the water ski seat. To modify for disabled skiing, a fiberglass chair with a customized (lowered) back can be easily mounted onto the plastic seat with a piece of plywood. Handlebars and extra floatation are often added.

The skier starts out from the beach by sitting in the ski seat with his feet in the binding, holding on to the handlebars and bending slightly forward to keep the ski tips up. Two assistants, one on either side, pull the seat to waist-deep water by holding on to the handlebars to keep the tips of the skis up. When the skier is just about to emerge from the water, the assistants release the handlebars, and the ski seat begins to plane. At this point, the skier is able to independently steer the ski by simply tilting his upper body.

For additional information on this device, contact:

- Ski Seat Water Sports Industries
  10230 Freeman Avenue
  Santa Fe Springs, CA 90670
  (213) 946-1323

Fig. 84. Water skier with above-knee amputation using a Belgian manufactured device that is similar in design and function to the Monoski. (Photo courtesy of the American Water Ski Association)

For those clinicians and/or amputees interested in obtaining additional literature on water skiing for those with handicaps, call or write:

- American Water Ski Assoc.
  c/o Bruce Kistler
  State Rd. 550 & Carl Floyd Rd.
  P. O. Box 1911
  Winter Haven, FL 33880
  (813) 324-4341

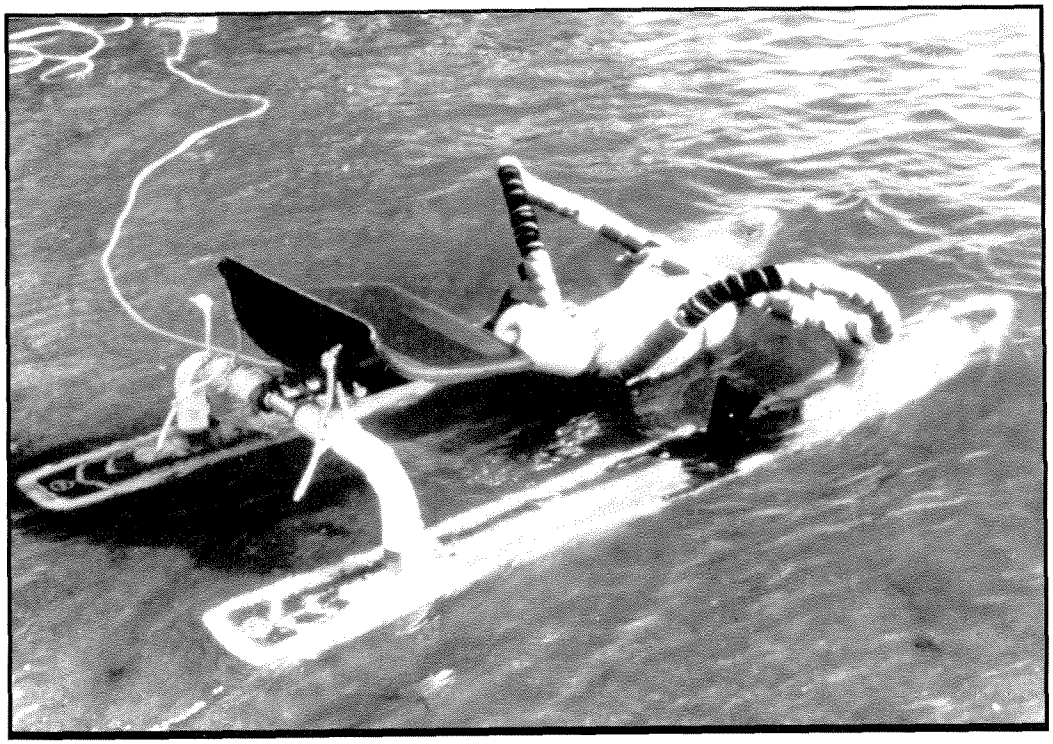
- Mission Bay Aquatic Ctr.
  c/o Tod Bitner
  1001 Santa Clara Point
  San Diego, CA 92109

- NHSRA of NY
  c/o Phil Phillips
  10 Westmoor Place
  Binghamton, NY 13905
  (607) 797-8788

- Christian Family Ski School
  c/o Fred and Wanda Horrell
  P.O. Box 7425
  Winter Haven, FL 33880
  (813) 299-4044

A booklet entitled "Water Skiing for the Physically Disabled" is available from the Mission Bay Aquatic Center, 1001 Santa Clara Point, San Diego, CA 92109, (619) 488-1036.

Water Skiing



Figs. 85a and 85b. Water ski seat. (Photos courtesy of the Mission Bay Aquatic Center)

Competitive Sports for Those with Lower Limb Amputation or Impairment: An Overview

Competitive Sports

The first World Amputee Competition was held in 1979 in Stoke-Mandeville, England for the purpose of promoting organized amateur sports competition for individuals with amputation.

By 1981, the first Annual Amputees Recreational and Competitive Meet was held in this country.

Today, in the United States and abroad, competitive events include swimming, track and field, weightlifting, air pistol, volleyball, and table tennis. Sit-down volleyball will be played at the June 1985 Amputee Games in Nassau County, New York, as will lawn bowling, pentathlon, and many other competitive events.

According to the U.S. Amputees Athletic Association, the current medical classifications for competitive sports for those with lower limb amputation are as follows:

- Class A1: Individuals with bilateral above-knee amputation;
- Class A2: Individuals with unilateral above-knee amputation;
- Class A3: Individuals with bilateral below-knee amputation;
- Class A4: Individuals with unilateral below-knee amputation.

For swimming competition, no prosthesis is allowed to be worn.

For discus, javelin, or shotput, a prosthesis is worn if the competitor wears one for everyday use. No crutches or other assistive devices are allowed. Class A1 competitors (those with bilateral above-knee amputation) wearing a prosthesis may throw from behind a hip-high barrier, but the discus, javelin, or shotput must be airborne before contact is made with the barrier. Many Class A1 competitors participate from a wheelchair.

For high jump competition, wearing a prosthesis is optional, but the competitor must take off from ground level on one foot. For long jump competition, participants jump without a prosthesis from a standing position at the take-off line **(Figs. 86a and 86b)**.

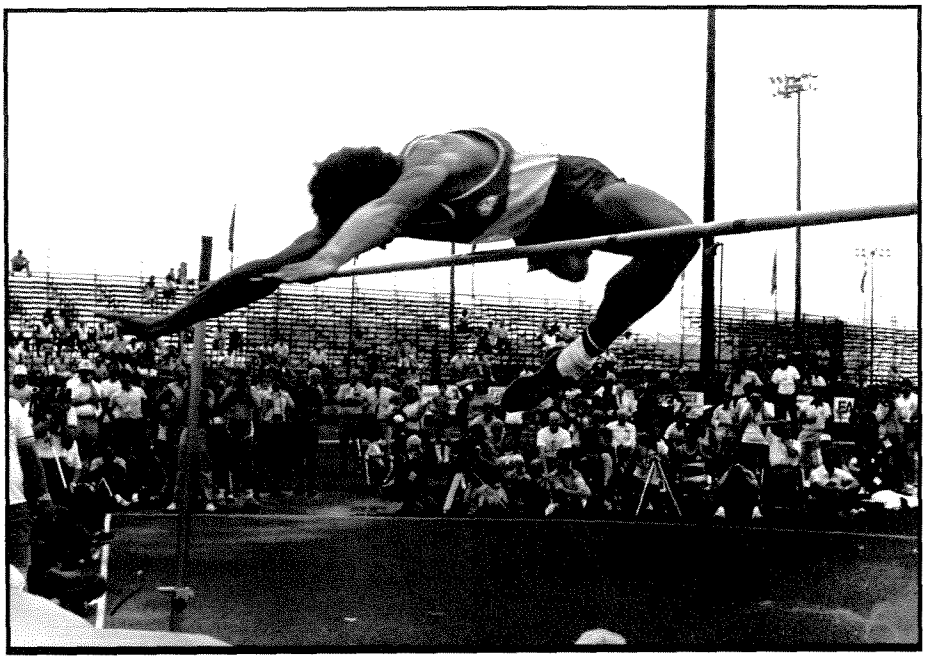


Fig. 86a. A unilateral above-knee amputee high jumping without a prosthesis. (Photo courtesy of *Ability Magazine*, Majestic Press, Copyright 1984)

Fig. 86b. For long jump events, competitors do not wear a prosthesis. (Photo courtesy of *Ability Magazine*, Majestic Press, Copyright 1984)

For table tennis, a prosthesis is worn, but crutches are not allowed **(Fig. 87)**. The rules permit only Class A1 competitors to play from a wheelchair.

For weightlifting competition, participants are weighed in the nude (without prostheses) one hour before the event. Those with amputation must then add 1/16th of their body weight for each below-knee amputation, 1/9 of their body weight for each above-knee amputation, and 1/16 of their body weight for each hip disarticulation.

For those people with amputation who choose to do weightlifting in nondisabled competition, a good quality prosthesis is of extreme importance. In order to do the squat and dead lift, a prosthesis offering a wide base of support is important. While the base of support has to be wide, it also has to remain vertical without causing too much stress of the knee ligaments. The foot needs to have some flexibility so that it stays flat. The prosthesis needs to be fabricated from material that will tolerate the torques and stresses applied to it by the excess weight. Arlon has proved to be a more adequate laminating material than fiberglass or acrylic.

For more information on this prosthesis, contact:

- Nashville Orthotic and Prosthetic Services Inc.
  c/o Jim McElhiney, C.P.O.
  1904 Hayes Street
  Nashville, TN 37203
  (615) 327-1546

Fig. 87. Table tennis is one of the sports included in world amputee competition. A prosthesis is worn, but crutches are not allowed. (Photo courtesy of *Ability Magazine*, Majestic Press, Copyright 1984)

For standing volleyball, each amputation is assigned a point value as follows:

- Both legs, below-knee: 4 points
- Both feet, through ankle: 3 points
- One leg, above or through knee: 3 points
- One leg, below-knee: 2 points
- One foot, through ankle: 1 point

Total points on the volleyball court at any one time must be 13, or more. A competitor's points must be recorded on his or her athlete's card and medical card **(Fig. 88**, on the following page).

Stand-up basketball for those with amputation is not as yet organized as a national competitive sport, but the United States Amputee Athletic Association (U.S.A.A.A.) has sponsored several small tournaments featuring six to eight teams. The rules are virtually the same as those for conventional basketball. In fact, it is not at all unusual for those with amputation to play basketball on the same team with those having no physical impairment.

Most people use their everyday prosthesis, with some additional suspension for safety. An above-knee suction socket wearer may choose to use a silesian belt, and a below-knee amputee usually adds a waist belt and pick-up strap. Most amputees will use some means of protecting their skin from too much friction by wearing a Daw Sheath or Spenco second

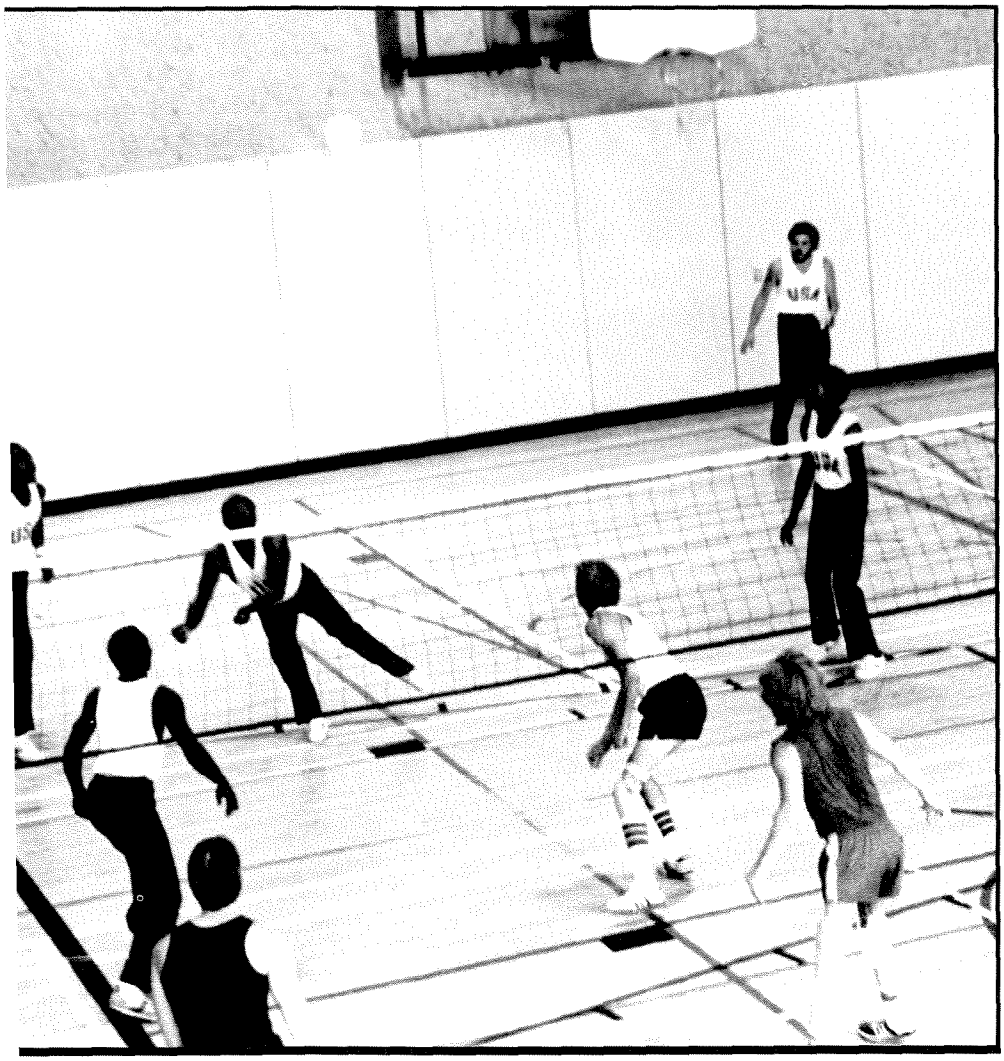


Fig. 88. Stand-up volleyball for athletes with amputation. (Photo courtesy of *Ability Magazine*, Majestic Press, Copyright 1982)

skin. Gel such as Ampu-Balm or Amp-Aid over sensitive areas is also often used. Occasionally, an amputee will choose not to wear his prosthesis and just hop, but very few people can last through a whole basketball game in this way.

For additional information on competitive sports for individuals with amputation, contact:

- Eastern Amputee Athletic Association
  c/o John Graff, Director
  (A new chapter of the U.S.A.A.A.)
  2080 Ennabrock Road
  North Bellmore, NY 11710
  (516) 221-0610

Also, see the **Sports Organizations and Resources** section and the **Sports Literature** at the back of this publication. One magazine of special interest to those with amputation who participate in competitive sports is *Ability Magazine*, P.O. Box 5311, Mission Hills, CA 91345.

Wheelchair Sports

Wheelchair Sports

Wheelchair sports became popular in the United States when World War II veterans with lower limb amputation and paralysis began forming wheelchair basketball teams, adapting the rules of regulation basketball to their needs.

The enthusiasm spread rapidly as rehabilitation programs for veterans recognized the value of wheelchair sports and encouraged more participation. Individuals with war-related amputation and paralysis were soon joined by those with many other kinds of disability, including the aftermath of polio, spina bifida, and other acquired and congenital orthopedic problems.

Since World War II, wheelchair sports have grown by leaps and bounds. In 1964, international competition was initiated in Tokyo. In the mid 1980s, here in the United States and throughout the world, wheelchair basketball, bowling, table tennis, and field events are commonplace for people with amputations and other impairments. Wheelchair square dancing, motorcycling, and other activities are generating interest as well.

For those individuals interested in learning more about wheelchair sports, there are many excellent magazines and books available. A partial listing follows:
(Also see **Sports Literature** section in this publication.)

- *A History of Wheelchair Sports*
  by Harriet May Savitz
  Thomas Y. Browell, New York, NY, 1978

- *So Get with it. A Celebration of Wheelchair Sports*
  by Marilee Weisman and Jan Godfrey
  Doubleday Canada Limited
  Toronto, Ontario, 1978

- *Sports 'N Spokes, The Magazine for Wheelchair Sports*
  Published bimonthly by
  Paralyzed Veterans of America
  5201 N. 19th Ave, Suite 111
  Phoenix, AZ 85015

Types of Chairs

Racing wheelchairs are now becoming sleek, low-to-the-ground, arm-powered go-karts **(Fig. 89)**. Wheelchairs are becoming more like racing bicycles, sometimes using tubular tires to accommodate over 100 pounds of pressure. These new designs offer high-quality bearings and lightweight, yet heavy duty, frames.

The first wheelchair expressly manufactured for sports use was a product of Stainless Specialities Company of Newport, California. This achievement was the result of years of extensive research. Contributing to the successful effort were invaluable ideas from the athletes and staff of the Rehabilitation-Education Center at the University of Illinois, Champaign, IL.

From 1968 to 1970, the lightweight chair now regarded as the forerunner of the modern sports chair, was popularized by the Illinois Gizzy Kids Wheelchair Basketball team. In addition, the Everest and Jennings Company of Los Angeles, California introduced a comparable chair that is now in wide use among athletes with amputation, paralysis, and other impairment. There are many new sports wheelchairs on the commercial market.

There are significant differences between the conventional wheelchair and the sports model. First, in the sports chair, overall weight is dramatically reduced by fabricating the frame of stainless steel. Also, where appropriate, the back of the chair is cut down to give the athlete more arm freedom (behind and laterally). The casters are placed inside the frame, allowing

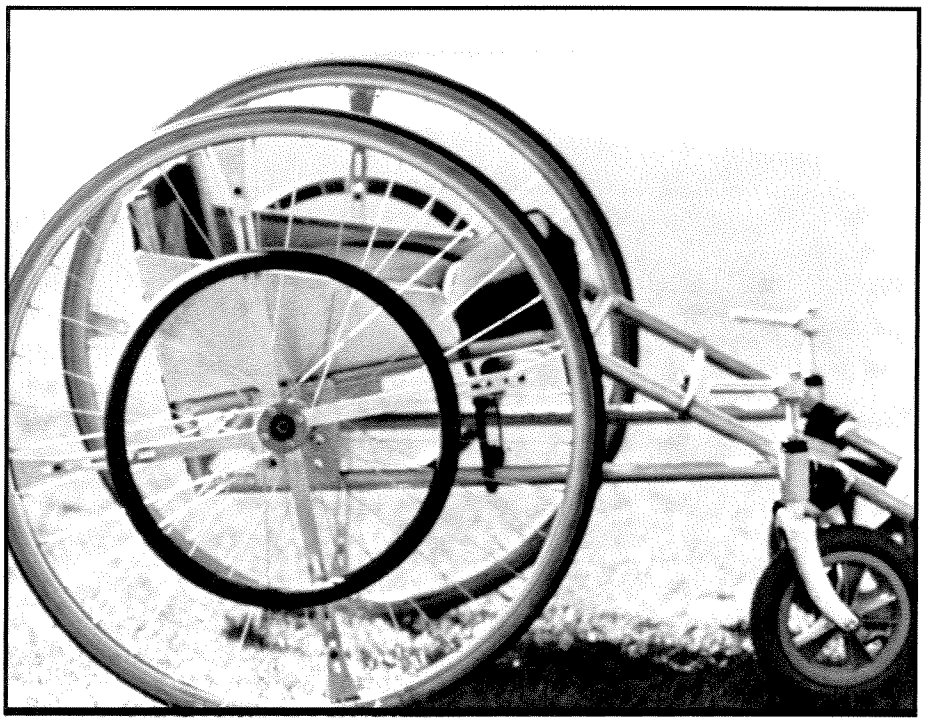


Fig. 89. Racing wheelchair. (Photo by Bernice Kegel)

for increased maneuverability through a shorter turning radius. Athletes have recently begun to canter or slant the rear wheels, giving the wheelchair a wider base. This technique provides excellent stability for racing, playing basketball, and competing in other sports.

New ankle housing and placements on the frame of the wheelchair have been introduced. These features serve to lower the seat of the chair in the back, thereby giving the athlete a longer stroke and thus greater power. Ankle housings that allow the rear wheels to be moved forward an inch or so have shortened the wheel base, giving better maneuverability.

The wheelchair used for basketball shares many of the features of the racing chair. Because of the facile movement and physical contact encountered in basketball, a safety factor has been added to the rear of the chair in the form of small, "anti-tip" casters on the kick bars. Should the athlete start to tip over, the casters will come into contact with the floor and prevent the chair from tipping over and causing injury.

Another safety feature of most sports chairs is a roll bar attached underneath the foot platforms in the front of the chair. The roll bar protects the playing surface in case the athlete tips forward and prevents the chair from folding in case of a spill.

Other differences between conventional and new sports wheelchairs relate to caster size and to a potpourri of attachments and special parts. Since most sports chairs are highly versatile, one chair, given appropriate modifications, can be used for a wide range of leisure-time activities.

The National Wheelchair Basketball Association and the National Wheelchair Athletic Association have specific regulations governing the type of chair that can be used in competition, i.e., the degree and type of modifications that can be undertaken. The chair's dimensions must conform to regulation. (The specifications are detailed in the rule books published by each organization.) With the exception of football and floor hockey, all chairs used in wheelchair competitive sports are required to be manually operated.

In addition to selection of the right chair, the serious sport competitor, especially the marathoner, will want to have water bottle bases, pump supports, and exercise rollers handy. Water bottle bases are mounting fixtures that allow easy attachment of water bottles to a bicycle or wheelchair. In this way, one can pause for a refreshing drink while coasting along.

Conditioning

To get in shape and train for competitive sports events, the individual with amputation might consider purchasing an exercise roller designed for use in the convenience of one's home. These devices are usually equipped with a ramp for easy exit and entry. The wheelchair is rolled onto the device and the user does the rest by pushing the handrims, while body weight provides the needed resistance. For precise measurement of activity, a speedometer or odometer is used.

One of several home exercisers to consider is the Rickshaw rehabilitation exerciser **(Fig. 90a)**. This device is particularly useful for developing upper body musculature while sitting in a wheelchair.

For additional information on the Rickshaw exerciser, contact:

- Columbia Medical
  P.O. Box 633
  Pacific Palisades, CA 90272
  (213) 454-6612

The American Wheelchair Roller is a treadmill which can be used while free wheeling, or with resistance **(Fig. 90b**, on the following page).

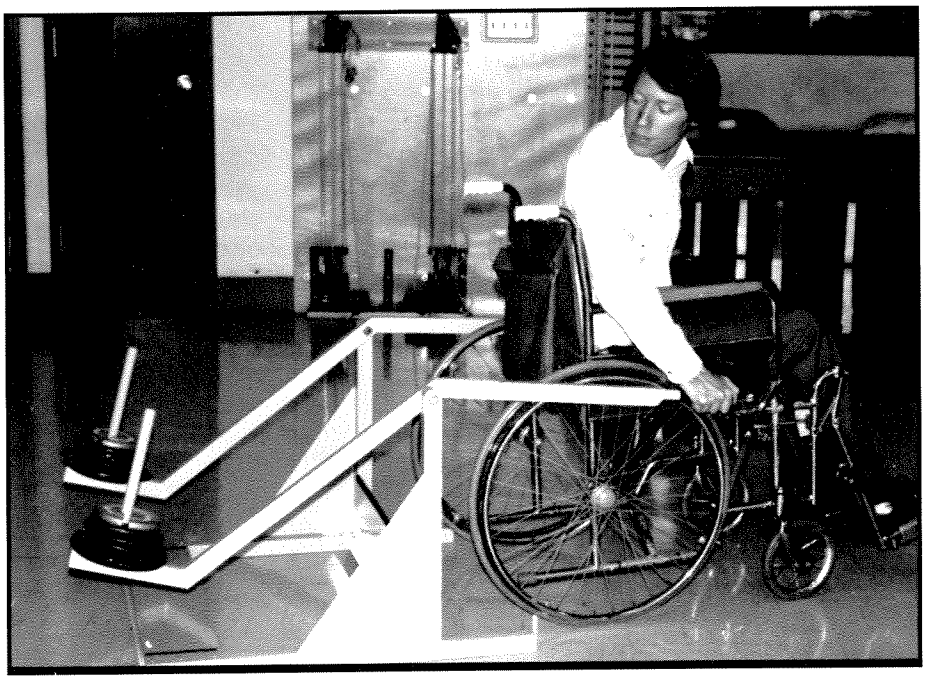


Fig. 90a. The Rickshaw rehabilitation exerciser. (Photo courtesy of Columbia Medical Manufacturing Company)

For more information contact:
- American Rollers
  P.O. Box 987
  Paramount, CA 90723
  (213) 634-4083

Another device available to those with amputation for building strength at home is manufactured by Hydra-Fitness Industries, Inc **(Fig. 90c)**. An attractive feature of this device is that it does not require constant readjustment of weights.

For more information, contact:
- Hydra-Fitness, Inc.
  Division of Hydra-Gym
  P.O. Box 599
  2121 Industrial Boulevard
  Belton, TX 76513
  (817) 939-1831

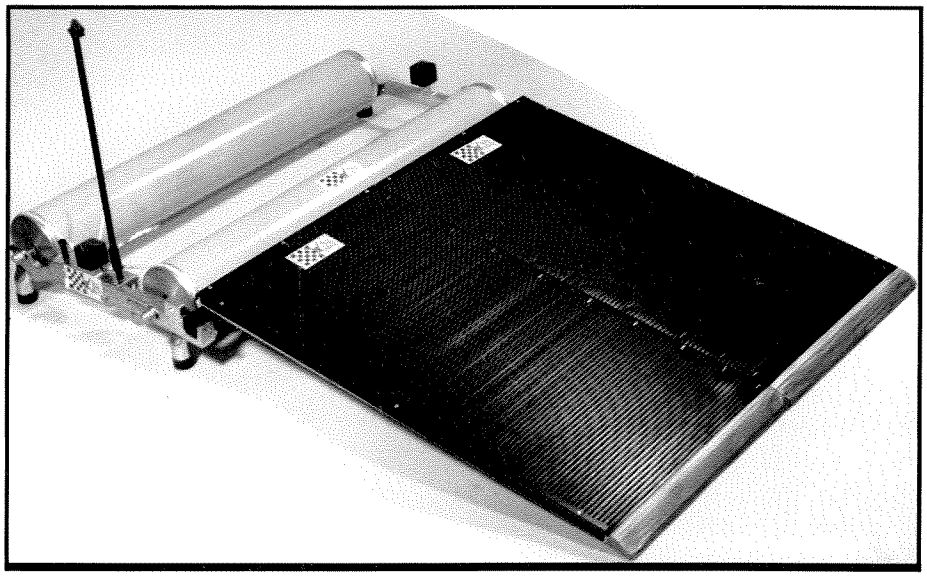


Fig. 90b. The exercise roller. (Photo courtesy of State Aluminum Foundry)

Wheelchair exercise equipment can also be obtained from:
- Helm Distributing
  Shoreline Route
  Polson, MN 59860
  (406) 883-2147

For more information on outdoor wheelchair exercise courses, contact:
- Landscaped Structures, Inc.
  601 7th St., South
  Delano, MN 55328
  (612) 479-2546

Places to receive information about the purchase of a sports/racing wheelchair include, but are not limited to, the following:
- Bair Enterprises
  Rt. 1, Box 682
  Esparto, CA 95627
  (916) 787-3902
- British Sports and Racing Wheelchair Co., Ltd.
  30 Hawthorn Crescent
  Stapenhill
  Burton upon Trent, Staffs
  England DE 15909
  0283-62799 or 0283-48012
- Carbonite Corporation
  1 Rowan Street
  Danbury, CT 06810
  (203) 748-0223

Fig. 90c. Exercising independent of an assistant. (Photo courtesy of Hydra-Fitness Industries, Inc.)

- Everest and Jennings, Inc.
  3233 E. Mission Oaks Blvd
  Camarillo, CA 93010
  (805) 987-6911
- Hall's Wheels
  15 Marlboro St.
  Belmont, MA 02178
  (617) 489-3246
- Hand-Crafted Metals
  4457 63rd Circle North
  Pinellas Park, FL 33565
  (813) 526-9419
- Invacare Corporation
  1200 Taylor St.
  Elyrio, OH 44036
  (216) 329-6000
- Liberation Concepts
  317 Sutton Place
  Santa Rosa, CA 95407
  (707) 584-7077
- Magic in Motion
  315 10th St. SW
  Puyallup, WA 98371
  (206) 848-6845
- Midwest Wheelchair Service
  6339 W. 89th Place
  Oak Lawn, IL 60453
  (312) 599-6699
- Motion Designs, Inc.
  2842 Business Park Ave.
  Fresno, CA 93727
  (209) 292-2171
- Ortop Meditech, Inc.
  Ortop Limited
  544 10th Street
  Palisades Park, NJ 07650
  (201) 947-0500
- Poirier S.A.
  Magnum International
  2930 West Central
  Santa Ana, CA 92704
  (714) 641-9696
- Production Research Corp.
  10217 Southard Drive
  Beltsville, MD 20705
  (301) 937-9633
- Quadra Wheelchairs, Inc.
  31166 Via Colinas
  Westlake Village, CA 91362
  (818) 991-6302
- X-L Wheelchairs
  4950 #D Cohasset Rd.
  Chico, CA 95926
  (916) 891-3535

Wheelchair Archery

Archery is one of the few sports in which athletes with amputation can compete on an equal basis with those without impairment. Wheelchair archers are required to shoot from their chairs during a competitive event (**Fig. 91**). Otherwise, the rules are the same for everyone. (With the exception of quadraplegic classifications, wheelchair archery events are not medically classified.)

The placement of the wheelchair should be at a 90-degree angle to the target. The next step is to find the proper seating position in the chair. To simplify this task, the wheelchair athlete needs to decide which location gives him or her optimal balance when holding the bow in a straight-arm posi-

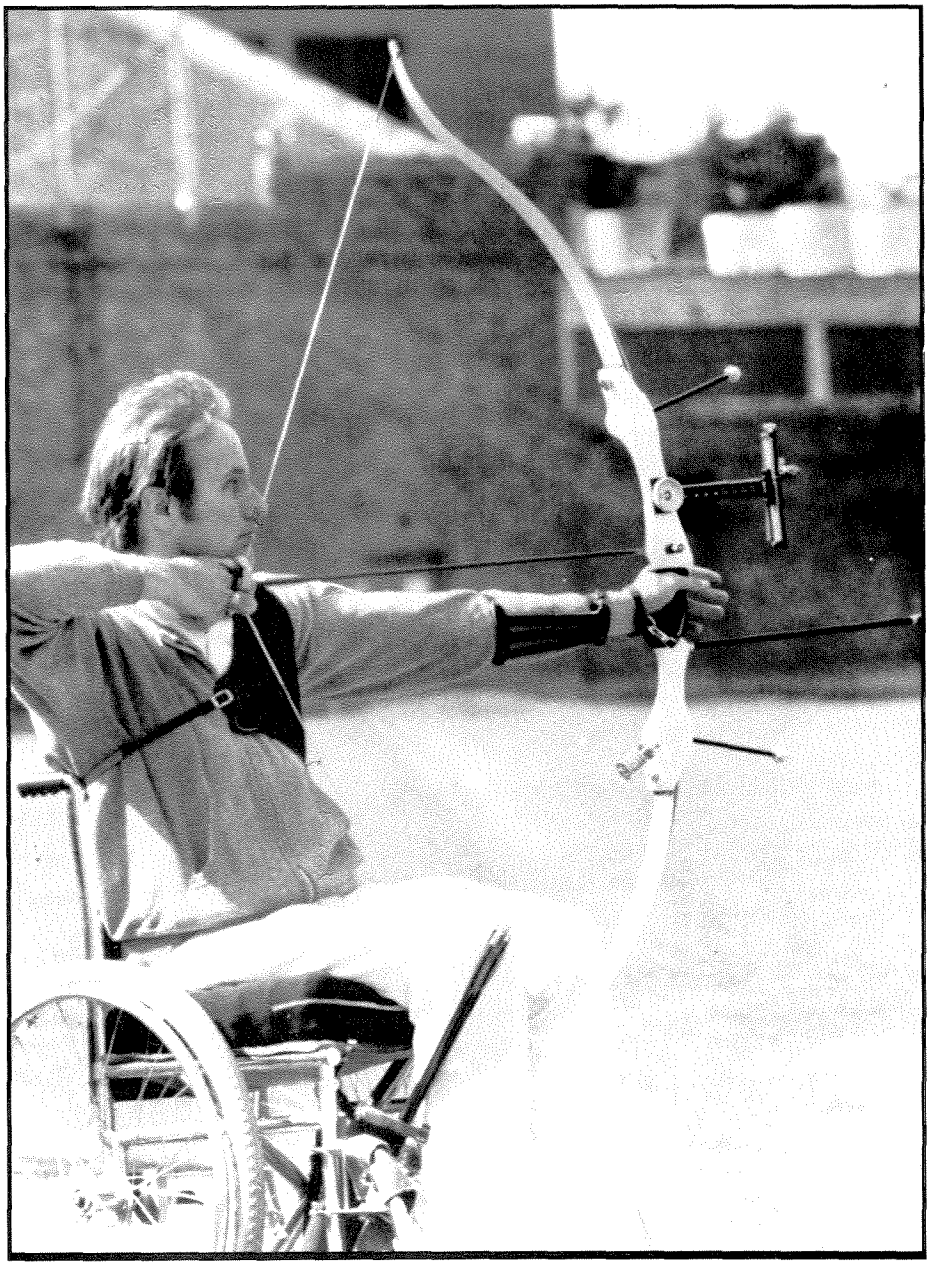


Fig. 91. Wheelchair archery. (Photo by Bernice Kegel)

tion toward the target. By merely moving the body as close to the target side of the chair as possible, the archer can relax and lean back against the back of the chair. One should be mindful of the left back frame of the chair (i.e. where it comes into contact with the rib cage). This is an important reference point for every shot. In no case, should one rest an arm on any part of the frame or push handle, or attempt to shoot while sitting up straight. Wheelchair archers need to master the art of relaxing against the chair back.

There are two methods for setting the bow arm. The traditional method is known as the extended shoulder form; the second, the recessed shoulder form.

The extended shoulder form is easier to perfect, but it can lead to fatigue during prolonged practice or tournament shooting. In spite of this problem, it is the preferred method for beginning wheelchair archers. Since individuals with amputation or other impairment often have greater shoulder strength than their companions without disability, fatigue is not really a serious problem. A clear advantage of the extended shoulder method is that it promotes a longer draw and, as such, helps to keep the bowstring off the wheel, or arm of the chair, particularly at short distances.

Once the shoulders are in a relaxed position, the bow arm is raised straight to the target, while keeping the shoulder in its starting position. Next, the elbow is locked in a down position as the archer draws the string to anchor. In summary, the idea is to maintain a relaxed hand and wrist, a locked elbow, and a shoulder that is extended slightly toward the target. When preparing to aim, the bowstring must be clear of the wheelchair's wheel and arm.

For additional information on archery see the **Sports Organizations and Resources** section of this publication.

Wheelchair Crossbow Shooting

Crossbow shooting provides a unique and challenging activity for those with amputation and other impairment. This sport can be therapeutic as well as recreational.

The first crossbow program for children with disability was started in 1968 at the University of Virginia's Children's Rehabilitation Center, Charlottesville, VA.

The crossbow is a short, powerful bow attached to a modified gun stock. The modern version is a precision-built sports weapon which is becoming increasingly popular among archery enthusiasts throughout the country. Much like a rifle, the crossbow gives the shooter built-in uniformity of power loading, sighting, and release. Another attractive feature is the silence of the arrow (bolt) when released, unlike the noise and recoil of a rifle.

Wheelchair Dartchery

Dartchery, a sport invented for those with disability as part of the International Stoke-Mandeville Games, is a modified archery event. The competitors shoot in pairs at a dart board target at a distance of 15 feet. The object of dartchery competition is to score 301 points, except in the finals when the score is increased to 501 points. Scoring in dartchery is by the subtraction method, similar to the game of darts.

A relatively new sport on the scene using a regulation basketball and a net is the Rabcan Bankshot basketball game developed in Israel in 1981. This game is often said to be to basketball what miniature golf is to golf. Bankshot basketball is a pure shooting sport involving 12 backboards of varying shapes **(Fig. 92)**.

The game requires different shooting strategies which become progressively more difficult as one moves from basket to basket. Each player is given his own scorecard. At each station, there are three circles. The player shoots twice from each circle. The circles are worth one, two, and three points respectively. If the player scores from each circle, he or she is awarded a bonus point, and is able to take a bonus shot from the circle of his or her choice. A maximum of ten points are possible at each station. The twelfth station has two baskets, so the perfect score is 130 points. Shooting accuracy, touch, intelligence, and concentration are the requisites to a successful game.

Bankshot basketball can be played either inside or outdoors. The game is a non-running, non-contact, and non-exclusionary one. This activity allows the wheelchair player to participate on an equal basis with the able-bodied person.

A partial listing of Rabcan bankshot locations follow:

U.S.A.

- Sesame Place Park of the Children's Television Workshop
  Langhorn, PA
- The Navy Recreation Center
  Solomons Island, MD
- Coler Memorial Hospital
  Roosevelt Island
  New York, NY
- Milford Recreation Center
  Milford, CT

Wheelchair Basketball

Fig. 92. A bankshot basketball court. (Photo courtesy of Rabcan Associates, Inc.)

- Route 18 Golf and Bat
  Recreation Center
  Old Bridge, NJ
- Gene's Miniature Golf and
  Bankshot Course
  Madison, WI
- The Fairgrounds
  Washington County, OH
- The West Seneca
  Developmental and
  Rehabilitation Center
  West Seneca, NY

Israel

- Tel Aviv Sportek Sports Field
  Tel Aviv
- Soldiers House
  Neot Afeka
- Ilan Sports Center for
  Handicapped Children
  Ramat Gan
- Man and Environment Expo
  Gan Aronim
- Childrens World (Medinot
  Yeledim) Exhibition Grounds
  Tel Aviv
- Tel Aviv Youth City
  Ir Hanoar

For more information, contact:

- Rabcan Associates
  485 Fifth Avenue
  New York, NY 10017
  (212) 682-1371

Wheelchair basketball started in the mid 1940s under the auspices of the Veterans Administration, and the National Wheelchair Basketball Association was established in 1949. The game's instant popularity soon spread across the nation, and before long was being played in Canada, England, and throughout the world **(Fig. 93)**. Today, the NWBA is comprised of more than 150 teams, organized by conferences on a geographical basis. A regular basketball season is followed by regional and sectional tournaments, sending four teams to the national tournament each March.

Players

Any individual with permanent, severe leg disability — and who requires the assistance of a wheelchair — is eligible to play wheelchair basketball.

Wheelchair

The approved sports chair is the standard Everest and Jennings Universal Model, or any equivalent. The height of the seat must not exceed 21 inches from the floor, and the height of the foot platform bumper must be 4⅞ inches from the floor. Class III (see classifications in this section) players are permitted to use foam rubber cushions of 2-inch thickness for specific medical and therapeutical reasons; all other players can choose cushions of up to 4-inch thickness. A heel strap of at least 1½ inches wide must be attached to the foot platform bars.

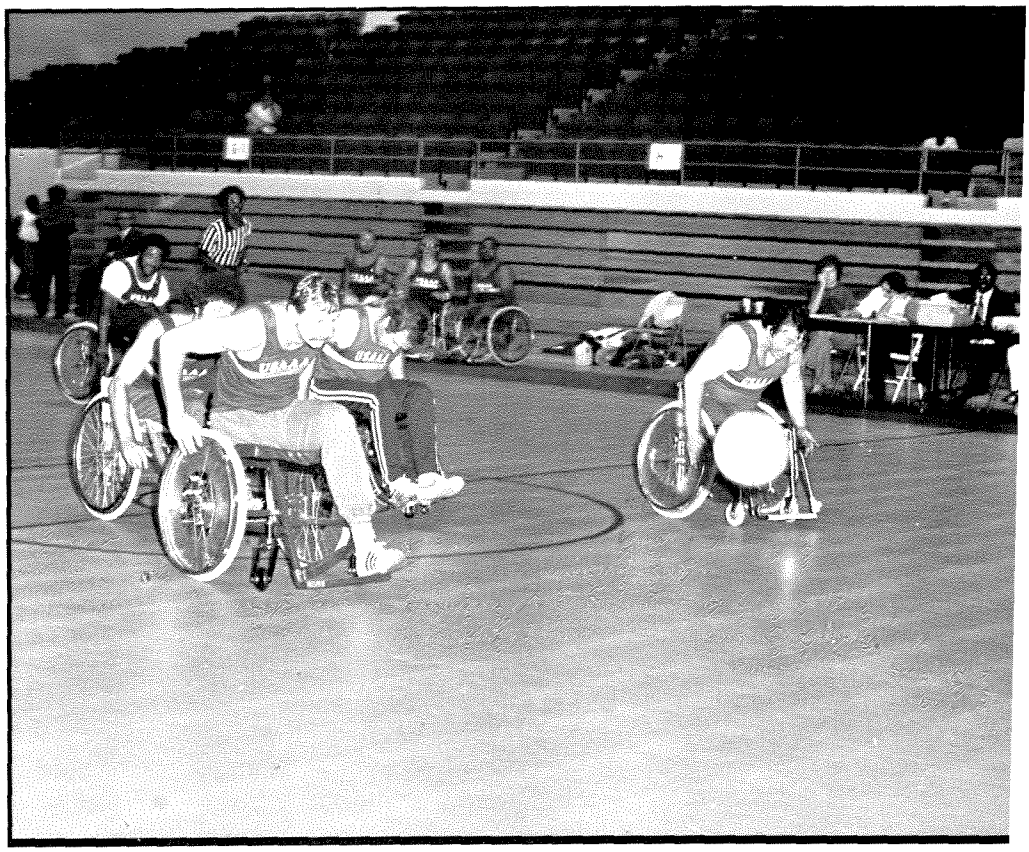


Fig. 93. Wheelchair basketball. (Photo courtesy of *Spokes 'n Spokes Magazine*, Paralyzed Veterans of America)

Wheelchair Basketball

Contact

The chair is considered a part of the player. General rules of contact in standard regulation basketball (charging, blocking, etc.) apply to wheelchair basketball as well.

Jump Ball

For any jump ball, each jumper must remain firmly seated in his chair (i.e., not lifting the buttocks from the seat). The player is also required to stay within the jumping circle at a 45 degree angle to his or her own basket.

Time Limit

An offensive player cannot remain in the free-throw lane for more than five seconds while his team is in possession of the ball.

Dribble

A player may wheel the chair and bounce the ball simultaneously. In addition, a player with the ball in his or her possession can take no more than two consecutive pushes, with one or both hands, in either direction. If he has taken two pushes, he must shoot, pass, or bounce the ball one or more times before pushing again. The latter can be repeated since there is no double dribble violation. Three or more consecutive pushes by a player with the ball in his or her possession constitutes a traveling violation.

Out of Bounds

A player is considered out of bounds when he, or any part of his wheelchair, touches on or beyond the playing boundary.

Physical Advantage Foul

Since there are varying causes and degrees of disability among participants, the basic rule that requires one to keep firmly seated in the wheelchair at all times and not to use a functional leg or residual limb for physical advantage over an opponent is strictly enforced. An infraction of this rule (during rebound, jump ball, etc.) constitutes a physical advantage foul, and is so recorded in the official score book. Three such fouls disqualify a player from the game. A free throw is awarded, and the ball is given out of bounds to the opposing team.

Back Court Foul

A defensive player who commits a personal foul in his opponent's back court is charged with a back court foul. The offended player is awarded two free throws.

Falling

If a competitor falls out of his chair during the game, the officials will immediately suspend play if there is any chance of danger to the fallen player. If not, the officials will withhold their whistles until the particular play in progress has been completed. If a player falls out of his chair to gain possession of the ball, or keeps his opponents from gaining possession of the ball, then the ball is awarded to the opposing team. If a player in possession of the ball makes any physical contact with the floor or tilts his or her chair so far backward that the safety casters touch the floor, a violation is called and the ball is awarded to the other team.

Classifying Players

There are several reasons for classification of players in wheelchair basketball:

- To provide an opportunity for severely disabled individuals to participate.
- To extend the competitive participation of individuals with similar disabilities.
- To encourage new teams.
- To make competition more equitable among existing and new teams.
- To maintain high standards of competition, quality of play, and spectator interest.

Player Classification

- Class I:
  Complete spinal paraplegia at T-9, or above, or comparable disability where there is a total loss of muscular function originating at T-9, or above.
- Class II:
  Complete spinal paraplegia at T-10, or below, or comparable disability where there is significant loss of muscular function of hips and thighs.
- Class III:
  All other disabilities, including amputation.

Team Balance

Each classification is given a numerical value as follows:
Class I : 1 value point;
Class II : 2 value points;
Class III: 3 value points.
At no time during a game is a team permitted to have players on the floor simultaneously with a total of greater than 12 points.

For more information, contact:

- National Wheelchair
  Basketball Association
  110 Seaton Building
  University of Kentucky
  Lexington, KY 40506
  (606) 257-1623

For information on wheelchair basketball camp, contact:

- Rollins Warhawk Wheelchair
  Basketball Camp and
  Coaching Clinic
  c/o Lou Zahn,
  Summer Camp Office
  Roseman Building 1004
  Univ. of Wisconsin
  Whitewater, WI 53190
  (414) 472-3169

Wheelchair Bicycling

Most individuals with lower limb amputation can ride a handcycle if they have use of their upper limbs. Handcycling is performed by pedaling with the hands rather than the legs **(Fig 94)**. This activity is a good form of exercise and is beneficial to cardiovascular and pulmonary function.

Standard handlebars are replaced by a hand-cranked chain wheel, and chain linkage to the front wheel, thus providing propulsion and a steering mechanism. Braking is achieved by back pedaling. Since the seat of the bicycle is positioned relatively low to the ground, the rider can use his hands for support on starting or stopping. Specially padded skateboarding gloves can be worn, and heavy-duty rollerskate wheels function as training wheels.

For additional information on handcycling, contact:

- Beneficial Designs Inc.
  Peter Axelson, President
  5858 Empire Grade Road
  Santa Cruz, CA 95060
  (408) 429-8447

Fig. 94. Pedaling with a handbike. (Photo by Colleen Monahan, courtesy of Beneficial Designs, Inc., Santa Cruz, CA)

Another alternative available to the cyclist with amputation is unicycling. A single wheel is attached to the front of a standard wheelchair, allowing it to be pedaled entirely by hand. (See photo, page 71.) Attaching the unicycle (i.e., the wheel) to a conventional chair can be accomplished in less than 30 seconds. Then, the cyclist is ready to travel at speeds of 10 to 15 miles an hour, covering 3 to 5 miles at this speed with minimal, if any, fatigue.

On reaching one's destination, he or she detaches the unicycle to have use of the wheelchair for day-to-day activities. The unicycle is durable and lightweight, around 17 pounds. Another attractive feature of this device is ease of storage. The unicycle is designed to stow in the trunk of a car.

With the 3-speed or 5-speed unicycle, steep hills can be crested in first or second gear without any problem. The 3-speed model uses a hub-type gear change with an effective coaster brake. For the avid unicyclist, there is the 5-speed model which uses a Shimano derailer system in conjunction with a clamp-type rim brake.

Obtaining repairs and parts is usually not a problem as most bicycle shops are equipped to fully service the unicycle. This innovative device, which was conceived and designed by a paraplegic, is a device that is becoming increasingly popular.

For more information contact:

- Unicycle, Inc.
  P.O. Box 276
  Station N
  Montreal, CN
  H2 X 3M4

For more information on the "Happy Wanderer," an outdoor electric wheelchair designed to look like an adult three-wheel bicycle, contact:

- Palmer Industries
  P.O. Box 707
  Union Station
  Endicott, NY 13760
  (607) 754-1954

Wheelchair Boating

For those people getting into a boat from a wheelchair, a hydro hoist is an effective device. The hoist lifts the boat completely out of the water on large fiberglass pontoons. Undesirable lateral motion is prevented by four mechanical arms attached to the side of the slip, keeping the boat centered in an immovable position. By lowering the boat so that the gunwale is level with the seat of the wheelchair, one can slide from the chair, to the gunwale, to the pilot's seat. If the boater is using crutches or a walker, he or she backs up to the gunwale, sits on it, swings legs over, and slides into the driver's seat. Once in the boat, the marine enthusiast generally encounters no significant inconvenience.

In preparing for a boating trip, it is a good idea to contact the local boat yards to find out which ones are equipped with hydro hoists. These devices are readily available since they are widely used by boat owners for keeping the hull of the boat out of water, clean, and free from any floating oil, algae, and barnacles.

Another boat that is available to those with disability is the pontoon. Transferring from the dock to the boat is relatively uncomplicated for a person in a wheelchair as the flat deck of a pontoon boat is nearly parallel to a floating dock, especially in nontidal water. Floatation devices are important for anyone who plans to spend any amount of time boating. Distribution of personal floatation devices relates to the water-immersed individual's center of gravity, which is roughly at the navel of an able-bodied person. Prosthetic devices or amputated limbs, however, tend to change one's center of gravity. Thus, floatation material has to be redistributed to ensure safety. For example, a person with lower limb amputation will have a higher center of gravity, thereby requiring more floatation material. In any event, those with amputation should experiment with floatation devices in a swimming pool before attempting to use them for boating.

For additional information on wheelchair boating, contact:

- Courage Center
  c/o Mary Lou Donovan
  205 West Second Street
  Duluth, MN 58802
  (218) 727-6874
- Mission Bay Aquatic Center
  c/o Ted Bitner
  1001 Santa Clara Point
  San Diego, CA 92109
  (619) 488-1036
- Tri-County Wheelchair Athletic Association
  c/o Richard Ciccotto
  Route 2, Box 589
  Moncks Corner, SC 29461
  (803) 761-2652
  (803) 552-0314
- Water Safety and Boating Program for the Disabled
  Office of Parks and Recreation
  c/o Glo Webel
  Sailboat House
  1520 Lakeside Drive
  Oakland, CA 94612
  (415) 444-3807

(See also the section on boating in **Sports Organizations and Resources**.)

Wheelchair Bowling

Bowling is a sport in which virtually anyone in a wheelchair can participate. Bowling for the physically handicapped grew in prominence during the years of 1946 to 1948. Wheelchair bowling was formally introduced at the National Wheelchair Games, held in New York in 1957.

For the beginning wheelchair bowler, balance point in the chair is important since balance point largely determines which bowling style is most appropriate for a given individual. To identify balance point, the bowler's legs should be in a comfortable and steady position because leg weight significantly affects the stability of the chair. Ideally, one should keep his feet flat on the foot plates. Avoiding unnecessary movement in the chair is a must for determining balance point.

The design of the wheelchair plays a major role in a bowler's success or failure at the game. Front casters and larger rear wheels are widely used, though some bowlers, including former national champion, John Prato, prefer larger wheels up front, with casters in the rear. Solid rubber casters are generally preferred, while air-filled, treaded tires (for the rear wheels) are popular since air provides a comfortable ride and serves as a leveling agent. The addition of heavier spokes to the wheels helps absorb motion and stress related to bowling.

To improve the holding power of brakes found on standard wheelchairs, one can purchase a brake attachment. These attachments, designed by George H. Snyder, Chairman of The American Wheelchair Bowling Association, Inc., are universally adaptable and fit virtually every wheelchair.

As for modifying the chair to facilitate bowling, a padded backrest to alleviate pressure on the

spinal column is highly recommended. Foot plates are important, too. They provide added leverage by keeping the player's heels firmly hooked. A strap, a piece of wood, or any adaptive device that works as a foot plate is fine for this purpose.

At the lane approach, the bowler should set the ball in its holder attached to the arm of the wheelchair, while pushing up to the foul line. The precise spot where the bowler sits at the foul line depends on whether he or she is right- or left-handed. Right-handed bowlers should sit with their front wheels behind the foul line and their left front wheel near the edge of the lane, thereby positioning the ball close to the center of the foul line. For left-handed bowlers, the marks are simply reversed. In addition, the person with amputation who is right-handed should try to remember to sit as far to the right of the chair as possible, while the left-handed bowler will want to sit to the extreme left. Some players find that padding the seat to fill up the unoccupied area prevents undesirable sideward movement. Removal of wheelchair armrests might also provide more mobility.

In addition to the foregoing, there are currently several special bowling devices on the market to aid the growing number of individuals interested in wheelchair bowling. The following is a brief description of these devices.

Bowling Ramp

The bowling ramp is a device which causes the ball to roll down the ramp, and then down the lane for a score. Though the ramp is not allowed in American Wheelchair Bowling Association national competition, it can be used by the bowler with amputation for recreation.

The Roll-A-Ball bowling ramp consists of two parts which can be easily assembled or broken down for storage. This ramp is made of chrome-plated tubular steel and designed to let those in a wheelchair place the ball on top of the ramp, aim it in the desired direction, and release it **(Fig. 95)**.

For additional information on the bowling ramp, contact:

- The Easter Seal Society of Iowa, Inc.
  c/o Randy Reid,
  Co-Coordinator/Cerro Cordo County Programs
  525 First N.E.
  Mason City, IA 50401
  (515) 289-1933
- Lee's Lanes
  Rolland Miles and Lyle Abrahamson, Owners
  RFD #2
  Mason City, IA 50401
  (515) 423-9883

Snap-Handle Bowling Ball

This is a regulation bowling ball which has a "spring-loaded" retractable handle. The handle snaps back flush with the surface of the ball, allowing a true roll. It is crucial that the bowler keep his or her elbow bent to maximize the device's usefulness and to avoid a pulled-out handle, which might cause the ball to bounce off the floor behind the foul line.

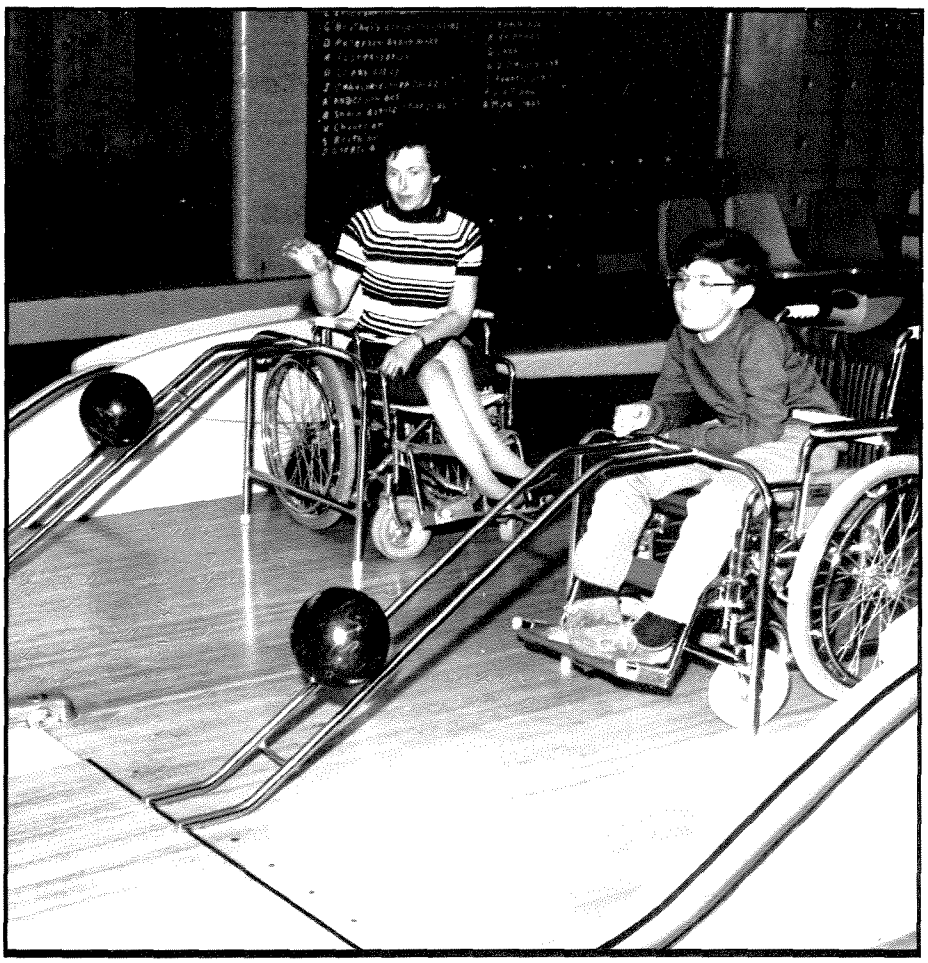


Fig. 95. Disabled bowlers using a bowling ramp. (Photo courtesy of The Easter Seal Society of Iowa, Inc.)

Wheelchair Bowling

For more information contact:

- Recreation Unlimited
  820 Woodend Road
  Stratford, CT 06497
  (203) 375-5853

Bowling Stick

This device, similar to a shuffleboard stick, works by pushing the ball down the lane for a score. The stick, which acts as an extension of the bowler, cannot cross the foul line upon delivery of the ball. Bowling sticks can be handcrafted from rigid aluminum tubing, or obtained by contacting:

- North American Sports
  P.O. Box 430, F.H. Station
  1175 State Street
  New Haven, CT 06513
  (203) 789-1811

- Phillip Faas
  3134 Bayshore Blvd. N.E.
  St. Petersburg, FL 33703
  (813) 526-6588.

- Therafin Corporation
  3800 S. Union Ave.
  Steger, IL 60475
  (312) 755-1535

Ball Holder

This is a "ring" device that clamps on the arm of the wheelchair so a bowler can carry his or her ball from the ball return rack to the foul line **(Figs. 96a and 96b)**. It serves as a third hand, is made of heavy duty aluminum in one piece with no nuts or bolts that can get lost, and is easy to attach to most wheelchairs. The ring is three-eighth inches in diameter. For availability of this device, contact:

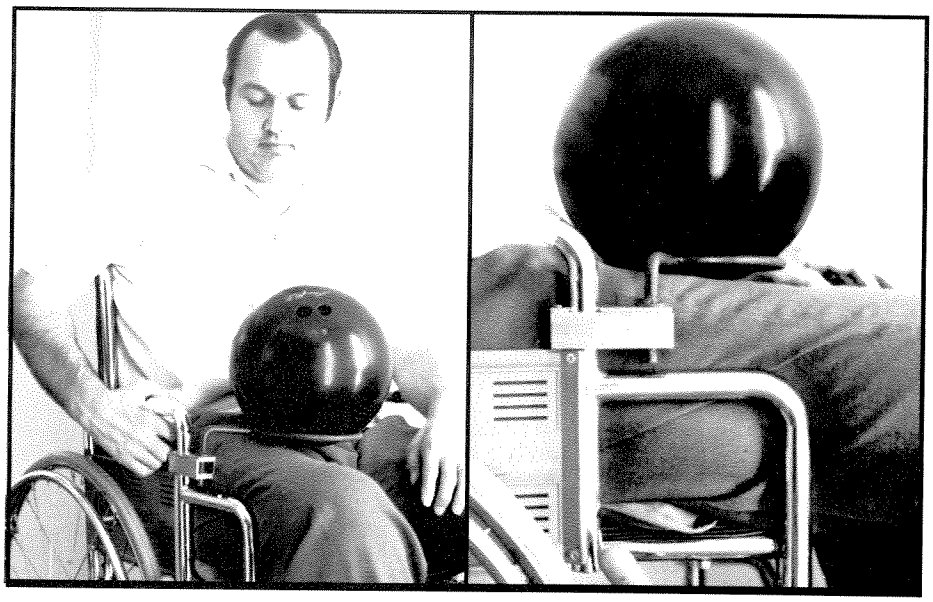
- George Snyder Enterprises
  5809 N.E. 21st Avenue
  Fort Lauderdale, FL 33308
  (305) 772-6526

For additional information on wheelchair bowling, contact:

- Wheelchair Bowling Assn., Inc.
  c/o Daryl Pfister, Chairman
  N54 W 15858 Larkspur Lane
  Menomonee Falls, WI 53051
  (414) 781-6876

Wheelchair Floor Hockey

Wheelchair floor hockey is played using 15 players and electric wheelchairs. The rules are the same as those for regular floor hockey. There are several wheelchair floor hockey teams in California **(Fig. 97)**.



Figs. 96a and 96b. Wheelchair bowling ball holder. (Photos courtesy of George Snyder, Enterprises)

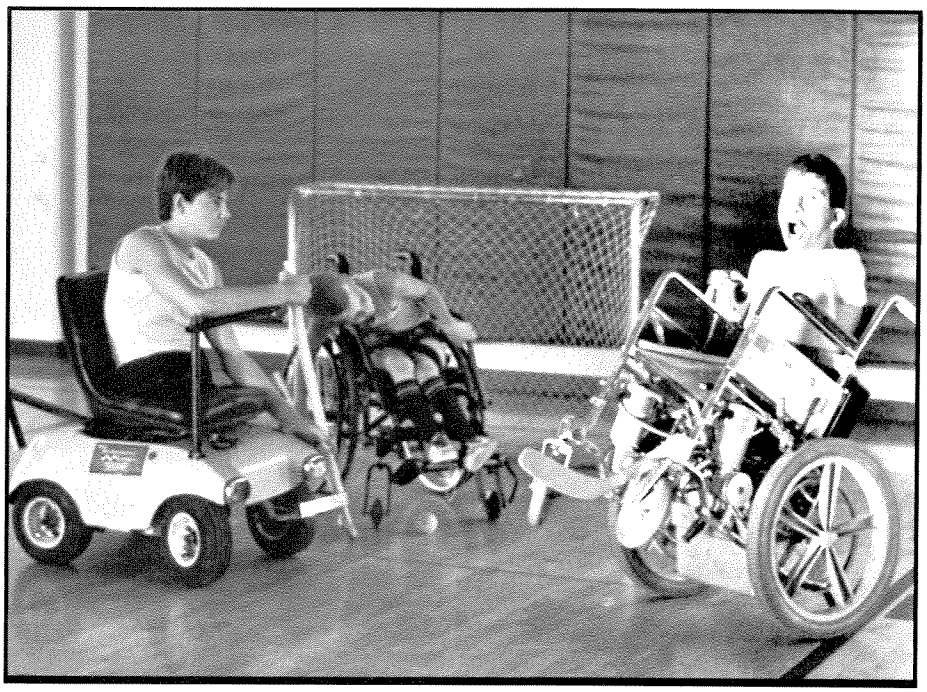


Fig. 97. A lower amelic and a quadra-amelic hard at a game of wheelchair floor hockey. (Photo courtesy of George Barksdale and Amputees in Motion)

Wheelchair Football

Wheelchair football is a fast, rigorous sport. Nowhere else in the world is the game played on the same scale or magnitude as it is at the University of Illinois. The rules governing wheelchair football preserve all the elements of regular football. Thus this sport demands routine physical conditioning, teamwork, agility in handling a wheelchair at top speed, and the stamina to take hard knocks and trauma. The teams use a repertoire of standard plays, including sweeps, traps, deep passes, and screen passes.

The University of Illinois' armory, with its expansive Tartan surface, provides an ideal setting for wheelchair football. The playing field measures 60 × 30 yards with 8-yard end zones. Each team has six playing members on the field at a given time. Two-handed touch substitutes for the tackle of regular football, while head-on ramming of wheelchairs constitutes blocking. Passing, running, and blocking are all part of the wheelchair football game.

Wheelchair football is officiated by sanctioned high school and/or college officials who follow the rules for collegiate football except for a few modifications, primarily to accommodate for the use of the wheelchair.

As in regular football, players are placed in positions based on their abilities and desire to play. These are serious athletes, and are treated as such. They assume the full responsibilities and obligations that go with being team members. Faithful practice, rigorous training, and good motivation is expected of all players.

As in regular football, each player has an assignment for each play. If, for example, the assignment is to block a defensive backfielder, he or she must have a clear idea of how to make the block as the offense sets up. Since the wheelchair takes up more space than the human body, the blocker has the advantage of creating a larger obstacle for the defensive person to move around. One's speed and timing are crucial to executing a good block. Rules of blocking apply in wheelchair football as in any football game.

Players must be properly instructed in how to cope with the eventuality of falling out of the wheelchair. When going over backwards, one needs to tuck his chin in and grasp either the front arm rest (up-right) or the hand rims. The handle bars will break the fall while the back cushions (usually of naugehyde) serve to reduce the trauma from the jolt. In falling forward, however, the player should put his hands in front of his face (elbows extended) and roll over onto the shoulder, and then the back, as contact is made with the ground.

Moving at high speed, tacklers can cause problems if they approach their tag with extended arms, or thrust too agressively at a ball carrier. For this reason, it is very important to impress players with the fact that a tag is sufficient if it merely touches the player; there is no purpose in injuring another athlete with an overly ambitious tag. Emphasis is on the enforcement of safety rules.

For additional information on wheelchair football, contact:

- University of Illinois
  Rehabilitation-Education Ctr.
  c/o Brad Hedrick, Supervisor
  1207 South Oak Street
  Champaign, IL 61820
  (217) 333-4600

(See also the section on football in **Sports Organizations and Resources.**)

Wheelchair Motorcycling

The Wheelchair Motorcycle Association (WMA) was founded in Massachusetts in 1975 by those who were seeking a way to give handicapped individuals a better chance to enjoy the world. One exciting by-product of this group's effort is a three-wheeled, all-terrain cycle that was already completely hand-controlled in its original manufacture. The machine is relatively small, compact, inexpensive, extremely versatile, and boasts a seat height that eases transfer from a wheelchair.

This all-terrain cycle has special handling qualities that are easily learned. With its three large, low-pressure, knobby tires, this machine can negotiate sand, mud, light snow, packed snow, shallow streams, puddles, and rocky trails. It enables those with disability to fully enjoy the world of wind, sun, and snow, to go camping, and to explore the great outdoors. These machines can be useful in performing daily chores such as landscaping, running errands, and other light tasks.

The Wheelchair Motocycle Association has researched motorcycles to assess their suitability for children and, as a result, recommends the Hornet ATV Go-Cart. This all-terrain vehicle has an electric start and two bucket seats so that an adult or friend can ride with the child. (Giving the child a CB radio is also helpful). This Association publishes a booklet entitled "Climb for Independence," which reviews the advantages and disadvantages of several of the vehicles on the market.

A motorcycle can also be operated from a wheelchair by using a custom-designed platform sidecar. There is no problem in licensing such vehicles. The cycle with a sidecar attached can maintain safe street speeds for in town and can cruise up to 55 mph on the open highway.

Wheelchair Motorcycling

For more information contact:

- Tomco Enterprises, Inc.
  7701 Hoover Road
  Valley Center, KS 67147
  (316) 755-2269

For additional information on wheelchair motorcycling, contact:

- Wheelchair Motorcycle Assoc.
  c/o Dr. Eli Factor
  101 Torrey Street
  Brockton, MA 02401
  (617) 583-8614

(See also the section on motorcycling in **Sports Organizations and Resources**.)

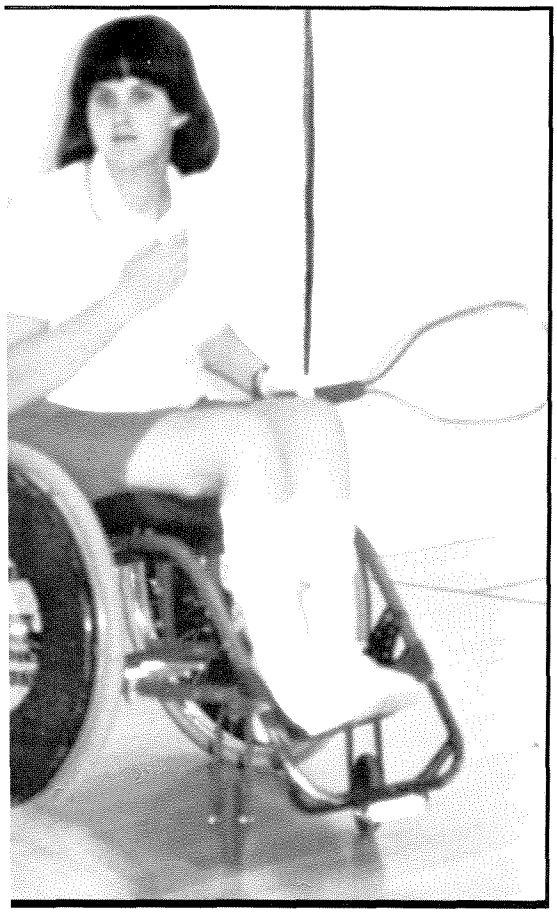


Fig. 98. A wheelchair racquetball player. (Photo by Bernice Kegel)

Wheelchair Racquetball

Since its inception in 1981, wheelchair racquetball has generated widespread enthusiasm. Today, there are men's and women's wheelchair divisions at the AARA's (American Amateur Racquetball Association's) National Singles Championship Tournament. Moreover, the NWRA (National Wheelchair Racquetball Association) has been formed as a separate part of the AARA **(Fig. 98)**.

The Diamond Racquetball Club in Diamond Bar, California was the location of the Casa Colina Invitational Wheelchair Racquetball Tournament held on March 9, 1984. This tournament was the first of its kind in that it was exclusively for wheelchair athletes.

Organized and sponsored by Casa Colina Hospital and Quadra Wheelchairs, the tournament was launched with an exhibition between Jim Leatherman and Chip Parmelly from Casa Colina Hospital. These two well-known athletes demonstrated the so-called "two-bounce" rule, or how racquetball can be played using two bounces. Leatherman and Parmelly convinced the capacity crowd that racquetball, with very little modification, offers an exciting opportunity to the wheelchair athlete.

For more information on wheelchair raquetball, contact:

- Jim Leatherman
  20 S. Kresson Street
  Baltimore, MD 21112
  (301) 732-1881
  (301) 594-3833

- National Wheelchair
  Racquetball Association
  c/o American Amateur
  Racquetball Association
  815 N. Weber/Suite 203
  Colorado Springs, CO 80903
  (303) 635-5396

Wheelchair Softball

The University of Illinois has informally conducted wheelchair softball for the past 36 years as a recreational program with regular series among disabled student teams playing in a short spring season. Problems with this program are that many players are needed and that it conflicts with the training and competitive season for wheelchair track and field, swimming, archery, and other spring and summer activities for the disabled.

However, the sport has been organized through the formation of the National Wheelchair Softball Association (NWSA), which held its first national tournament in August, 1977. This tournament is held in September each year. It consists of eight or more teams participating in a playoff. The NWSA game is played according to the official rules of 16-inch slow pitch softball with the following exceptions:

—All participants must be in wheelchairs, and the chairs must have foot platforms **Fig. 99)**.

—A player may not leave the chair to stop or catch a hit ball or to throw a ball. If a fielder leaves the chair to catch a ball, the ball is considered dead and the hitter is awarded two bases from the last base achieved by the hitter's team before the violation occured.

—The game is played on a smooth surface, such as a large, empty parking lot. Playing on grass creates difficulties for players in wheeling their chairs. The official diamond should have 50 feet between all bases and 70 feet 8½ inches from home base to second base.

—The bases are flat, 1-foot square, and inside the foul lines.

—A 4-foot in diameter circle is located at each base. A defensive player must have at least one wheel within the defensive circle

Wheelchair Square Dancing

to force a runner out. The base runner must have at least one wheel touching the circle to tag the base; or tag it by hand.

—All teams are required to include one quadriplegic player. If a team does not have a quadriplegic on the field, it must play the game one player short. When a team is at bat, there must be one quadriplegic on the hitting lineup. The ball used is larger than a regulation softball to slow it down.

For more information, write:

- The National Wheelchair Softball Association
  P.O. Box 737
  Sioux Falls, SD 57101-0737
  (605) 334-0000

- Steve Blacksher, Program Coordinator
  Baltimore County Department of Recreation and Parks
  301 Washington Ave.
  Towson, MD 21204
  (301) 494-3345

Those confined to a wheelchair can, and do, enjoy the challenge of square dancing, especially since the advent of sleek sports and dance-oriented chairs **(Fig. 100)**. Even the new chairs, however, occupy considerable space, so it is a good idea not to join a set with too many dancers. The speed with which the calls are given is important as well. The instructor will need to be familiar with dance language, new movements, and the various calls. He or she should also have the dances fully prepared for execution so as not to waste the dancers' time.

Though an individual in a wheelchair often moves faster than those not in a chair, wheelchair dancing is generally done at a somewhat slower rate than other dancing because of the chair manipulations involved. By reducing the tempo by 1/3 to 1/4, wheelchair square dancers can successfully keep up with the calls.

For additional information on this actvity, contact:

- The Colorado Wheelers
  Brenda Ohlson
  8179 W. Louisiana Ave.
  Lakewood, CO 80226
  (303) 782-9358

- Phyllis Ann Jones, Secretary
  Recreation & Athletics
  University of Illinois
  Rehabilitation-Education Ctr.
  1207 South Oak Street
  Champaign, IL 61822
  (217) 333-4600

(See also the section on square dancing in **Sports Organizations and Resources**.)

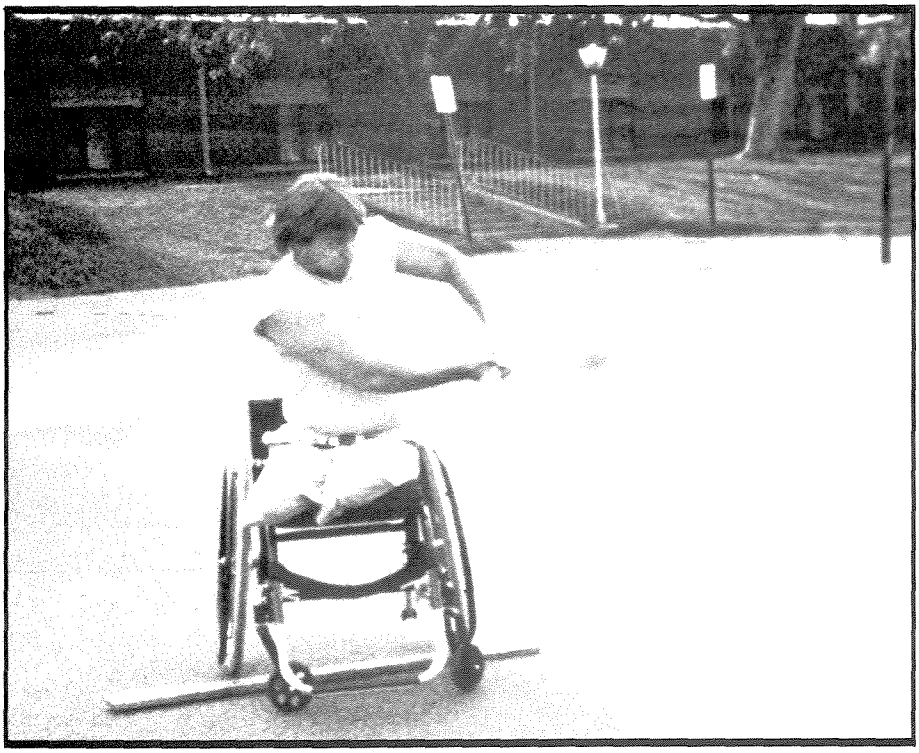


Fig. 99. A wheelchair softball player at bat. (Photo by Bernice Kegel)

Fig. 100. Wheelchair square dancers. (Photo by Bernice Kegel)

Wheelchair Tennis

Since its inception in the mid 1970s, wheelchair tennis has been the fastest growing of all wheelchair sports.

The first organized wheelchair tennis tournament was held in 1975 in Hawaii, followed by another in 1977 in Southern California. Wheelchair tennis enthusiasm has since spread across the country. To date, the game is played in 19 countries, including parts of Europe, Asia, the Middle East, the Caribbean, Canada, and the South Pacific.

In 1980, The National Foundation of Wheelchair Tennis (NFWT) was organized to develop, promote, and provide exposure for this challenging sport. As a result, clinics, tournaments, exhibitions, leagues, junior development programs, and research have been conducted throughout the world.

In 1981, the Wheelchair Tennis Players Association was formed under the auspices of the NFWT. As NFWT is the organizing body of wheelchair tennis, the WTPA is the controlling body of wheelchair tennis competition.

In 1984, some 200 disabled players participated in the U.S. Wheelchair Tennis Championships at the Racquet Club of Irvine, located in Irvine, CA. In addition to organizing competitive tournaments (including the Everest & Jennings Grand Prix circuit), NFWT organizes symposia, produces instructional manuals, videotapes, and a newsletter, and sponsors summer camps in Mission Viejo, CA, Orange, CA, and Denver, CO.

Wheelchair tennis can be played by people of virtually any age or disability **(Figs. 101a and 101b)**. It is highly recommended for the older person with amputation, as this is a sport one would be able to play for many years. The advantages of increased muscle usage and improved cardiovascular and respiratory function add to the appeal of tennis. One of the best advantages is that it can be played by able-bodied and disabled players simultaneously. It is relatively inexpensive with the only investment being a sports wheelchair.

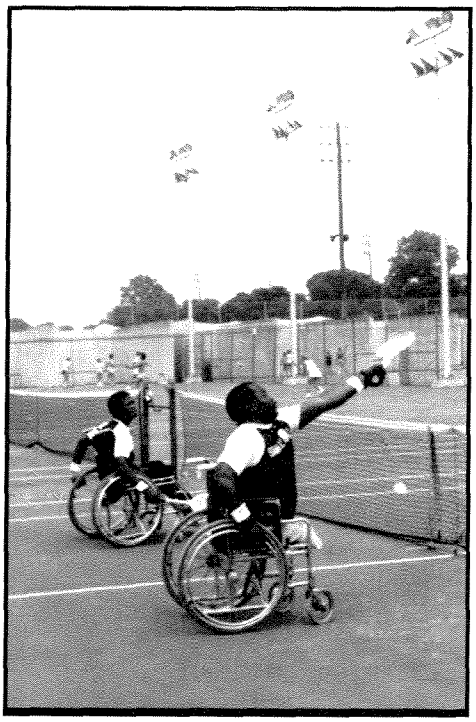


Fig. 101a. A bilateral amputee playing wheelchair tennis. (Photo by Lawrence J. Tabak, courtesy of the U.S. Tennis Association, Inc.)

In wheelchair tennis, a player has to not only master the game of tennis, but also use of the wheelchair. Learning to move in one's chair on the court is one of the most exciting and challenging aspects of the game. Players can use a regular chair, though removal of the armrests is helpful. As they progress, the facile maneuverability of a low-backed, lightweight sports chair is also helpful.

A chair with a low center of gravity is best. The athlete should make sure that when he or she leans backward to complete a serve, the chair does not tip over; a high-backed chair is a hindrance for serving. The player should also practice wheeling and avoiding lifting the front casters, as this will decrease speed.

For more information on wheelchairs designed for tennis playing, contact:

- Poirier S.A.
  Magnum International
  2930 West Central
  Santa Ana, CA 92704
  (714) 641-9696

It is important for the player to learn to keep his racket in his hand

Fig. 101b. Wheelchair tennis. (Photo by Bernice Kegel)

at all times. Too much time is wasted if he places it on his lap or between his legs to free his hands for wheeling the chair. The player should practise holding the wheel rim and racket simultaneously. He does this by holding the racket handle against the hand rim, with his thumb on top of the rim, and his fingers wrapped around the rim and racket at the same time.

To begin receiving ground strokes, Brad Parks (National Foundation of Wheelchair Tennis) recommends that the player start at 1 to 3 feet behind the baseline (in the middle of the court) with both hands on the wheels. This is called the "ready position" and gives the optimal access to the entire court.

For a forehand shot, the chair should be turned at a 45-degree angle to the net. As the player swings, he or she may need to hold on to the left knee or left side of the chair for balance; if the wheelchair has high push handles, they might interfere with the quality of the player's swing. For the backhand stroke, the chair should be turned perpendicular to the net. If the ball is directed straight at the player, the best tactic is to back up, and hit it on the second bounce. The preferred maneuver is to pull back on both wheels, and to angle the chair in the desired direction by pulling back one wheel.

United States Tennis Association (USTA) rules apply to wheelchair tennis, with the following exceptions:

- The wheelchair player is allowed two bounces.
- The first bounce must land inside the court boundaries.
- The rear wheels of the chair must be behind the service line when serving the ball.
- The chair is, in effect, a part of the body, with all applicable rules enforced.
- Any violation is given reasonable time to cure before defaulting a player.

In wheelchair tennis, the player may have two bounces before the ball is dead. The first bounce must be in the court, but the second can land outside the court. The reason for this rule is so that drop shots or short balls are easier to get to, and because it makes for a more interesting game if the player stays behind the baseline and rallies the ball back and forth across the net. If a wheelchair player receives a lob while at the net, he or she will usually lose the point due to lack of time. However, as the player becomes more proficient at playing and managing the wheelchair, he or she will usually take less advantage of the two bounce rule. Another rule is that the back wheels of the wheelchair act as the player's legs—during a serve, the back wheels of the wheelchair must be behind the serve line.

For additional information on wheelchair tennis, contact:

- International Foundation of Wheelchair Tennis
  c/o Steve Halverson
  2203 Timberlock Place
  Suite #26
  The Woodlands, TX 77380

- National Foundation of Wheelchair Tennis
  c/o Bradley A. Parks, Dir.
  3857 Birch Street, Box 111
  Newport Beach, CA 92660
  (714) 851-1707

- Peter Burwash Internatl. Ltd.
  1909 Ala Wai
  Suite 1507
  Honolulu, HI 96815
  (808) 946-1236

- USTA Education and Research Center
  729 Alexander Road
  Princeton, NJ 08540
  (609) 452-2580

The game of curling is traditionally played on ice, but now there is Unicurl, a game similar to the traditional form of curling. Unicurl allows everyone to play it anywhere. The game has been tested by the Swedish Handicap Sports Association, and is played in many European countries.

The Unicurl curling stone consists of three parts. The sliding surface is attached to the curling stone by inserting a removable handle through the stone. This enables the player to adjust the sliding surface to the playing surface, and to put on new sliding surfaces as well.

For indoor curling, the sliding surface is a smooth plane of polyurethane plastic used in combination with the curling mat.

For outdoor curling, a corrugated, thermoset-resin sliding surface, highly resistant to wear, can be used directly on all surfaces including concrete, asphalt, and even ice.

The Unicurl mat is an anti-static, needle-loom-felt floor covering, specially designed for indoor curling. It features a demarcated scoring point section and colors adapted for players with impaired vision. The mat measures 3.3 by 46 feet, weighs 77 pounds, and requires very little storage space.

Rules for playing Unicurl have been developed by the Swedish Handicap Curling Committee. According to these rules, each team consists of three players. Therefore, the Unicurl Package Set has been specially designed to accommodate six players.

For additional information on Unicurl, contact:

- Ahlqrist Agentur Ab
  Argongatan 8
  431 33 Molndal
  Sweden
  TEL: 03187 9220

Competitive Wheelchair Sports

Wheelchair Field Events

As the result of more sophisticated wheelchairs and more comprehensive training programs, competitive wheelchair sports are becoming increasingly popular.

In accordance with the rules governing competitive wheelchair sports, an individual must have a significant, permanent physical disability of the lower limbs (e.g., amputation, spinal disorder, poliomyelitis) in order to compete. While one does not have to be confined to a wheelchair to compete, he or she must use a chair for athletic competition.

Because these athletes have such diverse levels of disability, competition is regulated by classification to maintain fairness to all participants. Every prospective competitor is therefore required to undergo a special physical examination for the purpose of determining their level of muscular function. The examination must be conducted by a medical doctor or physical therapist.

There are basically two classification systems used. The first is the three-class system used for basketball. The second is the seven-class system used by the National Wheelchair Athletic Association for organized competition.

Many wheelchair athletes train year around and, as a result, have achieved notable success, including finishing the metric mile in less than 4 minutes, bench-pressing of up to 600 pounds, and marathon racing in under 2 hours.

The National Wheelchair Athletic Association (NWAA) is comprised of 16 regional groups. Each region sponsors meets in track, field, slalom, swimming, weightlifting, table tennis, and archery. Athletes meeting qualifying standards may compete in the national wheelchair competition in June of each year.

Wheelchair field events include discus, shot put, javelin, and club throw **(Figs. 102a** below **and 102b**, on following page). In these events the wheelchair remains motionless within a throwing circle 7 feet in diameter. The competitor throws the sport implement into an area marked by sector lines measuring 40 degrees from the center of the circle. The wheelchair may be anchored either by a mechanical holder connected to the wheelchair which keeps it stable **(Fig. 103**, on following page) or by a person holding it in place.

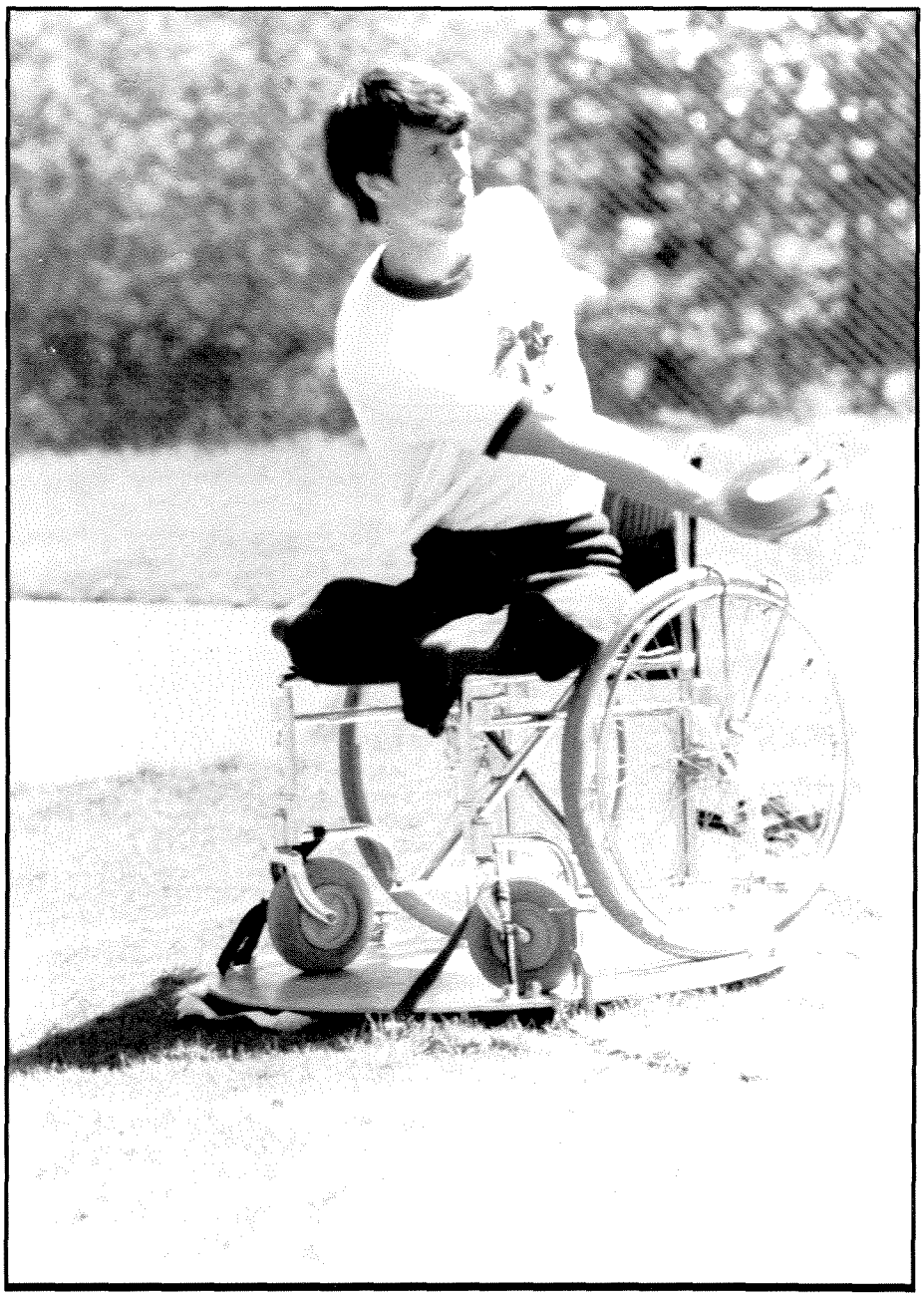


Fig. 102a. A bilateral above-knee amputee participating in discus throwing. (Photo by Bernice Kegel)

Fig. 102b. Bilateral above-knee amputees are allowed to throw javelin either from a wheelchair or from behind a hip high barrier. (Photo courtesy of *Ability Magazine*, Majestic Press, Copyright 1984)

Fig. 103. The wheelchair stabilized by a mechanical holder. (Photo by Bernice Kegel)

Wheelchair Highjump

This new competitive field event was introduced in 1981 at the 25th National Wheelchair Games. The athlete is required to "curb jump" the wheelchair onto a platform. The platform can be raised at one-half inch increments in a range of from 4 to 12 inches. The skill required is one of timing rather than strength. The athlete runs the wheelchair towards the platform and just before hitting it lifts his or her shoulders with a backward thrust of the head and torso, bringing the front wheels of the chair off the ground high enough to land the chair on top of the platform. This technique of lifting the front wheels of the chair into the air is called a "wheelie."

Wheelchair Track Events

Wheelchair racing in this country was introduced by Benjamin Lipton in 1956, when he organized the first national wheelchair games at Adelphi College in New York. In these games, a 40-yard race was run. Until 1969, the only official races were for distances of 40, 60, and 100 yards. Since that time, much progress has been made.

In 1971, the National Wheelchair Athletic Association record for the 880-yard race was 3:49.6 minutes (3.8 yards per second). By 1983, the American record for 800 meters was lowered to 2:11.7 (5.5 yards per second). In 1984, the women's 800-meter and men's 1500-meter wheelchair races were included in the Summer Olympic Games as an exhibition event. Eight athletes were selected to compete in each event.

Now, most road races include a wheelchair division on the race application form. Headstarts for the wheelchair races are usually 5 minutes or less depending on the terrain of the course. The headstart was created to allow a safe start for all athletes. Regular finishing chutes can be used by wheelchair athletes as long as they are wide enough. If a wheelchair athlete finishes ahead of the first footrunner, he or she is not considered the overall winner of the race.

In racing, the participant's pushing capacity is very important, with uniform speed essential. One should try to avoid backward movement as much as possible. Speed changes and sudden start/stop actions affect the stability of the chair. The racer should aim for a protracted push and keep the recuperation phase as brief as possible. It is desirable to use the maximum revolution time of the wheels for propulsion. The inexperienced athlete uses only one-

third of the revolution time for actual pushing. For maximum efficiency, the athlete should make a revolving circular motion with the hands in which the grip on the hand rims is only loosened to allow repositioning. The forward push of the hand is followed by a backward pull of the rim.

In the traditional propulsion technique, the athlete pushes forward and downward from the upper part of the hand rims with a contemporaneous forward trunk movement. Following release of the hand rims, his or her hands are positioned for another downward/forward push, accompanied by a backward trunk motion. This method, however, results in undesirable delays between propulsion phases. The newer circular propulsion technique is far preferred.

Shoulder mobility is important as is smooth backward movement of the arms. While small hand rims require less shoulder movement, lowered seat heights demand greater shoulder mobility.

In addition to the duration of pushing, propulsion is determined by the amount of force exerted during the push. Muscular strength is, in part, determined by the angle from which the muscles are used. By bending the trunk slightly forward at the hips, or by elevating the knees to a higher level, the pushing movement is less downward and more forward, a decided advantage to the athlete.

Air resistance is another factor in propulsion. Accordingly, the wheelchair should be constructed so that the athlete can sit low enough to decrease wind resistance. The height of the backrest need only be high enough to provide good lumbar support. The wheelchair seat is reclined backwards to enable the athlete to lean on his thighs with the lower part of the chest. The legs are stretched forward horizontally, and the buttocks are lower than the knees. With the wheelchair seat reclined, one can easily guide the hand rim. With legs stretched forward, the race chair, in effect, becomes longer and lower. To comply with regulations for track, however, the most distance allowed between the large and small wheels is 55 centimeter (1 foot 9.5 inches).

To eliminate the vertical position of the hand rims, the wheels and hand rims must slope so that the base of the wheels is broader than the distance between the tops. The hand then pushes in a plane that angles through the shoulder joint and the hand rim. The upper side of the wheels will come closer to the upper body and must be directed toward the armpit.

In this situation there is less chance that the inside of the athlete's arm will bump against the wheel or the hand-rim. Furthermore, the elbows will not spread so widely, resulting in less fatigue. The friction of the tire on the track also has to be minimal. To produce the smallest area in contact with the track, narrow tires that are highly inflated are needed. The maximum diagonal of the wheel allowed, including the inflated tire, is 70 centimeters instead of the former 65 centimeters. Little is known presently about the effect of various tread designs on the speed that a wheelchair moves over a surface.

The small front tires must be highly inflated and narrow. Their mobility must be considerably restricted to avoid flutter at high speeds, which can slow the wheelchair or cause it to overturn. The 8-inch zero pressure tire is the preferred size for racing.

It should be noted that larger hand rims are gradually being replaced by ones of smaller diameter, e.g., 30 centimeters (1 foot), especially for long-distance racers. The diameter selected depends partly on the racing terrain. The athlete must be able to apply sufficient force to cause the hand rim to revolve. The rim must permit adequate grip, while the surface cannot be too slippery. The spacers which attach from the rim of the wheel to the hand rim should be about 0.5-4 centimeters (¼ to 1½ inches) long to provide sufficient space for the handgrasp. Some athletes choose to shorten the spacers so that they can grasp the tire and hand rim simultaneously. The hand rim size and the seating angle are two factors that play an important part in competitive racing. Most athletes prefer a seat that is not horizontal, but that declines slightly backward. The height of the backrest need only be high enough to provide good lumbar support. The chair is lightweight, but durable, and is designed without frills—a basic shell for easy control.

Maintenance of the Chair

It is necessary to grease the axles and bearings in the large wheels and casters before using the chair for a race. The wheels should be checked by setting the chair upside down and slowly spinning them; they should move freely, with as little resistance as possible. The axles, too, should be adjusted to yield maximum freedom of movement. Finally, the front casters should be tightened to allow no more swivel movement than is necessary, and to prevent steering off course during a race (**Fig. 104**, on following page).

Starting the Race

The rules for wheelchair track require that the chair's casters be positioned behind the starting

line. The athlete should, therefore, slowly approach the starting line from roughly 2.4 meters (8 feet) behind the line to ensure that the casters are straight and that the chair is on course. If the casters extend over the line, the athlete must return to his or her original starting point and repeat the procedure. By arbitrarily backing up, he or she risks improper alignment of the casters, and related problems.

When the starter commands "set," the athlete should lean slightly forward in the chair while gripping the top of the rim. At the sound of the gun, he or she should quickly push forward and downward, extending the arms about three-quarters to the front. On completion of the push, he or she is ready to return the hands to the top of the rim and repeat the motion. In subsequent push movements, the athlete should fully extend the arms for accelerated speed.

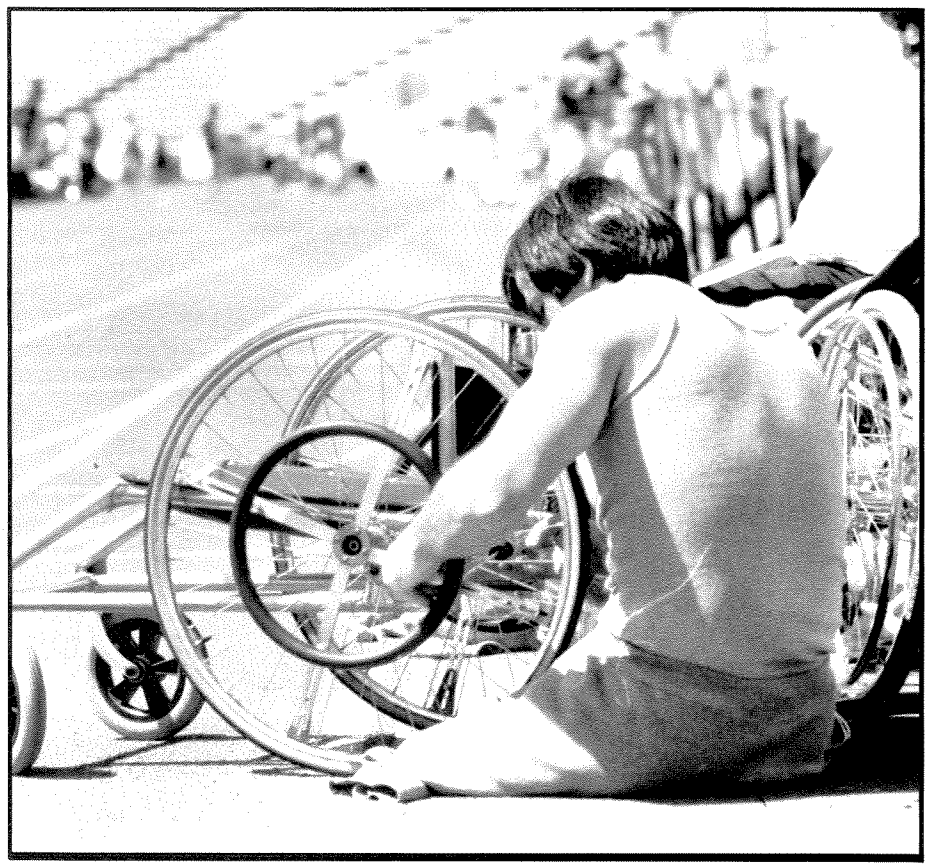


Fig. 104. A bilateral above-knee amputee prepares his wheelchair for competition. (Photo by Bernice Kegel)

The racer's initial grasp on the rim is crucial. The grasp must not be too far back in order to avoid the action of pulling upward before descending on the push. This undesirable motion causes the front part of the chair to lift, which can result in a delay significant enough to mean the difference between winning and losing the race.

The athlete's head and shoulders should be positioned slightly forward at the start of the race, and every effort should be made to keep them from making sudden backward movements as the first push is taken. With the head and upper torso leaning forward, the shoulders are in front of the vertical line through the axis of the large wheel, thereby enhancing the downward arm thrust on the front part of the wheel for more powerful action. If for some reason the head and shoulders are thrown back, a "wheelie" will occur. A "wheelie" means that the front wheels are pulled up from the ground, which slows the speed of the wheelchair.

The Race

Once the athlete has moved off the starting line and has completed the first three pushes, he or she should concentrate on two things: rapid repositioning of the hands and rhythmic pushing to build momentum. As the push phase is completed, the arms should be fully extended, without elbow flexion. At the release, the hands should be retracted as close to the wheel as possible. Many athletes make the mistake of finishing the push by swinging their hands outward and away from the wheel, thereby prolonging recovery. Since an athlete's rate of speed is dependent upon the number of complete pushes taken between the starting and finishing lines, it is important that the recovery be as quick as possible. A speedy recovery phase means more pushes can be made during the race.

In running shorter distances, e.g., 54 meters (the 60-yard dash), the athlete's rhythm should incorporate a strong, hard push and a swift recovery, whereas the longer distances require a different pushing technique. Here, a forceful arm thrust and slightly longer recovery phase, or resting period, is desirable as the chair goes into a glide. Breathing is coordinated so exhalation accompanies the pushing movement, with inhalation occurring at the recovery phase.

Training

Though training techniques of the wheelchair athlete have improved notably, there is still much to be learned. Every training program's effectiveness depends on the overall physical fitness of the trainee, specific disability notwithstanding. A number of excellent programs are available to enhance the athlete's fitness, strength, and endurance.

For example, a program of so-called interval, or graduated, training is excellent preparation for the dashes. Interval training involves a series of sprints in which the interval, or rest period, between each sprint is gradually shortened, and the distance lengthened. Sprinting on an uphill terrain has also proven to be very effective in training for the dashes.

Finally, in longer-distance racing where strength and stamina are crucial, the training programs are intense. Clearly, the more miles that a trainee can log, the stronger, more fit, and authoritative an athlete he or she will be. Many enthusiastic sports people maintain rigorous strength and fitness programs for many months at a time during training season and much earlier. These programs are worth discussing with an orthopedist or physical therapist.

For additional information on wheelchair field and track events, contact:

- National Wheelchair Athletic Association
  c/o Craig Brown, Exec. Dir.
  2107 Templeton Gap Road
  Suite C
  Colorado Springs, CO 80907
  (303) 632-0698

(See also the **Sports Organizations and Resources** section)

The first officially sanctioned 1500 meter wheelchair race was held in 1975 at the Pan American Wheelchair Games in Mexico.

Wheelchair marathon racing gained widespread popularity, however, when Bob Hall, a post-polio athlete from Boston, distinguished himself by wheeling the 1976 Boston Marathon in just 2 hours, 58 minutes. Though organized competition was slow in coming to the forefront, today many men and women with amputation are serious participants in a range of sporting events.

Two years before Hall's victory, the first organized wheelchair marathon was held in Toledo, Ohio. That event, together with the publicity generated by Hall at the 1976 Boston Marathon, encouraged scores of other wheelchair athletes to try racing. Subsequently, in 1977 and 1978, the National Wheelchair Marathon was held in conjunction with the famous Boston Marathon. As a result, today many marathons across the country include a wheelchair division when organizing this event. (As of this writing, the National Wheelchair Marathon is conducted under the auspices of the International Wheelchair Athletic Association.)

Currently, the entrants are limited to 20 wheelchair athletes. These individuals must have completed a marathon in less than 4½ hours within the year. Wheelchair marathoners cover the same course on the same day as able-bodied runners. The wheelchair athletes, however, start the race 15 minutes earlier, thus avoiding congestion at the starting line.

Of special interest is the "Continental Quest," an undertaking whereby three athletes (Phil Carpenter, George Murray, and Fred McBee) wheeled more than 3500 miles across the continental United States. They left Los Angeles on April 10, 1981, and arrived at the United Nations in New York City on August 26, 1981. During June of the same year, two wheelchair runners teamed up with an able-bodied runner to illustrate that wheelchair runners and foot runners can participate together in road race events. The racers made the 150-mile run from Albany, NY to Central Park in New York City in 48 hours. This race is known as the Empire State Challenge.

A person running expends more energy than while walking. A person on wheels expends even less energy than in walking because his center of gravity travels along a horizontal path (versus the vertical up and down path of foot runners). The wheelchair athlete, however, relies on upper body muscles, which are much less efficient than leg muscles. Therefore, the wheelchair marathon athlete probably has about the same net energy cost as the able-bodied runner **(Fig. 105)**.

Fig. 105. Wheelchair maraphon racing. (Photo by Bernice Kegel)

Wheelchair Marathon Racing

The risks of injury in wheelchair marathon racing are greatest on the downhill portion of the course. Racing wheelchairs are equipped with high-quality front casters to reduce shimmy, thus allowing for travel at high speeds. Athletes prefer not to use their brakes because doing so slows them down. The use of seat belts is discouraged as it is safer to fall free of the chair. Helmets are a good idea. Proper crowd control and maintenance of road surface are important preventative measures.

The shoulder joint bears the greatest stress in marathon racing, although shoulder derangements have not been reported to date. This is probably due to the fact that abduction and rotational elements are not incorporated into the propulsion technique. Also, wheelchair athletes have much hypertrophy in their rotator cuff muscles. Elbow and wrist injuries have not been a significant problem for marathon racers. The main areas of injury are the hands and fingers—skinned knuckles, avulsion of finger nails, and trauma to fingers and thumbs caught in wheelchair spokes. Some athletes use a dangerous technique to achieve maximum force at the start of the race, when they lock the thumb between the rim and the spoke for the initial thrust. If the thumb is not removed promptly, it can be damaged as the wheel passes fixed parts on the chassis.

The athlete does not grip the wheel. Instead the wheel or rim is grasped loosely and pushed mainly with the heel of the hand. This leads to the formation of thick calluses that become hard and may split, leading to possible infection. Use of protective gloves and tape is highly recommended. Abrasions and bruises of the inner aspect of the arm do occur because of repeated rubbing of the wheel against the arm. This problem is accentuated by the lowering of the wheelchair seat and tilting the wheels inward to maintain hand rim contact throughout the revolution of the wheel.

The skin of the buttocks is subjected to shear and pressure stresses. In order to diminish up and down movement of the center of gravity of the trunk, to diminish wind resistance, and to increase the duration of contact of the hand during a revolution of the wheel, the wheelchair athlete leans forward into a knee-chest position. The result is to place the body weight on the ischial tuberosities.

For additional information on wheelchair races, contact:

- Capital City Marathon Assn.
  c/o Dr. James McDowell, Pres.
  P.O. Box 1681
  Olympia, WA 98507
  (206) 786-1786

- International Wheelchair Road Racing Club
  c/o George Murray
  165 78th Avenue, N.E.
  St. Petersburg, FL 33702
  (813) 521-3420

- Moss Rehabilitation Hospital
  c/o Lois S. Levy
  12th Street & Tabor Road
  Philadelphia, PA 19141
  (215) 329-5715

- National Wheelchair Marathon
  c/o Bob Hall
  15 Marlborough Street
  Belmont, MA 02178
  (717) 439-3246

For information on high school wheelchair sports, write:

- Susan J. Grosse
  Physical Education Specialist
  Milwaukee Public Schools
  7252 West Wabash Avenue
  Milwaukee, WI 53223
  (414) 354-8717

Wheelchair Pentathlon

The pentathlon is a grueling 1-day event for men and women. It consists of five parts which test participants' skill in archery, swimming, javelin, shot put, and the wheelchair dash. There is an alternative test which replaces swimming and archery with discus and a second wheelchair race.

Final places are scored according to the total number of points accumulated in these five events. Points for each event are awarded on the basis of individual performance and are taken from a table of standardized scores for each pentathlon classification.

For additional information on wheelchair pentathlon, contact:

- Far West Wheelchair Athletic Association
  c/o Bruce Schreiber, Chairman of the Board
  P.O. Box 26483
  San Jose, CA 95159
  (408) 987-2828

- National Wheelchair Athletic Association
  c/o Craig Brown, Executive Director
  2107 Templeton/Suite C
  Colorado Springs, CO 80907
  (303) 632-0698

- Northwest Wheelchair Sports Association
  c/o Pat Karman, Executive Director
  3522 212 S.W. Street
  Bothell, WA 98021
  (206) 367-1771

- U.S. Amputee Athletic Association
  c/o Richard Bryant
  Route 2, County Line Road
  Fairview, TN 37062
  (615) 670-5453

Wheelchair Slalom

The slalom event is a race against time in which the athlete follows a clearly marked path through an obstacle course that measures from 70 to 100 yards in length. The course is marked by pairs of flags through which the athlete must maneuver, going between the flags, around them, backward, and forward. Failure to negotiate a curb or ramp results in disqualification, while touching a flag with the wheelchair adds one second to the finishing time. The athlete with the lowest time in a classification is the winner **(Fig. 106)**.

For more information, contact:

- Breckenridge Outdoor Education Center
  c/o Mike Mobley, Executive Director
  P.O. Box 697
  Breckenridge, CO 80424
  (303) 453-6422

- National Wheelchair Athletic Association
  c/o Craig Brown, Director
  2107 Templeton Gap Road
  Suite C
  Colorado Springs, CO 80907
  (303) 453-6422

- National Wheelchair Sports Association
  c/o Pat Karman, Executive Director
  3522 212 S.E. Street
  Bothell, WA 98021
  (206) 367-1771

- Recreation and Athletic Rehabilitation-Education Ctr.
  c/o Brad Hedrick
  University of Illinois
  1207 South Oak Street
  Champaign, IL 61820
  (217) 333-4606

Fig. 106. Wheelchair slalom competition. (Photo by Bernice Kegel)

Wheelchair Weightlifting

In wheelchair weightlifting competition, the bench lift is the only position that is recognized **(Fig. 107**, on the following page). The lifter has to lie supine on a horizontal bench, with his head, shoulders, buttocks, and legs remaining in contact with the bench throughout the lift. Putting a foot on the ground is not allowed and cushions are not permitted. The bar is placed at nipple level, about 1 foot above the chest. The maximum width of grip is determined by the requirement that the forearms have to be vertical at the commencing position. While the competitor may opt for a narrower grip, a wider grip is cause for disqualification.

A legal lift occurs when the pressing movement is continuous, with even arm extension. The press is completed when the lifter is motionless with the barbell under control at arm's length. The barbell is motionless; arms are extended. Upon the referee's signal, the competitor lowers the bar to the stands under control. The lift is not complete until the bar has been replaced onto the stands. Two out of three referees must agree that a lift is considered good. Each lifter is permitted three attempts in competition.

Weightlifting is not categorized by medical classification but by body weight. Weighing in of competitors takes place 1¼ hours before the competition, with competitors stripped down to tracksuit bottoms and no prosthesis. There are six categories as follows:

1. Light featherweight—up to 51 Kg. (112¼ lbs).
2. Featherweight—up to 57 Kg. (125¼ lbs)
3. Lightweight—up to 65 Kg (143¼ lbs)
4. Middleweight—up to 75 Kg (165¼ lbs)
5. Light heavyweight—up to 85 Kg (187¼ lbs)

Wheelchair Weightlifting

6. Heavyweight—over 85 Kg (187¼ lbs)

Weight classification for amputees are determined by adding weight factors to their body weight based on their degree of amputation. For a weightlifter with below-knee amputation, 1/18th of body weight is added. For a person with above-knee amputation, 1/9th of body-weight is added, and for someone with hip disarticulation, 1/6th of body weight is added.

As of this writing, competitive weightlifting is not open to women and is therefore not part of national competitions. Women do, however, often participate in weightlifting exhibitions at regional meets. As interest in this event widens, women's competitive weightlifting will likely become a national event.

For additional information on weightlifting, contact:

- Iron Athlete Training Center
  c/o Mark Lescow
  1940 East University Ave.
  Tempe, AZ 58281
  (602) 839-7872
- Fred Koch
  175 Lawrence Avenue
  Brooklyn, NY 11230
  (718) 436-7600

(See also the section on weightlifting in **Sports Organizations and Resources**.)

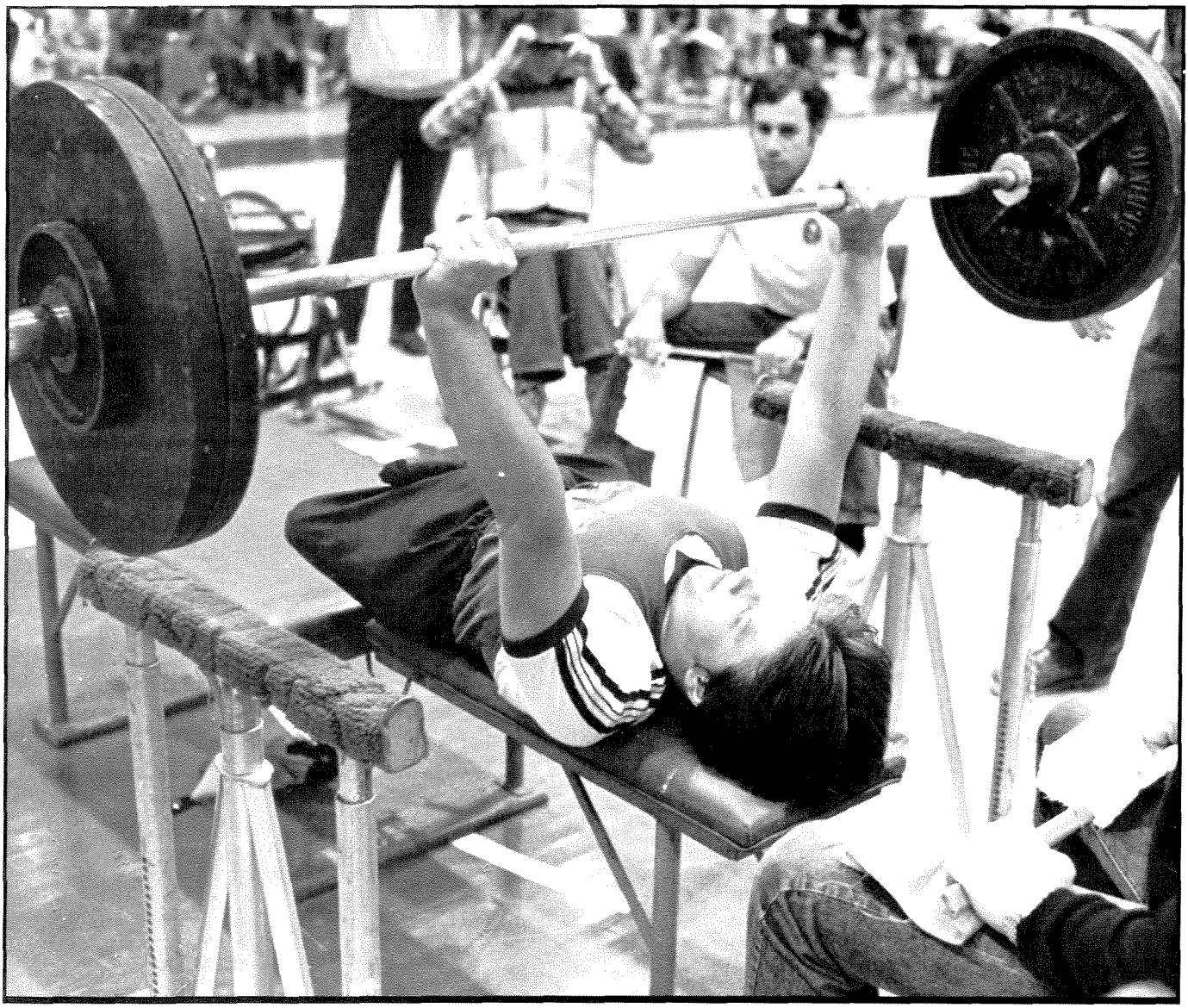


Fig. 107. Disabled weightlifter participating in a competitive event. (Photo by Bruce Terami, courtesy of the Northwest Wheelchair Sports Association)